PAPERmaking!

The e-magazine for the Fibrous Forest Products Sector

Produced by:
The Paper Industry Technical Association

Volume 2 / Number 1 / 2016

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

CONTENTS:

FEATURE ARTICLES:

1. **Papermaking**: Improving strength and retention with white-grade recycled pulps
2. **Sludge Management**: Using worms to process paper and pulp mill sludge
3. **Coating Pigments**: Designing TiO_2 nanopowders for paper coating applications
4. **Wood Panels**: Production of binderless boards
5. **Solenis**: Total Mill Perspective Helps Mills Stay Competitive
6. **ABB**: Energy Management: Lowering energy prices by managing supply & demand
7. **Salvtech**: Company profile
8. **Valmet**: Improved performance with Industrial Internet
9. **Marketing**: Green marketing initiatives in India
10. **Communication Skills**: Proven ways to improve communication skills
11. **Presentation Skills**: Hints and tips to improve presentation skills
12. **Leadership**: A leading soldier's views on leadership
13. **Self-Motivation**: Eight steps to improve motivation
14. **Leadership**: Understanding how the mind affects every day behaviour

SUPPLIERS NEWS SECTION:

Products & Services: Extended information on the latest products and services from:

ABB	Henkel	Sensonics Ltd
Archroma	Midland Pallet Trucks	**SKF**
Denver Gardner	Pilz	Versaperm

(**PITA Corporate Member**)

DATA COMPILATION:

Installations: Overview of equipment orders and installations since November 2015.

Research Articles: Recent peer-reviewed articles from the technical paper press.

Technical Abstracts: Recent peer-reviewed articles from the general scientific press.

PITA Calendar of World Events: Latest calendar of national and international events.

The Paper Industry Technical Association (PITA) is an independent organisation which operates for the general benefit of its members – both individual and corporate – dedicated to promoting and improving the technical and scientific knowledge of those working in the UK pulp and paper industry. Formed in 1960, it serves the Industry, both manufacturers and suppliers, by providing a forum for members to meet and network; it organises visits, conferences and training seminars that cover all aspects of papermaking science. It also publishes the prestigious journal *Paper Technology* and the *PITA Annual Review*, both sent free to members, and a range of other technical publications which include conference proceedings and the acclaimed *Essential Guide to Aqueous Coating*.

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Improvement in the Retention and Strength of Paper Made from White-grade Wastepaper

White ledger is white-grade recycled pulp that replaces the bleached kraft pulp (BKP) that typically forms the top ply of duplex boards. However, sheets made from white ledger are inferior in strength compared with those made from virgin pulp. Therefore, it is necessary to select a proper additive in order to overcome the disadvantages of using white ledger. In this study, the physical properties of white ledger used at a mill that produced duplex boards were analysed. The effect of cationic polyacrylamides (C-PAMs) with different charge densities and molecular weights on first-pass retention and paper strengths was simultaneously measured. White ledger contains fibre fines and filler fines, which reduced the strength of paper made from white ledger compared with paper made with BKP. This indicates that the improvement of first-pass retention and paper strength is important when the amount of white ledger increases in the top ply of a duplex board. The charge density of CPAM, which acts as a retention aid, is more important than its molecular weight in terms of improving the first-pass retention and paper strength of white ledger. The charge density of C-PAM must be high enough to catch anionic fine particles.

*Ji Young Lee,a Eun Hye Kim,b and Yong Joo Sung c,**

Contact information:
*a: Department of Environmental Materials Science/IALS and b: Department of Forest Products, Gyeongsang National University, Jinju 52828, South Korea; c: Department of Biobased Materials, College of Agriculture and Life Science, Chungnam National University, Daejeon 34134, South Korea; * Corresponding author: yosung17@cnu.ac.kr*.

Article submitted: January 26, 2016; Peer review completed: March 18, 2016; Revised version received: March 25, 2016; Accepted: March 31, 2016; Published: April 13, 2016.

DOI: 10.15376/biores.11.2.4718-4726

www.bioresources.com *BioResources 11(2) 4718-4726*

INTRODUCTION

Recycled pulp is an important raw material used in paper products. The use of recycled pulp has increased globally in recent years (Ibarra et al. 2012). Recycled pulp from old newspapers (ONP), old corrugated containers (OCC), old magazines (OMG), white ledger, and mixed office wastes (MOW) is widely used in the manufacture of paperboard. The production of paperboard accounts for 50% of the paper products created by the Korean paper industry.

Duplex boards or white lined chipboards are used to package food, pharmaceuticals, detergents, textiles, clothing, and more (Kiviranta 1997). Wood powder and other organic fillers have been added to the middle ply of duplex boards to reduce production costs in Korean duplex board mills (Lee et al. 2014a; Park et al. 2015). Reducing the use of virgin pulps is the first step toward lowering production costs and protecting domestic environments in Korea. The replacement of virgin pulp with recycled pulp is beneficial to the Korean paper industry and to the domestic environment.

A duplex board is typically made of many plies. The top ply generally consists of bleached kraft pulps (BKP), white ledger, and ONP. Other plies are made of recycled pulp of lower quality (Kiviranta 1997). Though the ratio of BKP is lower than that of other recycled pulp in the top ply of a duplex board, BKP must be replaced with white-grade recycled pulp to reduce production costs. White ledger consists of general office paper that is non-glossy and is either printed or unprinted; this office paper may include typing paper, copy machine paper, or white notebook paper. The production of white ledger has increased steadily as various printing technologies have developed. White ledger, which is of high quality in terms of its white colour, brightness, and strength, contains a higher portion of chemical pulp and a lower content of recycled materials compared with other recycled pulp (Lee et al. 2015). However, the quality of white ledger has decreased because papermakers have increased the use of high-yield pulp (Zhai and Zhou 2014) and inorganic fillers (Jung and Seo 2015) in general office paper to reduce production costs. The high ash content of other recycled pulp has reduced the yield of raw materials and paper strength (Zhao et al. 2008). Therefore, it is necessary to improve the first-pass retention and paper strength of duplex boards that are made from white ledger and that have high ash content.

This study explored the ideal conditions of cationic polyacrylamides (CPAMs) to improve the retention and strength of white ledger stock. The properties of white ledger used at an actual mill of duplex boards were analysed and compared with the properties of recycled pulp from the same mill. Next, the first-pass retention of white ledger stock was measured by adding six types of C-PAMs with different charge densities and molecular weights. After determining first-pass retention values, the handsheets were constructed, and their strength was measured.

EXPERIMENTAL CONDITIONS

Materials

Pulp slurries were collected from the Kleannara mill (Cheongju, Korea) where six-ply duplex boards were produced. The pulp was classified as either recycled pulp or virgin pulp, both of which were used for the manufacture of duplex boards. The recycled pulp included white ledger, ONP, and OCC. The virgin pulp consisted of mixed BKP, which combined softwood BKP and hardwood BKP at a ratio of 5:5. Bleached chemo-thermo mechanical pulp (BCTMP) was also included.

Because C-PAMs were used as dewatering agents at the Kleannara mill, CPAMs were selected as the retention aid in the white ledger line. However, a conventional C-PAM does not react well with increases in white ledger in the top ply line. Therefore, six types of C-PAMs were obtained from Songkang Industrial Co., Ltd. (Eumseongkoon, Korea), and their charge densities and molecular weights are shown in Fig. 1.

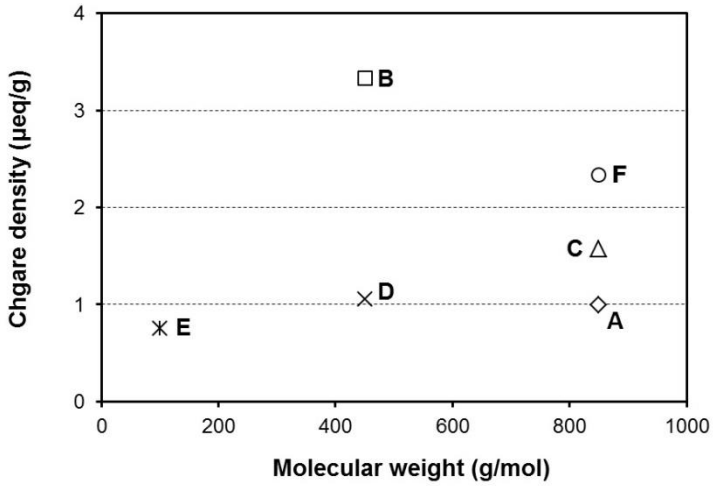


Fig. 1. C-PAMs as functions of molecular weight and charge density

Methods

Analysis of the properties of recycled pulp and virgin pulp

The pulp slurries were obtained from the machine chests of stock preparation lines. The initial consistencies of the pulp slurries were measured and diluted to 1.0% using tap water. The pulp properties, including freeness (TAPPI T227 om-09 2009), ash content (TAPPI T244 cm-99 1999), and fines content (TAPPI T261 cm-10 2010) were measured. The average fibre length was also measured using a fibre analyser (Kajaani FiberLabV.3, Metso, Finland).

The handsheets were prepared from recycled pulp and virgin pulp. After handsheets with grammages of 100 ± 4g/m^2 were produced, the sheets were wet-pressed at 3.5kgf/cm^2 for 5 min using a laboratory wet press and dried at 120°C using a cylinder dryer. The dried handsheets were conditioned at 23°C and 50% relative humidity (RH) to control the moisture content of the handsheets at 8%. The physical properties of the handsheets were determined, which included bulk (TAPPI T411 om-10 2010), breaking length (TAPPI T494 om-06 2006), burst index (TAPPI T403 om-10 2010), and compressive strength (TAPPI T818 cm-07 2007).

Measurement of the first-pass retention of white ledger stock

First-pass retention was measured in terms of TAPPI T261 cm-10 (2010). The white ledger stock was diluted to 0.5% using tap water. Next, the C-PAMs were diluted to a concentration of 0.1% with distilled water. Then, 500 mL of the diluted white ledger stock was added into a dynamic drainage tester (Daeil Machinery, Daejeon, Korea) and stirred at a rate of 600 rpm for 30 sec. C-PAMs were added at the same mixing speed. The filtrate was collected from the stock after 90 sec. The filtrate was weighed, filtered, and dried at 105°C to achieve a stable weight. Equation 1 was used to calculate first-pass retention,

$$\text{First pass retention} = \left[1 - \frac{A \times W}{U \times T}\right] \times 100 \qquad (1)$$

where A is the weight of the original sample, W is the weight of the solids (fines) in the filtrate, U is the weight of the filtrate, and T is total amount of fines in the sample.

Preparation of handsheets with white ledger stock and the measurement of their physical properties

White ledger stock was diluted using tap water to a consistency of 0.5% to prepare the handsheets. Handsheets with grammages of 100 ± 4g/m^2 were produced according to TAPPI T205 sp-06 (2006), after the C-PAMs were added to the pulp and mixed for 30 sec at 600 rpm. The addition levels of C-PAMs were 0.03, 0.05, and 0.07% of oven-dried fibers. The handsheets were wet-pressed at 3.5kgf/cm^2 for 5 min using a laboratory wet-press and were dried at 120°C for 4 min using a cylinder dryer. The dried handsheets were conditioned at 23°C and 50% RH to control the moisture content of the handsheets at 8%. The physical properties, including the bulk (TAPPI T411 om-10 2010), breaking length (TAPPI T494 om-06 2006), burst index (TAPPI T403 om-10 2010), compressive strength (TAPPI T818 cm-07 2007), and ash content (TAPPI T244 cm-99 1999) of the handsheets were measured.

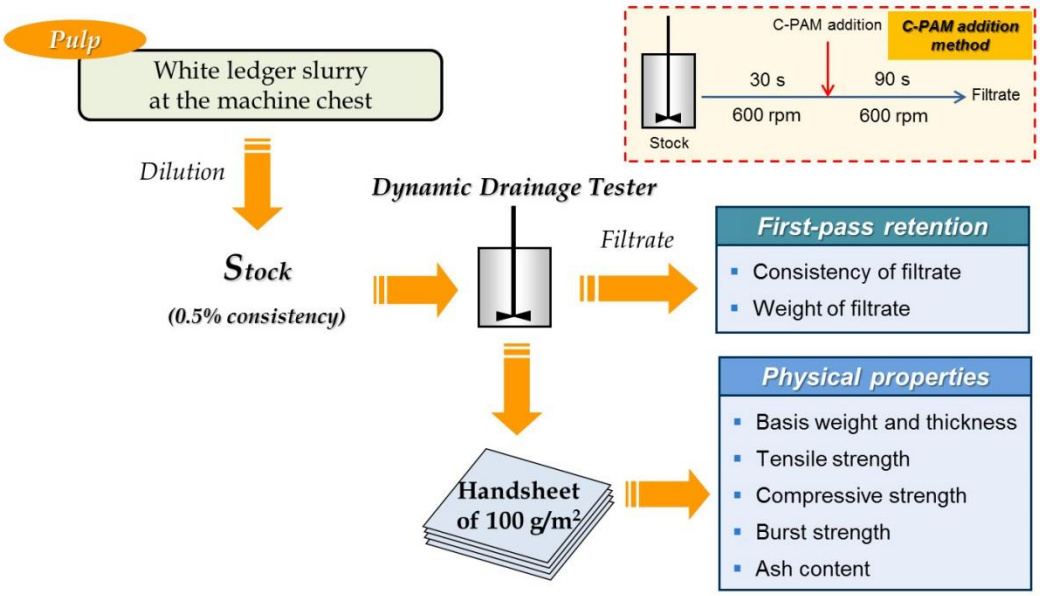


Fig. 2. Flow diagram of the experimental process

RESULTS AND DISCUSSION

Pulp Properties of Recycled and Virgin Pulp

The pulp properties of recycled and virgin pulp are shown in Figs. 3 and 4. The Canadian standard freeness of white ledger was lower than that of OCC and that of virgin pulp, but the freeness of white ledger was higher than that of ONP. The fines content of white ledger was higher than that of virgin pulp but lower than that of ONP and OCC. The average fibre length of white ledger was the lowest of the six types of pulp, and its ash content was the second lowest among the five types of pulp. White ledger contains more fine particles (such as fibre fines and filler fines) than BKP. This indicates that

papermakers should monitor the yield or retention of fibre fines and filler fines when the amount of white ledger increases in the top ply of a duplex board.

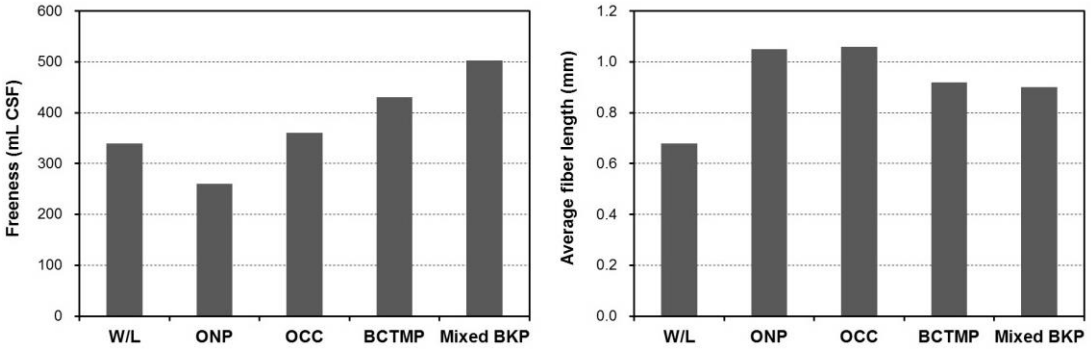


Fig. 3. Freeness (left) and average fibre length (right) of recycled and virgin pulp (W/L = white ledger)

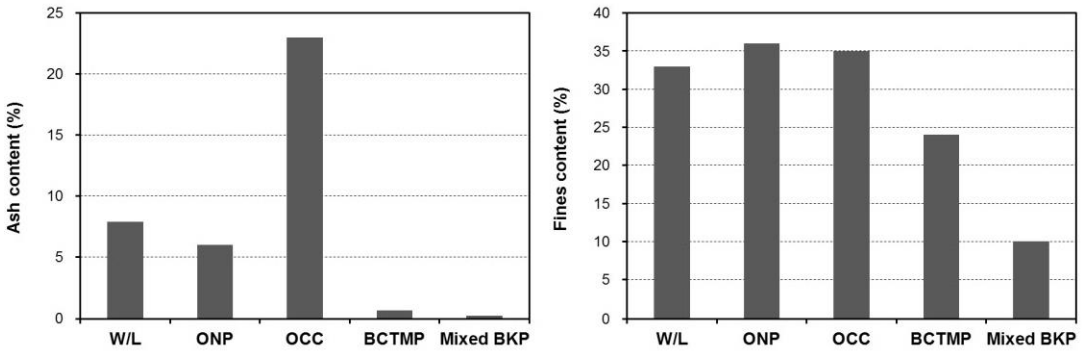


Fig. 4. Ash content (left) and fines content (right) of recycled and virgin pulp (W/L = white ledger)

Figures 5 and 6 show the physical properties of the handsheets, which consist of recycled and virgin pulps. The bulk of the white ledger handsheets was similar to that of the OCC and ONP handsheets, and lower than that of the BCTMP and BKP handsheets (Seo et al. 2014). The strength of the white ledger handsheets was greater than the strength of ONP and OCC. However, the strength of the white ledger handsheets was lower than the strength of the BCTMP and BKP handsheets. The low strength of the white ledger handsheets in comparison with those made exclusively with virgin pulp is directly related to its low average fibre length (Retulainen et al. 1997) and high ash content (Kroguerus 1997; Lee et al. 2014b). In addition, the changes in the fibre properties reduced the paper strength during the recycling process (Hubbe et al. 2007; Gulsoy et al. 2013).

The white ledger slurry produced handsheets that were lower in strength compared with BKP handsheets. The slurry contained fillers, pigments, and short fibres. Therefore, it is necessary to improve the first-pass retention and paper strength of white ledger handsheets. However, improving first-pass retention tends to result in increased ash content in sheets made from white ledger. Therefore, it is very important to select a proper retention aid that improves both first-pass retention and paper strength.

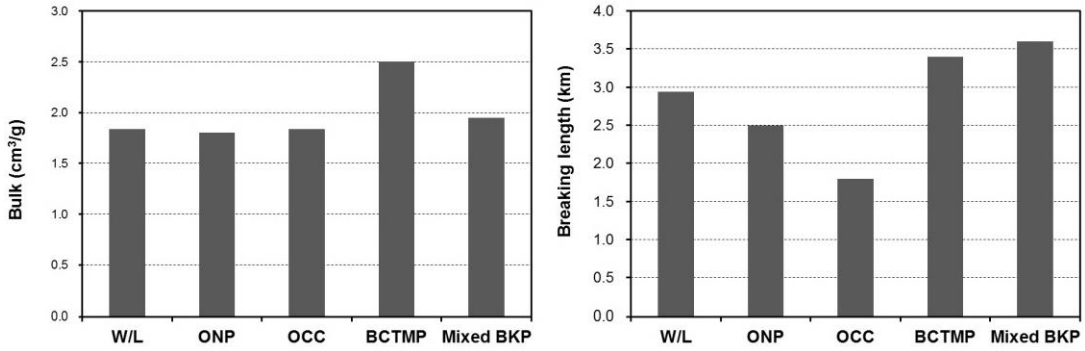


Fig. 5. Bulk (left) and breaking length (right) of handsheets made from recycled and virgin pulp (W/L = white ledger)

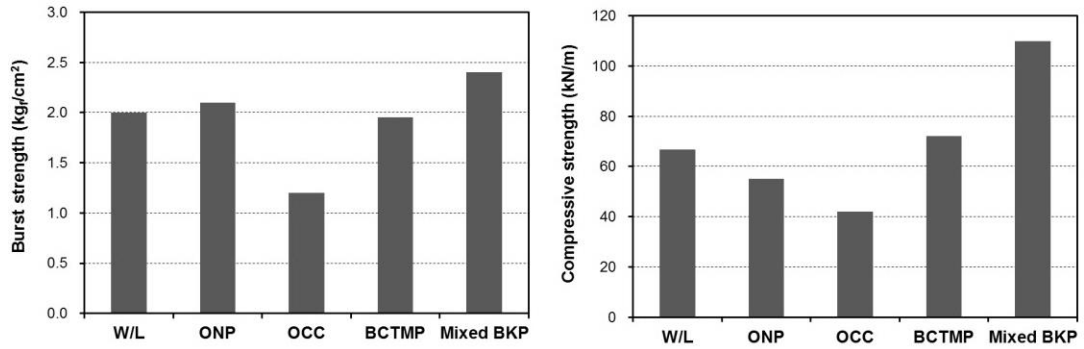


Fig. 6. Burst strength (left) and compressive strength (right) of handsheets made from recycled and virgin pulp (W/L = white ledger)

Evaluation of First-Pass Retention and the Physical Properties of Handsheets Made from White Ledger

Figure 7 shows the first-pass retention of white ledger stock using different dosages and types of C-PAMs. C-PAMs have different molecular weights and charge densities; therefore, the first-pass retention values were products of the varying dosages and types of C-PAMs. The majority of the C-PAMs led to increases in the first-pass retention of the white ledger stock. C-PAM C showed the highest first-pass retention, while B and F displayed the second highest first-pass retention values among the C-PAMs. A, D, and E did not produce noticeable increases in first-pass retention compared with the other C-PAMs. C-PAMs C and F had molecular weights that were similar to the molecular weight of C-PAM A, but their charge densities were higher than that of C-PAM A. Moreover, C-PAM B had the highest charge density among the C-PAMs. Because white ledger contains many fillers and pigments, a C-PAM must have a high charge density to gather anionic fillers and pigments (Gess 1998; Im et al. 2015). Charge density is an important property of C-PAMs for the improvement of the first-pass retention of white ledger.

As mentioned previously, the retention aid should improve the paper strength. In the current study, the strength of white ledger was lower than the strength of BKP. In this study, three C-PAMs (B, C, and F) that had the highest first-pass retention were selected for further study. Handsheets from white ledger stock with C-PAMs B, C, and F were evaluated for the ability of these C-PAMs to improve paper strength. Paper strength is affected by ash content (Xu et al. 2005; Jung et al. 2015). Therefore, the effect of C-PAMs on paper strength was analysed as a function of ash content. Figures 8 through 10 show the breaking length, burst strength, and compressive strength of the handsheets. B and F were similar in strength because of their ash content. C had the lowest paper strength,

though its ash content was similar to the ash content of B and F. Compared with C-PAMs B and F, C-PAM C contained a low charge density, suggesting that charge density was an important factor in first-pass retention and strength. The molecular weight of the C-PAMs was also important. The molecular weight of C-PAM B was lower than that of C-PAM F. Of the six C-PAMs, the molecular weight of C-PAM B was the median value. This result indicated that the C-PAM with the highest charge density should also have a molecular weight that is higher than average in order to improve both first-pass retention and paper strength.

The charge density of a C-PAM, which acts as a retention aid, is more important than its molecular weight for improving the first-pass retention and strength of white ledger sheets. The charge density must be sufficiently high to allow the CPAM to gather anionic fine particles.

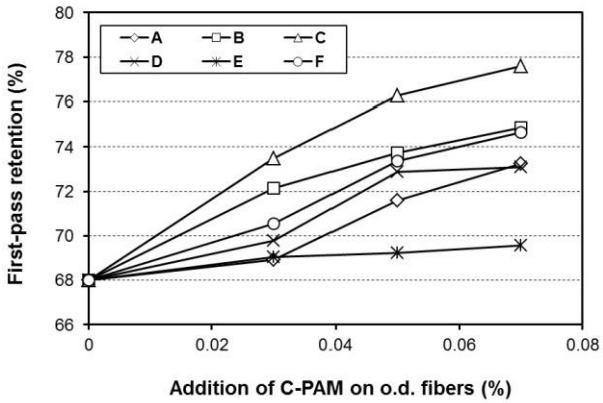


Fig. 7. First-pass retention values of white ledger with different dosages and types of C-PAMs

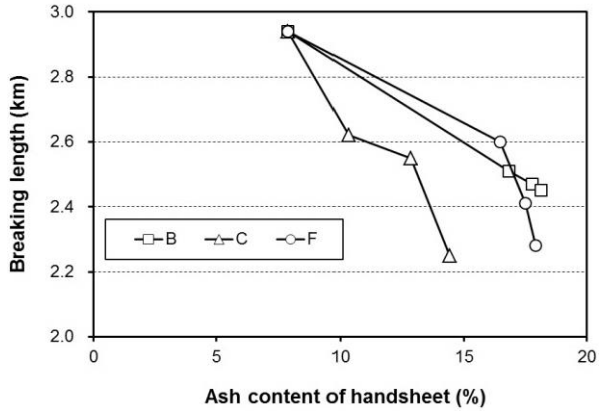


Fig. 8. Breaking length as a function of ash content in handsheets made from white ledger and C-PAMs

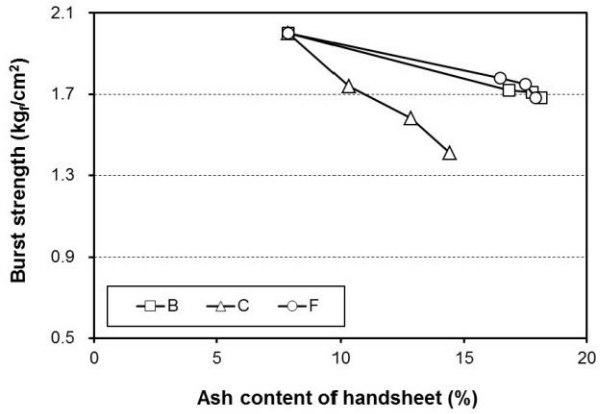


Fig. 9. Burst strength as a function of ash content in handsheets made from white ledger and C-PAMs

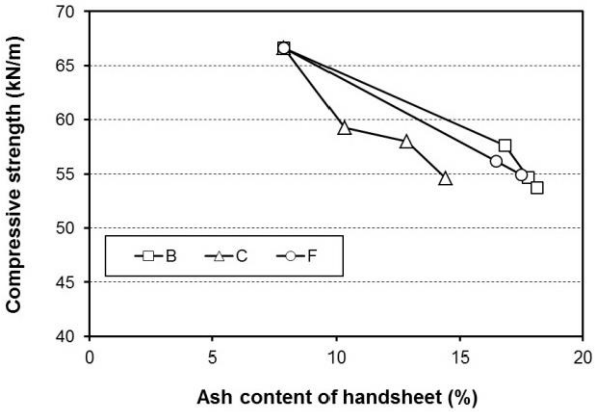


Fig. 10. Compressive strength as a function of ash content in handsheets made from white ledger and C-PAMs

CONCLUSIONS

1. White ledger contained fibre fines and filler fines, which resulted in inferior paper strength compared with the strength of paper made with BKP. Thus, first-pass retention is very important when the amount of white ledger increases in the top ply of a duplex board. Sheet strength must be monitored because an increase in first-pass retention is directly related to an increase in ash content. In addition, a proper additive must be selected.

2. The charge density of a C-PAM, which acts as a retention aid, is more important than its molecular weight in terms of simultaneously improving the first-pass retention and strength of white ledger paper. The charge density must be sufficiently high to allow the C-PAM to catch anionic fine particles.

ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. NRF-2015R1A2A2A01006463).

REFERENCES CITED

- Gess, M. D. (1998). "Retention in neutral and alkaline papermaking," in: Retention of Fines and Fillers during Papermaking (1st Ed.), TAPPI Press, Atlanta, GA, USA.
- Gulsoy, S. K., Kustas, S., and Erenturk, S. (2013). "The effect of old corrugated container (OCC) pulp addition on the properties of paper made with virgin softwood kraft pulps," BioResources 8(4), 5842-5849. DOI:10.15376/biores.8.4.5842-5849
- Hubbe, M. A., Venditti, R. A., and Rojas, O. T. (2007). "What happens to cellulosic fibers during papermaking and recycling? A review," BioResources 2(4), 739-788. DOI: 10.15376/biores.2.4.739-788
- Ibarra, D., Monte, M. C., Blanco, A., Martínez, A. T., and Martínez, M. J. (2012). "Enzymatic deinking of secondary fibers: Cellulases/hemicellulases versus laccase-mediator system," Journal of Industrial Microbiology and Biotechnology 39(1), 1-9. DOI: 10.1007/s10295-011-0991-y
- Im, W. H., Seo, D. I., Oh, K. D., Jeong, Y. B., Youn, H. J., and Lee, H. L. (2015). "Effects of preflocculated filler flocs and nano-sized coating binder on fold cracking of coated paper," Journal of Korea TAPPI 47(5), 91-97. DOI: 10.7584/ktappi.2014.47.5.091
- Jung, J. K., and Seo, Y. B. (2015). "Development of hybrid calcium carbonate for high loading paper: Manufacture and application of hybrid calcium carbonate," Journal of Korea TAPPI 47(4), 30-37. DOI: 10.7584/ktappi.2015.47.4.030
- Kiviranta, A. (1997). "Paperboard grades in paper and board grades" in: Papermaking Science and Technology (1st ed.), TAPPI Press, Atlanta, GA, USA.
- Kroguerus, B. (1997). "Fillers and pigments in papermaking chemistry," in: Papermaking Science and Technology (1st Ed.), TAPPI Press, Atlanta, GA, USA.
- Lee, T. J., Choi, D. C., Kim, M. S., and Ryu, J. Y. (2015). "Studies on deinking properties of recovered paper for manufacturing eco-friendly thermal recording paper," Journal of Korea TAPPI 47(6), 98-105. DOI:10.7584/ktappi.2015.47.6.098
- Lee, J. Y., Kim, C. H., Seo, D. J., Lim, G. B., Kim, S. Y., Park, J. H., and Kim, E. H. (2014a). "Fundamental study on developing wood powder as an additive of paperboard," TAPPI Journal 13(11), 17-22.
- Lee, J. Y., Lim, G. B., Kim, S. Y., Park, J. H., Kim, E. H., Sung, Y. J., Heo, Y. J., Kim, Y. H., and Lee, S. R. (2014b). "Application evaluation of physical and strength properties of paperboard by kraft pulp mixing made from agricultural byproducts," Journal of Korea TAPPI 46(5), 43-50. DOI:10.7584/ktappi.2014.46.5.043
- Park, J. H., Lee, J. Y., Kim, C. H., and Kim, E. H. (2015). "Effects of lignocellulosic bulking agents made from agricultural byproducts on physical properties and drying energy consumption of duplex board," BioResources 10(4), 7889-7897. DOI: 10.15376/biores.10.4.7889-7897
- Retulainen, E., Niskanen, K., and Nilsen, N. (1997). "Fibers and Bonds in Paper Physics," in: Papermaking Science and Technology (1st ed.), TAPPI Press, Atlanta, GA, USA.
- Seo, Y. B., Lee, M. W., Lee, Y. H., and Jung, J. K. (2014). "Application of in-situ CaCO3 formation method for better utilization of recycled fibers: Enhancing attachment of CaCO3 to fibers by polymer pre-treatment," Journal of Korea TAPPI 46(5), 19-26. DOI: 10.7584/ktappi.2014.46.5.019
- TAPPI T244 cm-99. (1999). "Acid-insoluble ash in wood, pulp, paper, and paperboard," TAPPI Press, Atlanta, GA.
- TAPPI T205 sp-06. (2006). "Forming handsheets for physical tests of pulp," TAPPI Press, Atlanta, GA.

- TAPPI T494 om-06. (2006). “Tensile properties of paper and paperboard (using constant rate of elongation apparatus),” TAPPI Press, Atlanta, GA.
- TAPPI T818 cm-07. (2007). “Ring crush of paperboard (flexible beam method),” TAPPI Press, Atlanta, GA.
- TAPPI T227 om-09. (2009). “Freeness of pulp (Canadian standard method),” TAPPI Press, Atlanta, GA.
- TAPPI T261 cm-10. (2010). “Fines fraction by weight of paper stock by wet screening,” TAPPI Press, Atlanta, GA.
- TAPPI T403 om-10. (2010). “Burst strength of paper,” TAPPI Press, Atlanta, GA.
- TAPPI T411 om-10. (2010). “Thickness (caliper) of paper, paperboard, and combined board,” TAPPI Press, Atlanta, GA.
- Xu, Y., Chen, X., and Pelton, R. (2005). “How polymers strengthen filled papers,” TAPPI Journal 4(11), 8-12.
- Zhai, R., and Zhou, X. (2014). “Enhanced effect of NaOH/thiourea/urea aqueous solution on paper strength of high yield pulp,” BioResources 9(2), 2154-7166. DOI: 10.15376/biores.9.2.2154-2166
- Zhao, Y., Kim, D. H., White, D., Deng, Y., Patterson, T., Jones, P., Turner, E., and Ragauskas, J. A. (2008). “Developing a new paradigm for linerboard fillers,” TAPPI Journal 7(3), 3-7.

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Simultaneous biodegradation of organic (chlorophenols) and inorganic compounds from secondary sludge of pulp and paper mill by *Eisenia fetida*

Background: Present research communicates the role of Eisenia fetida in converting pulp and paper mill sludge into valuable products by removing the high concentration of different chlorophenols and metals present in the sludge.

Conclusions: By observing chlorophenols concentration, metals and carbon–nitrogen ratio, Eisenia fetida is acting as a potential candidate for the reclamation of industrial sludge. The result indicated that vermicomposting with Eisenia fetida is better option to manage the sludge or convert the sludge into nutrient-rich composted material in a short span of time.

Santosh Kumar Karn • Swapan Kumar Chakrabarti

S. K. Karn, Key Laboratory of Marine Environmental Corrosion and Biofouling, Institute of Oceanology, Chinese Academy of Sciences, No. 7 Nanhai Road, Qingdao 266071, Shandong, China e-mail: santoshkarn@gmail.com

S. K. Chakrabarti, Environment Management Division, Thapar Centre for Industrial Research and Development, Yamunanagar 135001, India 123

Received: 4 May 2014 / Accepted: 3 February 2015 / Published online: 15 February 2015

Int J Recycl Org Waste Agricult (2015) 4:53–62
DOI 10.1007/s40093-015-0085-3

Introduction

The rapid increase in population and the increasing demand for industrial establishments overexploitation of available resources to meet human requirements have created problems such as pollution of the land, air and water environments. Pulp and paper mills generate significant amount of biodegradable sludge (34 and 105kg/t product in large and small paper mills, respectively) during the papermaking and pulp making stages (Pokhrel and Viraraghavan 2004). The disposal of industrial sludge from effluent treatment plant is a global concern to the industries, not a unique problem for the pulp and paper industry. Among the four major modes of sludge disposal; sea discharge, landfill, incineration and land application, nowadays most of industry disposing the sludge by only land application. According to the recent estimate carried out by the US-EPA (1991) half of the 6,500 municipal landfill sites have been closed by the end of the last century and another 54% of the remaining landfills will be closed within next 5 years. The final disposal route for excess sludge generated by wastewater treatment is becoming a serious issue mainly due to the growth of population and sludge accumulation in large cities and growth in the amount and complexity of the related industrial activities. For this reason, it is necessary to reduce the amount of sludge generation by improving the efficiency of the treatment methodologies and implementing new technologies able to use sludge as raw material for compost, generate biomolecules and energy.

To cope with this problem United States undertook a long-term research and demonstration program involving all the segments of society from regulators to farmers for the utilisation of biosolids for gainful purposes and to find a long-term solution. Organochlorines are found in the sludge produced at pulp and paper mills. Accounting for as much as four percent of the total weight of the material contaminated sludge is spread on the land, buried in landfills or incinerated releasing chlorinated by-products into the air including polychlorinated phenols and dioxins (Mantykoski et al. 1989). In forests where pulp mill sludge has been dumped chlorinated phenols/dioxins have accumulated in the tissues of field animals and caused biochemical effects in birds (ERT 1987). Vermicomposting are well-known processes for solid organic waste reclamation: the final product vermicompost can be used as sources of organic matter for soil amendment, as sources of nutrients for soil fertilisation or as growing media constituents for soilless cultivation (Gonzalez et al. 2010). Vermicomposting is a bio-oxidative process which engages earthworms and microorganisms. The microorganisms both in the earthworm guts and in the feedstock are responsible for the biochemical degradation of the organic matter while the earthworms are responsible for the fragmentation of the substrate which increases the surface area exposed to the microorganisms. Hence the earthworms directly modify the physical properties of the material and indirectly modify its chemical properties. It is well-established that a large number of organic wastes can be ingested by earthworms and egested as peat-like material termed as vermicompost. It is much more fragmented, porous and microbially active than parent material (Edwards 1988; Edwards and Bohlen 1996) due to humification and increased decomposition. Recent study conducted by Huang et al. (2014) found that changes physiochemical properties and microbial profiles during vermicomposting to make the reliable material and Hanc and Chadimova (2014) found nutrient recovery after vermicomposting. Due to the certain limitations of the other processes, vermicomposting receiving more attention for stabilisation of various wastes including for decreased duration of treatment process, increased pathogen reduction and better product quality (Hait and Tare 2011). Butt (1993) showed that solid paper mill sludge was a suitable feed for *Lumbricus terrestis* under laboratory conditions. Elvira et al. (1998) have also reported vermicomposting of paper mill sludge using *Eisenia andrei* under laboratory as well as field conditions. Gajalakshmi et al. (2002) studied the

vermicomposting of paper waste using anecic earthworm *Lampito mauriti*. Today this is needful to treat the industrial sludge for the removal of organic and inorganic contaminants and manage it properly for the useful application; therefore, present study deals with the treatment of chlorophenols and inorganic constituents from the sludge of pulp and paper mill using *Eisenia fetida* further it can be applied as a compost material.

Materials and methods

Collection of sludge sample

Dewatered secondary sludge samples of pulp and paper mill were collected from the effluent treatment plant of BILT, Unit-Shree Gopal, Yamunanagar, Haryana, India. This mill adopts kraft process for pulping of raw materials mainly eucalyptus, poplar and bamboo. The effluent and sludge generated by the process is treated in activated sludge process for the biological removal of organics.

Vermicomposting set up

Dewatered secondary sludge was collected in large-sized plastic containers and then brought to the laboratory for further processing. Sludge was mixed with composted material in different proportions Set up: 1 (95:5) Set up: 2 (80:20) and Set up: 3 (50:50) to maintain the moisture content and reduce the toxicity level of the secondary sludge for the adaptation of worms. Vermicomposting experiments were performed in plastic trays. No external addition of Nitrogen (N) and Phosphorus (P) was added during vermicomposting. pH, temperature and moisture were maintained in the range of 7.5–8.5; 27–30°C and 60–75%, respectively throughout the period of study (for 90 days). The trays were covered with a jute mat and were kept in the shed. The composted material with earthworm 1 kg was spread and mixed at the top layer. Normally (1kg worms present in 10kg dry material). Earthworm species *Eisenia fetida* were obtained from a stock culture of Krishi Vigyan Kendra (KVK) Tepla Ambala, Haryana an ICAR unit of Govt. of India, with decomposed cow dung spiked with plant litters. Wheat straws (WS) were used to prepare as bedding materials for the experiments.

Further in another set chlorophenols degradation ability *E. fetida* was observed in sludge (proportion like set up: 2) with artificially spiked concentration of PCP in the sludge at the rate of 100mg/kg and mixed thoroughly in plastic trays mentioned above and inoculated $^{E. fetida}$ and incubated under the same condition for 3 months. The tray were covered with jute mate to maintain the pH; temperature, moisture as mentioned as before.

Sludge characterization

The sludge sample were analysed for physiochemical characteristic such as moisture, pH, carbon, hydrogen, nitrogen, sulphur, zeta potential, absorbable organic halogen (AOX) and extractable organic halogen (EOX). Two grams of sludge sample was taken and dried into oven at 105°C for 24h. The sample was then ground in mortar pestle to obtain particles having size of about 0.1mm. The dried sludge sample (10-100mg) was taken for CHNS analysis using Elemental analyzer (Thermo Scientific, USA). Zeta potential was analysed by maintaining pH of the sample to neutral and placing the sample in zeta potential analyzer, Muteck SZP06 (BTG Mutek GmbH, Germany). The AOX and EOX concentrations were determined using Euroglas Netherlands instrument ECS-2000 according to the manufacturer's recommended procedure.

Determination of chlorophenol

Chlorophenols extraction and analysis was done by (NCASI (1986) method CP-85.01) method with a little modification. Secondary sludge samples were taken in ice bath and

sonicated using a Sonicator (SG-25) Roop Telesonic Ultrasonics Ltd. India with variable power intensity between 3 and 7.4W/cm2 and a frequency of 24kHz. The sample was immersed in ice and sonicated for total of 10 min with 1.5 min burst followed by 5 min rest in ice. Next added 1.3ml K2CO3 (pH 11.5) again sonicated for 2 min and added 1.5ml of acetic anhydride and sonicated for 2 min again added 0.5ml acetic anhydride further added 5ml of hexane and again sonicated and centrifuged and further extracted with hexane. After centrifugation at 10,000 rpm for 15 min, the supernatant was used to analyse the chlorophenols.

The GC analysis were performed in electron capture detection mode with a gas chromatograph Nucon GC-5765 (Centurion Scientific, India) capillary column DB-5 (30 metre length 0.025mm i.d. 0.25 lm film thickness) was used at a temperature program of 50°C (2 min) then raised to 10°C/min to 280°C where it was held for 10 min. Helium was used as the carrier gas at a constant flow of 1.2ml/min. The samples were analysed in splitless mode at an injection temperature of 250°C and detector temperature 280°C. The injected volume was 0.1µl.

Determination of metals

Metals was determined as per (APHA 1995) first sludge sample was digested with nitric and perchloric acid (3:1) and filtered through Whatman no.42 paper. The filtrate was used for characterisation of phosphorus content and the trace elements were analysed on furnace atomic absorption spectroscopy (AAS) and rest were analysed on flame AAS. The hydride forming elements were analysed using hydride generator.

Statistical analysis

Data were statistically analysed by analysis of variance (ANOVA) and the mean differences were compared by Tukey–Kramer Multiple Comparison Test at $p<0.05$. All experiments were performed in three replicates and analyses were performed using GraphPad Prism (v 4.03) software. (CA, USA).

Results and discussion

Characterisations of sludge

In recent time, interest for vermicomposting (using earthworms to breakdown organic materials) has increased (Hand 1988; Edwards 1988; Edwards and Bohlen 1996) due to its potential. In its basic form, this is a low-cost technology system that primarily uses earthworms in the processing or treatment of organic wastes (Hand 1988). Certain species of earthworm can consume organic material residuals very rapidly and fragment them into much finer particles and reducing the pollutants by passing them through a grinding gizzard. The earthworms derive their nourishment from microorganisms that grow upon these materials. At the same time, they promote further microbial activity since the faecal material or casts that they produce is much more fragmented and microbially active than what they consume (Edwards 1988; Edwards and Bohlen 1996). During this process, the important plant nutrients in the material (particularly the N, K, P and Ca) are released and converted through microbial action into forms that are much more soluble and available to plants than those in the parent compounds. Therefore, first, collected secondary sludge samples were characterised for various physical and chemical characteristics such as pH, organic matter, CHNS, AOX, and EOX described in (Table 1). All the twelve different chlorophenols were also analysed and described in (Table 2) and metals are described in (Table 3). Sludge sample were rich in organic C, H, N and S content. Vermicomposted material significantly modified the physical and chemical properties of all sets mixtures.

The vermicompost was much darker in colour than before and has been processed more homogeneous mixture after 90 days of earthworm activity, the pH observed normal about 7.2 in the final vermicompost. Organic percentages were increased after composting for Set 1 it increased 36 % for Set 2; 35 % whereas for Set 3, it increased up to 50 %. The C:N ratio, one of the most widely used indicating for maturity of organic waste. In our experiments C:N ratio was between 9.4 and 18.4 after 90 days of worms activity. In Set 1, we observed 9:4; in Set 2, 13:4 and Set 3, 18:4. In initial stage, C:N ratio was 8:4 for Set 1, 9:3 for Set 2 and was 14:3 for Set 3. According to Senesi (1989) a decline of C:N ratio to less than 20 indicates an advanced degree of organic matter stabilisation and reflects a satisfactory degree of maturity of organic waste. Total K and N were also increased by the end of vermicomposting due to mineralisation of organic matter. Previously Benitez et al. (2000) has also reported that decomposition of organic materials by earthworm accelerates the N mineralisation process and subsequently changes the N profile of the substrate. Kaushik and Garg (2004) have reported a 2.0–3.2 fold increase in TKN during vermicomposting of textile mill sludge mixed with cow dung and wheat straw. Therefore, vermicomposting is a considerable technology for the waste or specially sludge to increase the soil nutrient condition. Different organochlorine contaminants like AOX and EOX in the sludge were analysed (described in Table 4). AOX values ranged from 451 to 5,140mg/kg dry solids. However, 93–95% decreases in the AOX and 90–92% decrease in EOX level, after composting which makes it less toxic more stable and reliable material for use. Earthworms accumulate many lipophilic organic pollutants from the surrounding soil environment not only through passive absorption through the body wall of the dissolved fraction in the interstitial water but also by intestinal uptake during the passage of soil through the gut. The accumulation increases as the concentration of the pollutant in the soil environment (Belfroid et al. 1995a, b).

Table 1 Chemical characteristic of secondary sludge from pulp and paper mill and material containing *Eisenia fetida*

Parameter	Secondary sludge	Material containing worms
Moisture (%)	89.5 ± 2.1	51.34 ± 1.8
Organic (%)	72 ± 1	78 ± 2.4
Carbon (%)	24.2 ± 1.3	27.1 ± 2.1
Hydrogen (%)	5 ± 0.5	2.4 ± 0.7
Nitrogen (%)	3.2 ± 0.6	1.5 ± 0.05
Sulphar (%)	0.7 ± 0.01	0.5 ± 0.01
Kjeldhal Nitrogen (%)	5.8 ± 1.1	2.2 ± 0.6
AOX (mg/Kg)	2,400 ± 67	580 ± 11
EOX (mg/kg)	812 ± 16	132 ± 6
C/N ratio	7.5 ± 0.8	8.4 ± 0.3
Zeta potential (mv)	−15.2 ± 0.05	−12.1 ± 0.04

Values are given as (Mean ± SE)

ND not detected

Table 2 Chlorophenols concentration in secondary sludge from pulp and paper mill and also material containing *Eisenia fetida*

Chlorophenolic compounds	Secondary sludge (mg/kg)	Material containing worms (mg/kg)
2,4,6-TCP	0.351 ± 0.02	<0.011
2,4,5-TCP	0.191 ± 0.01	ND
2,3,4,5-Tetrachlorophenol	0.154 ± 0.06	ND
3,4,6-Trichloroguacol	0.153 ± 0.03	ND
3,4,5-Trichloroguacol	0.123 ± 0.02	ND
4,5,6-Trichloroguacol	0.143 ± 0.04	ND
3,4,6-Trichlorocatecol	0.322 ± 0.07	ND
3,4,5-Trichlorocatecol	0.373 ± 0.01	ND
Tetrachloroguaiacol	0.362 ± 0.01	ND
Tetrachlorocatecol	0.312 ± 0.02	ND
Trichlorosyringol	0.299 ± 0.01	0.05
Pentachlorophenol	0.345 ± 0.01	ND

Values are given as (Mean ± SE)

ND not detected

Table 3 Metallic characterizations of secondary sludge and material containing *Eisenia fetida*

Metals	Secondary sludge (mg/kg)	Material containing worms (mg/kg)
Na	1,300 ± 19	2,110 ± 43
K	2,600 ± 26	5,033 ± 13
Mg	5,423 ± 12	3,555 ± 19
Ca	1,400 ± 23	4,929 ± 22
Al	2,900 ± 27	943 ± 12
P	416 ± 11	368 ± 11
Fe	2,453 ± 41	1,791 ± 33
Cr	36 ± 7	2.8 ± 0.7
Mn	133 ± 11	127 ± 2
Co	2.0 ± 0.3	0.7 ± 0.02
Zn	19 ± 3	67 ± 2
Ni	24 ± 1	1.8 ± 0.2
Cu	87 ± 4	18 ± 2
Cd	2 ± 0.05	0.1 ± 0.02
Pb	28 ± 3	3.2 ± 0.2
Hg	ND	ND
Se	ND	ND
As	ND	ND

Values are given as (Mean ± SE)

ND not detected

Table 4 Chlorophenols concentration in three different sets before and after treatment with *Eisenia fetida*, results shown of every month analysed chlorophenols concentration and also compared with control (untreated)

Chlorophenolic compounds (mg/kg)	Mixed Secondary sludge + composted material 5 % (untreated)	After 1 month	After 2 month	After 3 month	Control (without worms)	Mixed secondary sludge + Composted material 20 %	After 1 month	After 2 month
2,4,6-TCP	0.335 ± 0.022cA	0.303 ± 0.06cA	0.142 ± 0.01cC	0.012 ± 0.01dE	0.345 ± 0.03cA	0.280 ± 0.03cB	0.220 ± 0.03dC	0.101 ± 0.02dD
2,4,5-TCP	0.182 ± 0.071eA	0.152 ± 0.022eB	0.075 ± 0.06eD	ND	0.095 ± 0.001fC	0.152 ± 0.02eB	0.110 ± 0.03eC	0.099 ± 0.07dC
2,3,4,5-Tetrachlorophenol	0.148 ± 0.02eA	0.110 ± 0.011eB	0.043 ± 0.05fC	ND	0.146 ± 0.03eA	0.124 ± 0.01eB	0.086 ± 0.002fB	ND
3,4,6-Trichloroguacol	0.150 ± 0.062eA	0.105 ± 0.04eB	0.039 ± 0.03fD	ND	0.057 ± 0.002gC	0.122 ± 0.03eA	0.099 ± 0.01eC	ND
3,4,5-Trichloroguacol	0.117 ± 0.03fA	0.101 ± 0.06eA	0.042 ± 0.001fC	ND	0.119 ± 0.01gA	0.098 ± 0.001fA	0.067 ± 0.02fB	ND
4,5,6-Trichloroguacol	0.136 ± 0.02eA	0.107 ± 0.04eB	0.038 ± 0.001fD	ND	0.039 ± 0.001fD	0.115 ± 0.001A	0.076 ± 0.01fC	ND
3,4,6-Trichlorocatecol	0.305 ± 0.08dA	0.276 ± 0.02dA	0.150 ± 0.02cC	0.12 ± 0.01dDE	0.307 ± 0.03dA	0.258 ± 0.03dA	0.218 ± 0.03 dB	0.086 ± 0.01dD
3,4,5-Trichlorocatecol	0.354 ± 0.04cA	0.310 ± 0.03cB	0.120 ± 0.02dC	0.021 ± 0.01cD	0.349 ± 0.02cA	0.298 ± 0.01cB	0.252 ± 0.06cB	0.103 ± 0.02dC
Tetrachloroguaiacol	0.343 ± 0.04cA	0.323 ± 0.01cA	0.134 ± 0.01cD	0.014 ± 0.001cE	0.310 ± 0.04dA	0.290 ± 0.02cC	0.262 ± 0.07cC	0.125 ± 0.06cD
Tetrachlorocatecol	0.312 ± 0.022dA	0.287 ± 0.02dA	0.136 ± 0.02cB	0.019 ± 0.001cD	0.320 ± 0.04dA	0.250 ± 0.04 dB	0.221 ± 0.02 dB	0.089 ± 0.01dC
Trichlorosyringol	0.296 ± 0.056dA	0.254 ± 0.01dA	0.118 ± 0.02dC	0.021 ± 0.001cD	0.278 ± 0.02dA	0.240 ± 0.02 dB	0.219 ± 0.02 dB	0.097 ± 0.01dC
Pentachlorophenol	0.327 ± 0.043cA	0.296 ± 0.03cA	0.143 ± 0.02cB	0.022 ± 0.001cCD	0.333 ± 0.03cA	0.276 ± 0.02cA	0.232 ± 0.04dA	0.122 ± 0.07cB
AOX	2,674 ± 19aA	1,989 ± 23aC	739 ± 41aE	198 ± 12aF	2,497 ± 16aA	2,413 ± 22aB	1,786 ± 23aC	678 ± 41aE
EOX	957 ± 26bA	764 ± 27bB	278 ± 29bD	73 ± 16bE	873 ± 26bA	765 ± 12bB	513 ± 11bC	219 ± 13bD

Chlorophenolic compounds (mg/kg)	After 3 month	Control (without worms)	Mixed secondary sludge + composted material 50 %	After 1 month	After 2 month	After 3 month	Control (without worms)
2,4,6-TCP	0.012 ± 0.01dE	0.243 ± 0.03 dB	0.177 ± 0.01cC	0.100 ± 0.003cD	0.025 ± 0.002dE	ND	0.113 ± 0.02eD
2,4,5-TCP	ND	0.171 ± 0.05eA	0.098 ± 0.002 dC	0.029 ± 0.001dE	ND	ND	0.086 ± 0.01eC
2,3,4,5-Tetrachlorophenol	ND	0.132 ± 0.02eA	0.078 ± 0.001 dB	0.022 ± 0.001dC	ND	ND	0.56 ± 0.01fB
3,4,6-Trichloroguacol	ND	0.063 ± 0.001fC	0.077 ± 0.001dC	0.019 ± 0.001dD	ND	ND	0.072 ± 0.01fC
3,4,5-Trichloroguacol	ND	0.086 ± 0.002fB	0.062 ± 0.001 dB	0.031 ± 0.001dC	ND	ND	0.071 ± 0.03fB
4,5,6-Trichloroguacol	ND	0.122 ± 0.02eA	0.072 ± 0.003dC	0.034 ± 0.001dD	ND	ND	0.063 ± 0.01fC
3,4,6-Trichlorocatecol	ND	0.289 ± 0.01dA	0.167 ± 0.02cC	0.122 ± 0.06cC	0.026 ± 0.001dD	ND	0.153 ± 0.06dC
3,4,5-Trichlorocatecol	0.026 ± 0.001cD	0.267 ± 0.02 dB	0.188 ± 0.05cC	0.113 ± 0.07cC	0.034 ± 0.003cD	ND	0.185 ± 0.04cC
Tetrachloroguaiacol	0.020 ± 0.01cE	0.286 ± 0.03dC	0.182 ± 0.03cD	0.099 ± 0.02cD	0.019 ± 0.001dE	ND	0.178 ± 0.06cD
Tetrachlorocatecol	ND	0.341 ± 0.02cA	0.157 ± 0.04cB	0.124 ± 0.03cB	0.043 ± 0.001cD	ND	0.163 ± 0.01cB
Trichlorosyringol	ND	0.289 ± 0.03dA	0.152 ± 0.01cB	0.122 ± 0.04cB	0.049 ± 0.001cD	ND	0.153 ± 0.02 dB

Table 4 continued

Chlorophenolic compounds (mg/kg)	After 3 month	Control (without worms)	Mixed secondary sludge + composted material 50 %	After 1 month	After 2 month	After 3 month	Control (without worms)
Pentachlorophenol	0.012 ± 0.01dD	0.255 ± 0.01dA	0.175 ± 0.03cB	0.119 ± 0.03cB	0.056 ± 0.003cC	ND	0.187 ± 0.02cB
AOX	134 ± 17aF	2,363 ± 28aB	2,367 ± 43aB	1,532 ± 21aD	697 ± 24aE	128aF	2,287 ± 29aB
EOX	45 ± 11bE	713 ± 17bB	612 ± 21bC	456 ± 15bC	198 ± 13bD	52bE	567 ± 17bC

Values sharing common lowercase letter within column and uppercase letter within row are not significant at $P < 0.05$ value. Data are mean and standard deviation of triplicates. All the concentration represented in the table in mg/kg

ND not detected

The secondary sludge sample was also characterized for 12 chlorophenolic compounds identified by USEPA as carcinogenic compound described in later section.

Chlorophenol concentration

Chlorophenols are important biocides and as by-product of bleaching in the pulp and paper industry. Their widespread use has resulted in broad distribution of these compounds in the environment. Environmental contamination with chlorophenols is widespread due to the importance of these chemicals as industrial intermediate, pesticides and solvents. *Eisenia fetida* can be a significant fate for the chlorophenol removal because physical and chemical methods are not feasible due to high cost and generate secondary pollutants and a single microorganism is unable to mineralise a wide range of different chlorophenols. Field and Sierra-Alvarez (2008) wrote a comprehensive review on the aerobic and anaerobic biotransformation of chlorophenols by microorganism. From the present result, we found that all the 12 different chlorophenols decreased significantly as compared to control having very high concentration (Table 4). Chlorophenols were decreased gradually with time; at 90 days from all the three sets, we did not observe any chlorophenols from the sample whereas in control chlorophenols, concentration was remaining the same (Table 4). From the 2nd experiment having spiked concentration of PCP about (100mg/kg) after 90 days, we found that there is also significant decrease in the concentration of PCP and left about 0.02mg/kg, which shows that vermicomposting having high potential for the removal of chlorophenol from the pulp and paper mill sludge. It is well-established that a large number of organic wastes can be ingested by earthworm and egested as peat-like material termed as vermicompost. Edwards (1988); Kaushik and Garg (2003, 2004) have reported the vermicomposting of textile mill sludge using *Eisenia fetida*. Butt (1993) showed that solid paper mill sludge was a suitable feed for *Lumbricus terrestis* under laboratory conditions. Elvira et al. (1998) have reported vermicomposting of paper mill sludge using *Eisenia Andrei* under laboratory as well as field conditions and found suitable for mineralisation and compost formation.

Some report also indicates that other annelids, such as aquatic Polychaetes, can metabolise benzopyrene, because they possess cytrochrome P450 enzymes capable of degrading this compound (Driscoll and McElroy 1997). The same enzymatic activity was found in terrestrial earthworms such as *Eisenia fetida* (Achazi et al. 1998). This may be a reason for *Eisenia fetida* to remove organic compounds and metabolise successfully. Autochthonous microorganisms degrade hydrocarbons (Johnsen et al. 2005), but if earthworms are added to soil, they will improve aeration, and stimulate microbial activity, thus increasing biodegradation. Eijsackers et al. (2001) reported that there was a steady decrease in the concentrations of Phenenthrene in soil when they added worms and only very low concentrations of Phenanthrene were detected after 40 days.

Table 5 Metallic concentrations in all the three sets before and after treatment. Metal concentration was observed at every month shown in table composted by *Eisenia fetida*

Metals (mg/kg)	Mixed secondary sludge + composted material 5 %	After 1 month	After 2 month	After 3 month	Control (without worms)	Mixed secondary sludge + composted material 20 %	After 1 month	After 2 month
Na	1,346 ± 20eD	1480 ± 43eC	1,568 ± 22eB	1,594 ± 12eB	1,332 ± 21eD	1,693 ± 4 dB	1,680 ± 16eB	1,850 ± 2eA
Mg	3,046 ± 26cB	3,287 ± 23cB	3,690 ± 43cA	3,619 ± 13cA	3,012 ± 22cB	2,843 ± 12bC	3,300 ± 76bB	3,520 ± 22cA
Al	4,894 ± 33aC	5,097 ± 21aB	5,476 ± 44aA	5,505 ± 32aA	4,767 ± 12aC	4,729 ± 21aC	5,096 ± 67aB	5,597 ± 21aA
K	1,850 ± 13cD	2,100 ± 22dC	2,320 ± 56 dB	2,378 ± 13 dB	1,798 ± 31dD	2,037 ± 12cC	2,300 ± 31cB	2,450 ± 12 dB
Ca	3,561 ± 32bCB	3,898 ± 35bB	4,400 ± 23bA	4,526 ± 31bA	3,572 ± 12bB	2,854 ± 13bD	3,200 ± 21bC	3,789 ± 13bB
Fe	2,025 ± 14dA	2,100 ± 17dA	2,150 ± 87dA	2,156 ± 12dA	2,017 ± 13dA	1,902 ± 4cA	1,995 ± 2dA	2,012 ± 12eA
Cr	12.4 ± 2 hB	13.5 ± 13iA	13.9 ± 2hA	14.1 ± 2hA	11.9 ± 2iB	11.5 ± 2hB	12 ± 1iB	12.1 ± 2iB
Mn	124 ± 21fB	128 ± 12fAA	130 ± 41eA	130 ± 21eA	129 ± 11fA	112 ± 2eC	115 ± 21fC	124 ± 6fB
Co	1.2 ± 1iA	1.1 ± 0.2jA	1.2 ± 0.4iA	1.2 ± 0.5jA	1.0 ± 0.2kB	1.2 ± 0.2jA	1.2 ± 0.1A	1.1 ± 0.1A
Ni	15.5 ± 3hA	16.1 ± 2iA	16.5 ± 2hA	16.7 ± 2hA	15.3 ± 2iA	13.3 ± 2hB	13.5 ± 1iB	13.7 ± 1iB
Cu	22.5 ± 2hB	24.8 ± 2hB	27.5 ± 3gA	28.2 ± 10gA	21.87 ± 3hB	19.9 ± 3gB	19.5 ± 2hB	19.0 ± 2hB
Zn	74.5 ± 7gB	77.8 ± 12gA	80.9 ± 11fA	82.2 ± 13fA	74.1 ± 12gB	65.8 ± 4fC	66.0 ± 4gC	66.5 ± 6gC
Cd	1.0 ± 02iA	0.8 ± 0.1jB	0.0kE	1.0 ± 0.2jA	0.8 ± 0.1kB	0.7 ± 0.1jB	0.5 ± 0.1kC	0.5 ± 0.1kC
Pb	3.7 ± 1jA	2.2 ± 0.5jB	0.9 ± 0.05iC	4.0 ± 1iA	3.3 ± 1j	3.4 ± 1iA	3.0 ± 1jA	3.0 ± 1jA
Hg	ND	ND	ND	ND	ND	ND	ND	ND
Se	ND	ND	ND	ND	ND	ND	ND	ND
As	ND	ND	ND	ND	ND	ND	ND	ND

Metals (mg/kg)	After 3 month	Control (without worms)	Mixed secondary sludge + composted material 50 %	After 1 month	After 2 month	After 3 month	Control (without worms)
Na	1,898 ± 6eA	1,634 ± 45 dB	1,214 ± 23dD	1,350 ± 12dD	1,455 ± 17dC	1,466 ± 23dC	1,321 ± 33dD
Mg	3,575 ± 19cA	2,794 ± 21bC	2,422 ± 24bD	2,600 ± 15bC	3,078 ± 19bB	3,106 ± 13bB	2,403 ± 12bD
Al	5,739 ± 14aA	4,716 ± 17aC	3,055 ± 45aE	3,340 ± 23a	3,600 ± 12aD	3,724 ± 19aD	3,032 ± 23aE
K	2,469 ± 12 dB	2,002 ± 9cC	2,102 ± 16bC	2,466 ± 11cB	2,780 ± 8bA	2,818 ± 12cA	2,023 ± 11cC
Ca	3,963 ± 12bB	2,817 ± 11bD	2,154 ± 12bE	2,300 ± 6cE	2,542 ± 9cD	2,662 ± 11cD	2,107 ± 16cE
Fe	2,015 ± 13eA	1,876 ± 21cB	1,412 ± 3dC	1,450 ± 9dC	1,452 ± 11dC	1,446 ± 15dC	1,398 ± 17dC
Cr	12.3 ± 2iB	10.9 ± 1hC	7.7 ± 2D	7.5 ± 2h	7.5 ± 2hD	5.7 ± 2hE	7.1 ± 2hD
Mn	124 ± 5fB	113 ± 4eC	95 ± 2eE	105 ± 11eC	115 ± 2eC	117 ± 11eC	87 ± 13eE
Co	1.3 ± 0.3A	0.97 ± 0.1B	0.8 ± 0.2j	1.2 ± 0.2iA	1.1 ± 0.2kA	1.1 ± 0.3jA	0.7 ± 0.2jC
Ni	13.9 ± 2iB	13.8 ± 2hB	9.6 ± 2hD	10.2 ± 2hD	10.7 ± 2hC	10.7 ± 1gC	9.4 ± 2hD
Cu	18.5 ± 2hB	19.1 ± 1gB	14.9 ± 2gD	15.9 ± 1gD	16.2 ± 3gD	16.2 ± 2gD	14.7 ± 3gD
Zn	67.0 ± 4gC	64.23 ± 2fC	55.2 ± 3fD	56.5 ± 6fD	57.2 ± 4fD	57.2 ± 6fD	54 ± 5fE
Cd	0.6 ± 0.1kC	0.6 ± 0.1jC	0.5 ± 0.1jC	0.6 ± 0.1C	0.7 ± 0.2kB	0.7 ± 0.1jB	0.4 ± 0.1jD
Pb	2.8 ± 1jB	3.3 ± 1iA	2.7 ± 1iB	2.5 ± 1iB	2.4 ± 1jB	2.4 ± 1iB	3.1 ± 1iA

Table 5 continued

Metals (mg/kg)	After 3 month	Control (without worms)	Mixed secondary sludge + composted material 50 %	After 1 month	After 2 month	After 3 month	Control (without worms)
Hg	ND	ND	ND	ND	ND	ND	ND
Se	ND	ND	ND	ND	ND	ND	ND
As	ND	ND	ND	ND	ND	ND	ND

Values sharing common lowercase letter within column and uppercase letter within row are not significant at $P < 0.05$ value. Data are mean and standard deviation of triplicates. Metals described in the table in mg/kg

ND not detected

Metal concentration

Metals concentration in present sludge having higher concentration is described in (Table 5) because of various source such as metal in the raw material and process involved in pulping and paper-making stage. So, the vermicompost made from pulp and paper mill sludge may have higher metal concentrations. Many metal in the sludge mentioned in table is essential and plays significant role for the plant growth and nutrition, but sometime in higher concentration may have detrimental effect on the plant growth. Therefore, before application of the composted material, determining the heavy metals concentration is needed. From the present study, we found that after vermicomposting metals concentration was increased in the composted material as compared to before, in as such

sludge. Essential elements such as Na, K, Mg, Ca which is necessary for the plant growth, metabolism were increased after composting these metals also need for external supply for the plant growth. Previously, Suthar and Singh (2008) have reported that an earthworm processed waste material contains a higher concentration of K due to enhanced microbial activity during the vermicomposting therefore, enhances the rate of mineralisation. Garg and Kaushik (2005) have also reported an increase in Ca content during the vermicomposting of industrial waste. Result showed that heavy metals such as Fe, Cu, Zn, Cr, Ni concentration in the final vermicompost in all three sets were slightly increased as compared to the initial concentration described in (Table 5). High concentration of Cu and Cr may be harmful for the plant but Zn having beneficial effect to plants. Pb and Cd concentration in final vermicomposted material shown decreased which is more toxic to the plants. Wang et al. (2013) also evaluated the role of earthworm in the sewage sludge and observed the reduction of Pb and Cd concentration after vermicomposting. Al concentration was also increased in the composted material. Singh and Kalamdhad (2012) reported that, the contents of total metals (Fe, Cu, Zn Cr, Ni) concentration increased during the water hyacinth (*Eichhornia crassipes*) composting process. Likewise, similar results were obtained by Singh and Kalamdhad (2013) concerning the increase of these heavy metals during the vermicomposting of water hyacinth employing *E. fetida*. Hait and Tare (2012) reported in their experiments that vermicomposting caused a significant increase in total heavy metals (Cu, Co, Fe, Mn, Zn, Cr) contents and a significant decrease in water-soluble heavy metals contents as compared to the compost material. Heavy metal like Hg, Se, As was not found in the present sludge. Metal such as Co, Mn was also increased which plays a major role as micronutrients and this result is supported by the finding of Hait and Tare (2012). Elvira et al. (1998) also reported an increase in heavy metals concentrations in vermicompost of paper mill sludge. Deolalikar et al. (2005) suggested that weight and volume reduction due to breakdown of organic matter during vermicomposting may be the reason for increase in heavy metal concentrations in vermicompost. In present results, we also observed weight loss which was about 13, 17 and 20 % gradually for Set 1, Set 2 and Set 3.

Conclusions

We would like to recommend that earthworms (*Eisenia fetida*) have a great potential to remove chlorophenol from the sludge, even mineralise many metals that are resistant to degradation. Earthworm is extremely resistant to toxic chlorophenols and able to tolerate the high concentrations, normally not present in the soil. Applying *Eisenia fetida* to a contaminated sludge/site might be an environmentally friendly way to remove the chlorophenols.

Author contribution All the lab work was performed by SKK and suggestion was provided by SKC. Manuscript was prepared by SKK and checked by SKC. Both the authors have read and approved the final manuscript.

Acknowledgments The authors are thankful to KVK Tepla, for providing Eisenia fetida sp. and TCIRD Yamunanagar, for providing the industrial sludge and Biotechnology Engineering Department, Ambala College of Engineering and Applied Research for providing the facilities for the work.

Conflict of interest The authors declare that they have no competing interest.

References

- Achazi RK, Flenner C, Livingstone DR, Peters LD, Schaub K, Schiwe E (1998) Cytochrome P450 and dependent activity in unexposed and PAH-exposed terrestrial annelids. Comp Biochem Physiol C 121:339–350
- APHA (1995) Standard methods for the examination of water and wastewater, 19th edn. American Public Health Association, American Water Works Association, Water Environment Federation, Washington, DC
- Belfroid A, Meiling J, Drenth HJ, Hermens J, Seinen W, Gestel KV (1995a) Dietary uptake of super lipophilic compounds by earthworms (*Eisenia andrei*). Ecotoxicol Environ Saf 31:185–191
- Belfroid A, Meiling J, Drenth HJ, Hermens J, Seinen W, Gestel KV (1995b) Dietary uptake of super lipophilic compounds by earthworms (*Eisenia andrei*). Ecotoxicol Environ Saf 31:185–191
- Benitez E, Nogales R, Masciandro G, Ceccanti B (2000) Isolation by isoelectric focusing of humic urease complexes from earthworm (*Eisenia fetida*) processed sewage sludges. Biol Fert Soils 31:489–493
- Butt KR (1993) Utilization of solid paper mill sludge and spent brewery yeast as a feed for soil-dwelling earthworms. Biores Technol 44:105–107
- Deolalikar AV, Mitra A, Bhattacharyee S, Chakraborty S (2005) Effect of vermicomposting process on metal content of paper mill solid waste. J Env Sci Eng 47:81–84
- Driscoll SBK, McElroy AE (1997) Elimination of sediment-associated benzopyrene and its metabolites by polychaete worms exposed to 3-methylcholanthrene. Aqu Toxicol 39:77–91
- Edwards CA (1988) Breakdown of animal, vegetable and industrial organic wastes by earthworms. In: Edwards CA, Neuhauser EF (eds) Earthworms in waste and environmental management. SPB Academic Publishing, The Hague, pp 21–31
- Edwards CA, Bohlen PJ (1996) Biology and ecology of earthworms. Chapman & Hall, London Eijsackers H, Van Gestel CAM, DeJonge S, Muijs B, Slijkerman D (2001) Polycyclic aromatic hydrocarbons-polluted dredged peat sediments and earthworms: a mutual interference. Ecotoxicology 10:35–50
- Elvira C, Sampedro L, Benitez E, Nogales R (1998) Vermicomposting of sludge from paper mill and dairy industries with Eisenia andrei: a pilot scale study. Biores Technol 64:205–211
- ERT (1987) A resource engineering company land treatment effects on wildlife populations in red pine plantations. Nekoosa Papers, Inc, Wisconsin, US
- Field AJ, Sierra-Alvarez R (2008) Microbial degradation of chlorinated phenols. Rev Env Sci Biotech 7:211–241
- Gajalakshmi S, Ramasamy EV, Abbasi SA (2002) Vermicomposting of paper waste with the anecic earthworm Lampito mauriti Kingburg. Int J Chem Technol 9:306–311
- Garg VK, Kaushik P (2005) Vermistablisation of solid textile mill sludge spiked with poultry droppings by an epigeic earthworm Eisenia fetida. Biores Technol 96:1063–1071
- Gonza´lez M, Go´mez E, Comese R, Quesada M, Conti M (2010) Influence of organic amendments on soil quality potential indicators in an urban horticultural system. Biores Technol 101:8897–8901
- Hait S, Tare V (2011) Optimizing vermistabilization of waste activated sludge using vermicompost as bulking material. Waste Manage 31:502–511

- Hait S, Tare V (2012) Transformation and availability of nutrients and heavy metals during integrated composting vermicomposting of sewage sludges. Ecotoxicol Env Saf 79:214–224
- Hanc A, Chadimova Z (2014) Nutrient recovery from apple pomace waste by vermicomposting technology. Biores Technol 168:240–244
- Hand P (1988) Earthworm biotechnology (vermicomposting). In: Greenshields R (ed) Resources and applications of biotechnology. The Macmillan Press Ltd., London, pp 49–58
- Huang K, Li Fusheng, Yongfen W, Xiaoyong F, Xuemin C (2014) Effects of earthworms on physicochemical properties and microbial profiles during vermicomposting of fresh fruit and vegetable wastes. Biores Technol 170:45–52
- Int J Recycl Org Waste Agricult (2015) 4:53–62 61
- 123
- Johnsen AR, Wick LY, Harms H (2005) Principles of microbial PAH-degradation in soil. Env Pollut 133:71–84
- Kaushik P, Garg VK (2003) Vermicomposting of mixed solid textile mill sludge and cow dung with the epigeic earthworm Eisenia foetida. Biores Technol 90:311–316
- Kaushik P, Garg VK (2004) Dynamics of biological and chemical parameters during vermicomposting of solid textile mill sludge mixed with cow dung and agricultural residues. Biores Technol 94:203–209
- Mantykoski K, Paasivirta J, Mannila E (1989) Combustion products of biosludge from pulp mill. Chemosphere 19:413–416
- NCASI method CP-85.01 (1986) NCASI methods for the analysis of chlorinated phenolics in pulp industry wastewater. National Council of the Paper Industry for Air and Stream Improvement, New York, USA
- Pokhrel D, Viraraghavan T (2004) Treatment of pulp and paper mill wastewater a review. Sci Total Env 333:37–58
- Senesi N (1989) Composted materials as organic fertilizers. Sci Total Env 81(82):521–524
- Singh J, Kalamdhad AS (2012) Concentration and speciation of heavy metals during water hyacinth composting. Biores Technol 124:169–179
- Singh J, Kalamdhad AS (2013) Effect of Eisenia fetida on speciation of heavy metals during vermicomposting of water hyacinth. Ecol Eng 60:214–223
- Suthar S, Singh S (2008) Feasibility of vermicomposting in biostabilization of sludge from a distillery industry. Sci Total Environ 394:237–243
- US Environmental Protection Agency (1991) Proposed regulation of land application of sludge from pulp and paper mills using chlorine and chlorine derivative bleaching processes. Fed. Reg. 56(91), 40 CFR. Part 744, OPTS-62100; FRL 3873
- Wang L, Zheng Z, Zhang Y, Chao J, Gao Y, Luo X, Zhang J (2013) Biostabilization enhancement of heavy metals during the vermiremediation of sewage sludge with passivant. J Hazard Mater (244/245):1–9

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Synthesis, characterisation and application of TiO_2 nanopowders as special paper coating pigment

TiO_2 nanopigments in two pure crystallographic forms (anatase and rutile) have been synthesised successfully by two methods; hydrothermal and hydrolysis. The produced pigments from the two methods were investigated physicochemically by several analyses tools. Then they were applied in paper coating mixtures and their influence on coated paper properties was systematically investigated.

Samya El-Sherbiny • Fatma Morsy • Marwa Samir • Osama A. Fouad

S. El-Sherbiny F. Morsy M. Samir, Paper and Printing Laboratory, Chemistry Department, Faculty of Science, Helwan University, Helwan, Egypt
e-mail: samya.elsherbiny@gmail.com

O. A. Fouad, Nanostructured Materials and Nanotechnology Laboratory, Advanced Materials Department, Central Metallurgical Research and Development Institute (CMRDI), P.O. Box 87, Helwan, Cairo 11421, Egypt
e-mail: oafouad@yahoo.com

Appl Nanosci (2014) 4:305–313
DOI 10.1007/s13204-013-0196-y

Introduction

The advancing technologies of printing and packaging have placed greater demands on the surface of the paper sheet. To meet the more stringent requirements, many papers are coated with suitable pigment-rich formulation to provide gloss, smoothness, colour, print detail, and brilliance by filling in the void area on the surface of the paper sheet and covering the highest sitting fibres on the base paper surface (Smook 1997). The coating mixtures are highly concentrated water-based suspensions containing, among other additives, inorganic pigments, binder thickeners and other additives.

Pigment is the most abundant component in the coating, so pigment is naturally the most important factor affecting the properties of the coating materials (Gullichsen et al. 2000). Pigments are used as a blend of different sizes and shapes of various pigment materials. Various speciality pigments with higher cost are often introduced in small amounts to optimise the coating properties (Ninness et al. 2003).

One of the most commonly used paper coating pigments are clays. Clays are hydrous aluminium silicates combined with many other mineral species. Kaolin as one kind of clay minerals have been used as the leading white pigment in paper fillers, paper coating and other different applications such as ceramics, paint, cracking catalyst, cements, waste water treatment, and pharmaceutical industries. Although Kaolin is a commercially available and low-cost paper coating pigment, the need for special paper with special optical characteristics has limited its use in paper coating. Kaolin has comparable whiteness, but lower light scattering index (83.5m^2/kg) than that of the TiO_2 micropowder pigment (254.7m^2/kg), nowadays used commonly (Murray and Elzea 2005).

Recently, titanium dioxide nanopowder has received much interest. This is due to its use in various applications such as cosmetics, paper and medical devices coating and gas sensors (Deorsola et al. 2008; Kobayashi et al. 2008; Wang et al. 2008). Several papermaking trends necessitate more use of TiO_2 including reduction in basis weight and the increasing use of cheap, discoloured fibres. Also, because TiO_2 is used in a large variety of products, its global demand growth is increasing rapidly along with its exceptionally high price. It has variety of advantages such as high surface tension, specific surface area, magnetic property, lower melting point, good thermal conductivity and environmentally friendly (John 2006; Qiong et al. 2008). TiO_2 is a polymorphic compound that exists mainly in three crystallographic phases: anatase, rutile and brookite. They are different in their synthesis and properties among which rutile and anatase are the most commonly synthesised phases owing to their good thermodynamic characteristics and physical properties. Rutile phase has a more compact tetragonal crystal structure than anatase pigment, which might be the reason for its higher refractive index (2.903). In photocatalysis research, where an external UV source is used, anatase titania is usually considered to be more active than rutile but rutile titania possesses better photoabsorption property in visible light wavelength range. In addition, rutile titania exhibits an excellent refractive index, high dielectric constant, higher hiding power and superior chemical stability (Bok et al. 2007; Yamamoto et al. 2009 and Jiaguo et al. 2003).

Titanium dioxide nanopowder was prepared by different methods such as combustion (Deorsola and Vallauri 2008), solvent evaporation (Fumin et al. 2007), hydrothermal (Kobayashi et al. 2008; Yamamoto et al. 2009; Inagaki et al. 2001; Kumar et al. 2009) and hydrolysis (Mahshid et al. 2007; Zhang et al. 2009; Jun et al. 2007; Dahlvik et al. 2000). Its particle size could be precisely controlled in industrial applications to maximise its reflectance. It is used in paper coating to increase both brightness and opacity. Because of

the shortness of Ti resource and its relatively high value, low-cost synthesis techniques for TiO_2 pigment have been investigated. Moreover, phase control in TiO_2 synthesis is an interest for many research groups.

Here we report on the preparation of titanium dioxide nanopigments with various morphologies by two methods namely; hydrothermal and hydrolysis at room temperature. A comparison between the characteristics of the produced titanium dioxide nanopigments from both routes is explored. Moreover, the use of the produced titanium dioxide nanostructures as a pigment in paper coating is also investigated.

Experimental

Materials

The materials used in the present study to prepare nano titanium dioxide particles were, Titanium (IV) isopropoxide ($C_{12}H_{28}O_4Ti$, TTIP, 97%, Aldrich), Tetrabutyl-orthotitanate ($C_{16}H_{36}O_4Ti$, 97%, Fluka), as titanium precursor. Hydrochloric acid (HCl, assay 30%, Sic) was used as a hydrolysing agent. Ethyl alcohol (C_2H_5OH, 95%, Adwic) was used as washing, drying and non-aqueous media agent. Urea ($NH_2.CO.NH_2$, 99%, Adwic) was also used as a structure directing agent. All reagents were of chemical grade and were used as received without any further treatment.

Acrylic copolymer latex (Acronal S801, BASF), clay pigment (EMAK company) and sodium hexametaphosphate dispersant (99%, Fine chemical company) were used for preparation of coating mixture.

Preparation of titanium dioxide nanopigments

Titanium dioxide nanopowders were prepared using two methods namely: (i) hydrothermal method and (ii) hydrolysis method at room temperature.

In the case of hydrothermal method, a clear solution was obtained through addition of 0.2 molar of titanium isopropoxide dropwise into a mixture of 0.79 molar ethanol and 0.58 molar concentrated hydrochloric acid under magnetic stirring. Then the above mixture was diluted by adding distilled water. After stirring for half an hour, the mixture was transferred into Teflon-lined stainless steel autoclave. The autoclave was sealed and subjected to heat treatment at a temperature ranges from 100 to 140°C for 24 h.

In the case of hydrolysis method at room temperature, the typical experimental procedure was as follows: 0.02 molar of tetrabutyl orthotitanate [$Ti(OC_4H_9)_4$] was dissolved in 1.59 molar ethanol. After stirring for half an hour, the resulting solution was added dropwise into a 100ml of 0.25 molar urea in an ice bathed diluted hydrochloric acid aqueous solution under vigorous stirring to form a misty mixture. After further stirring for 4h, the mixture was allowed to stand at room temperature for almost 2 weeks.

The obtained products from the two methods were washed several times with distilled water and then were centrifuged and kept in the suspension status for further paper coating applications.

Application of the prepared nano TiO_2 pigment in paper coating

Preparation of coatings

The basic coating formula used in this study consisted of 100pph clay pigment, 15 pph binder and 0.3 parts of dispersant (pph = part per 100 parts of dry pigment). This sample

was used as a reference sample. The prepared titanium dioxide nanopigments were used at 30 and 50pph in conjugation with clay.

The coating mixtures were prepared in three steps. First, the pigment was dispersed in water in a high shear mixer for 20 min at 50% solids content with sodium hexametaphosphate dispersant. Second, the pre-dispersed binder was gradually added, over a 5-min period to the pigment slurry; for this step the impeller speed was reduced to a moderate speed. Finally, water was added to obtain the desired solids content. The pH was adjusted to 8.5 by adding few drops of 1M sodium hydroxide solution to the coating mixture.

Preparation of coated paper samples

A K-bar semiautomatic coater (model NOS k101, R&K print coat instruments Ltd, United Kingdom) was used for applying the coating mixtures. A wire-wound coating bar was chosen to give a 6ml thick wet film. Paper samples to be coated were cut to overall dimensions of 200 x 300mm using strip cutter, and were coated under standard conditions of temperature and humidity 23 ± 1°C and 50 ± 2% RH according to ISO 187.

Characterisation of the prepared pigments and coated paper samples

The crystal structure, phase identification, purity, crystallinity and crystallite size for the prepared pigments were done by X-ray diffraction (XRD; Bruker axs D8, Germany) using Cu-Kα (k = 1.5406Å) radiation and secondary monochromator in the range 2Θ from 10 to 80. Crystallite size is automatically calculated from XRD data. Bonding structures were analysed using Fourier Transform Infrared spectrometer (FTIR-460plus, JASCO model 6100, Japan). The pigment samples were ground with KBr (1:100 ratios) and mounted as a tablet to the sample holder in the cavity of the spectrometer. The spectra were recorded on a single-beam spectrometer with a resolution of 4cm^{-1} at room temperature in the range 400–4,000cm^{-1}. The specific surface area (SBET), pore volume and pore size distribution of the prepared samples were determined by N_2 adsorption desorption technique using BET surface area analyser (Auto Sorp-1-Mp surface area 2008). The samples were degassed at 250°C for 3 h before analysis, and the N_2 isotherms were obtained at 196°C. The morphological structure of the pigment samples was investigated using scanning electron microscopy (SEM, Jeol-JSM-5410, Japan) and high resolution analytical transmission electron microscopy (TEM, Jeol, JEM-2010, Japan) operating at a maximum of 200kV. The optical properties of the prepared pigment materials were measured in air at room temperature. The UV–visible absorption spectra were recorded in the wavelength range of 200–800nm using a spectrophotometer (UV–Vis, JASCOV-570, Japan). Photoluminescence (PL) spectra were collected in the scan range from 300 to 900nm using a luminescence spectrometer (RF-5301) with xenon lamp as the excitation source. UV–Vis and PL spectra were measured using a quartz cuvette (Q10) of 1cm path length. Ultrasonically dispersed TiO_2 nanopowders in ethanol solution were introduced into the cuvette and exposed to source light. As the UV light could be absorbed pretty quickly so the sample suspensions should be very dilute.

The properties of coated papers including the prepared nanopigments were evaluated using standard tests for physical and optical properties. The surface microstructure is observed by scanning electron microscope (XL30, Philips). Gloss is a property that refers to the quality of lustre, or ability of the surface to show an image. A micro glossmeter was used, at an angle of 75°, to measure the gloss of coated paper samples. Paper brightness is referred to the overall reflectivity i.e., visual efficiency of the paper. The measurements were conducted on brightness and colorimeter instrument (model 68-59-00-002, Buchel-

B.V, Netherlands) according to standard method of ISO 2470-1 (2009). Opacity was also measured using the same instrument according to ISO 2471 (2008). Paper roughness is defined as the measurement of the extent to which the surface of the paper deviates from plane; it is measured by the rate of flow between the paper sample and another standard surface in contact with it. It was measured in ml/min by roughness tester (Bendtsen; model K531, Messmer Bunchel) according to ISO 8791-2 standard. Air permeance is the mean flow of air through unit area under unit air-pressure difference in unit time under specified conditions and it was measured in ml/min by the roughness tester according to ISO 5636 standard.

Results and discussion

Characterisation of titanium dioxide nanopigments

Crystal and bond structures

Figure 1 shows the XRD patterns of the prepared nano titanium oxide samples at various experimental conditions. In general, the XRD patterns show low intensity and relatively broad diffraction peaks. This might be due to the fact that the prepared materials are of very small size and tend to be amorphous. Figure 1a is the XRD pattern of titanium oxide sample prepared using hydrothermal method at 120°C. The diffraction peaks at 2Θ of 25.30°, 37.78°, 47.88°, 54.50° and 63.32° are ascribed to the crystallographic structure anatase phase (TiO_2, JCPDS card #84-1286). No other phases could be detected in the pattern. It is worth mentioning that the samples prepared at higher temperature (140°C) gave a mixture phases. Figure 1b is the XRD pattern of the prepared sample using hydrothermal method at 100°C. The XRD pattern exhibits diffraction peaks at 2Θ of 25.43°, 27.51°, 30.76°, 36.10°, 37.82°, 48.00°, 54.30°, 63.04° and 69.13°, respectively. The presence of these diffraction peaks indicating that the deposited titanium dioxide pigment present in the form of mixed phases. The diffraction peaks can be assigned to mainly a mixture of anatase (TiO_2, JCPDS card #84-1286) and brookite phases (TiO_2, JCPDS card #72-0100) with the presence of traces of rutile phase (TiO_2, JCPDS card #75- 1753). Figure 1c is the XRD pattern of the prepared sample using hydrolysis method. The XRD pattern exhibits diffraction peaks at 27.26°, 36.14°, 41.16°, 43.79°, 54.23°, 56.30°, 62.92° and 68.67°. All the diffraction peaks are assigned to rutile phase (TiO_2, JCPDS card #75-1753).

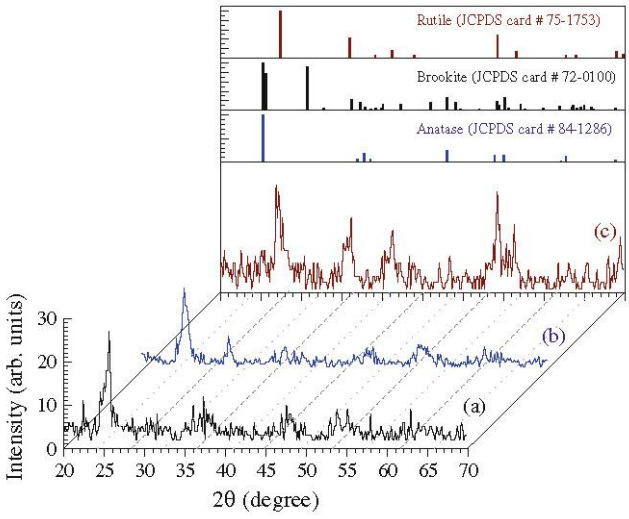


Fig. 1 *X-ray diffraction patterns of TiO_2 nanopigment samples prepared by a hydrothermal method at 120°C b hydrothermal method at 100°C c hydrolysis method*

The crystallite size (d_{RX}) for the prepared samples was determined by measuring the broadening of a most intense peak of the phase (main peak) in a diffraction pattern associated with a certain planar reflection within the crystal unit cell according to Debye–Scherrer equation as follows:

$$d_{RX} = k\lambda/\beta\cos\Theta \qquad (1)$$

where d_{RX} is the crystallite size, k = 0.9 is a correction factor account for particle shapes, β is the full width at half maximum (FWHM) of the most intense diffraction peak plane, λ is the wavelength of Cu target = 1.5406 Å , and Θ is the Bragg's angle.

Here in the three XRD patterns for the three samples that prepared at different conditions, the diameters of the TiO_2 nanopigments are around 6.2, 11.7, and 9.9nm for samples (a), (b) and (c), respectively.

The FT-IR spectra of the prepared TiO_2 nanopigments with different methods are given in Fig. 2. Many absorption bands belong to the organic functional groups such as OH and alkane (C_nH_n–) are detected. In anatase sample, a broad band in the range of 3,600–3,200cm^{-1} is observed which related to stretching hydroxyl group (O–H), representing the presence of surface water as moisture. The other peak located at 1,635cm^{-1} is for stretching of titanium carboxylate, which might be originated from TTIP precursor and ethanol. The presence of such peak might be due to incomplete washing process of the prepared powders. The bands between 800 and 450cm^{-1} are assigned to the Ti–O stretching bands and give the characteristic absorption (transmittance) peak at around 500cm^{-1} which is in excellent agreement with XRD results for rutile sample. Table 1 summarises the results of FT-IR analysis.

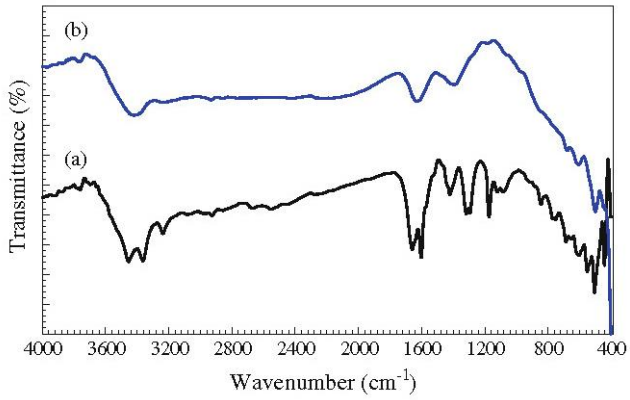


Fig. 2 *FT-IR spectra of different TiO_2 nanopigments a anatase and b rutile samples*

S. no.	Peaks (cm ^{1})	Intensity (%)	Assignment	Phase	
				Anatase	Rutile
1	3,200, 3,363, 3,455 and 3,600	86.81, 82.22, 82.14 and 95	O–H	+	–
2	3,423	86.69	O–H	+	+
3	1,635	82.8	Titanium carboxylate	+	–
4	1,420	93.35	C–H	+	–
5	1,390	91.82	C–H	–	+
6	1,080	93.81	C–O	+	–
7	551, 602, 650, 685 and 800	80.47, 83.16, 86, 85.46 and 91.7	Ti–O	+	–
8	449, 500 and 678	71.25, 71 and 80.7	Ti–O	–	+

Table 1 *FT-IR data obtained from analysis of TiO_2 nanopigments samples*

Morphology

Figure 3 is the SEM micrographs of the deposited TiO_2 sample in the form of anatase. The sample was prepared via hydrothermal method at 120°C. It is obvious that the sample has amorphous structure and it is mainly in the form of compact and nonporous structure.

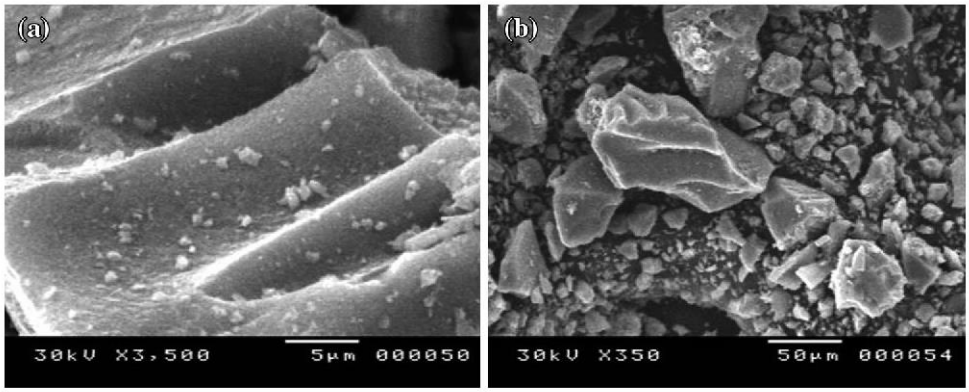


Fig. 3 *SEM micrographs of prepared TiO_2 nanopigment sample (anatase) via hydrothermal method at 120°C a high magnification b low magnification*

TEM was used to further examine the particle size, crystallinity and morphology of samples. TEM bright field micrographs of anatase, mixture of anatase and brookite and rutile are shown in Fig. 4. It is clearly seen that the TiO_2 nanopigments in anatase phase (Fig. 4a) are mostly of spherical-like morphology whereas in Fig. 4b TiO_2 nanopigments are consisting mainly of both rod and spherical-like structures. This result is in agreement with that obtained from XRD data where the sample is composed mainly of two mixed phases (anatase and brookite). The TiO_2 nanopigment in rutile phase, Fig. 4c, mostly has needle-like morphology.

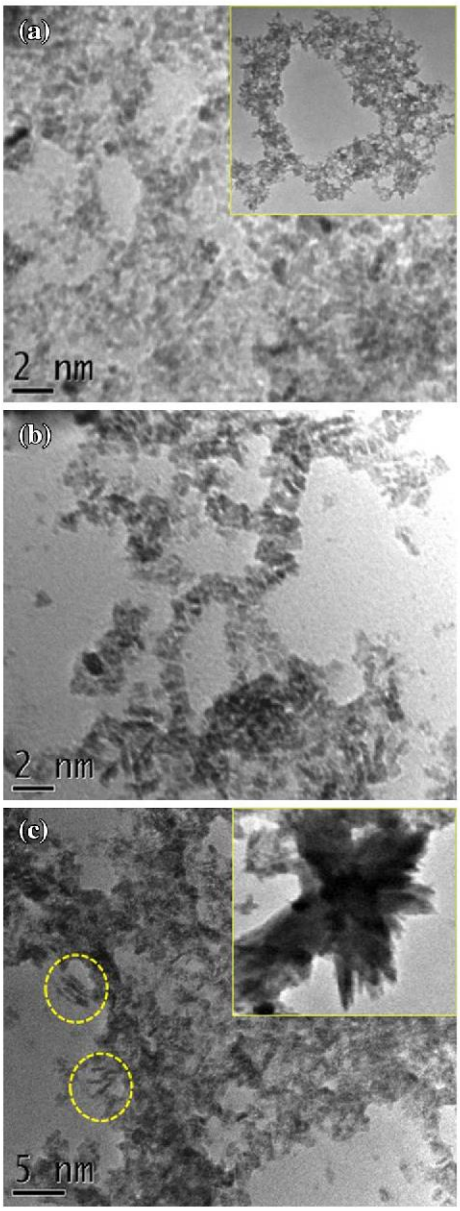


Fig. 4 *TEM micrographs of TiO_2 nanoparticles of a anatase, b anatase + brookite c rutile phase structures. Inset in a represents general view of anatase spherical nanoparticles. Inset in c is a general view of rutile needle clusters. Dotted circles refer to individual single needlelike structures*

Figure 5 shows the nitrogen adsorption–desorption curves of the prepared TiO_2 nanopigments. In general, the results reveal that the isotherms can be classified according to the IUPAC as reversible type IV. Type IV materials are characterised by mesoporosity with high energy of adsorption p/p°. It also shows hysteresis loop of type H1 where the two branches are almost vertical and nearly parallel indicated by the slit-shaped pores for anatase and rutile particles. This also implies the presence of regular even pores without interconnecting channels. The anatase manifested the highest BET surface area which amounted to 140.74m^2/g, pore diameter amounted to 18.33Å, and the total volume of pores was 0.237cc/g. A lower BET specific surface area was demonstrated by rutile, which amounted to 60.621m^2/g. A decrease in diameter and volume of pores could also be noted, which amounted to 14.669Å and 0.122cc/g, respectively.

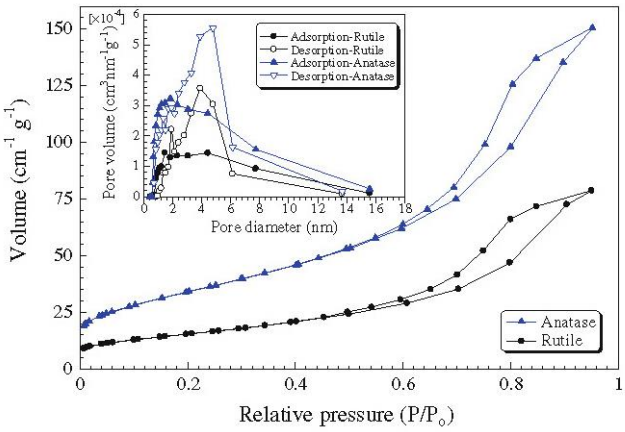


Fig. 5 *N_2 adsorption–desorption isotherms and pore size distribution of the anatase and rutile prepared pigment*

UV–Vis and photoluminescence spectroscopy

Figure 6 shows the UV–visible absorption spectra of the TiO_2 nanopigments of the three prepared samples. The spectra reveal that the rutile sample shows the most narrow intensive peak at wavelength of 320nm which is consistent with its known high refractive index and high brightness. In the case of anatase and brookite samples, the peak obtained at wavelength equal to 280nm is broader than the other peak due to the appearance of the two phases as confirmed by XRD analysis. The anatase sample obtained less intensive peak than rutile peak at approximate wavelength of 300nm. The band gap energies (E_g) of TiO_2 nanopigments were calculated using the equation:

$$E_g = hC / \lambda_{int} \qquad (2)$$

where h is Planck's constant (4.135 x 10^{-6} eV nm); C, the velocity of light (3 x 10^8ms^{-1}), and λ is the wavelength (in nm) corresponding to the intersection of extension of linear parts of the spectrum of y-axis and x-axis. From Fig. 6, the energy gaps for anatase, mixture of anatase and brookite and rutile are 3.36, 3.30 and 3.37eV, respectively. Bulk titanium oxide has a band gap in the range of ~3eV. For low dimensional nanostructured TiO_2 materials, electrons and holes are expecting to move shorter distances approximated by the indirect band gap between highest occupied and lowest unoccupied states. However, due to the large surface-to-volume ratio, lower dimensional TiO_2 nanostructures tend to have larger band gaps.

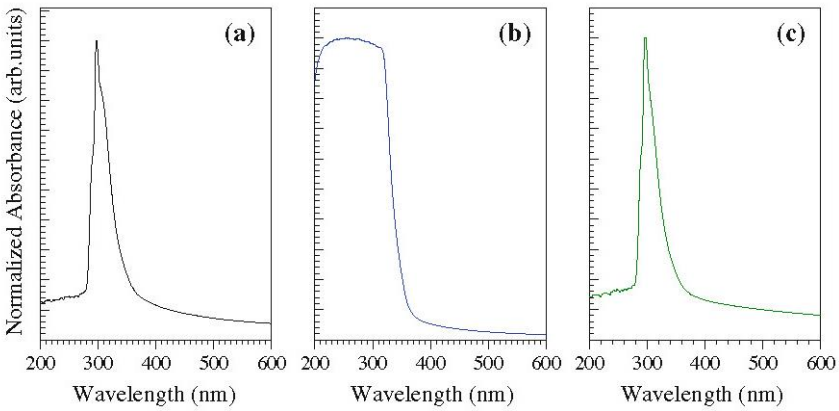


Fig. 6 *UV-Vis absorption spectra of TiO2 nanopigments a Anatase, b Mixture of brookite and anatase and c rutile samples*

Figure 7 shows the PL spectra of TiO_2 nanopigments collected after an excitation at wavelength of 320nm. As seen from the spectra, relatively broad bands at 358nm and at 380nm are detected for all samples. These emission bands are most probably originated from quantum confinement in nanocrystals.

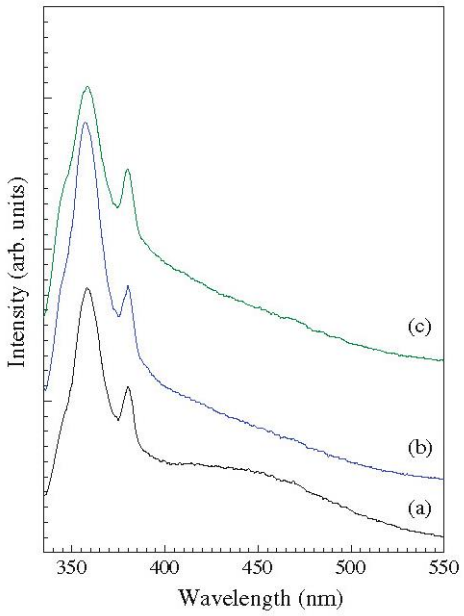


Fig. 7 *Photoluminescence spectra of TiO_2 nanopigments. a Anatase, b anatase + brookite and c rutile samples. The samples are excited at wavelength of 320nm*

Application in paper coating

Optical properties

The optical properties of paper products are very important parameters, mostly due to their aesthetic aspects; however, they also play an important role in print or writing showing through paper product. The properties are defined by reflecting ability, absorbing capacity and penetration of light through paper. Table 2 illustrates the effect of the prepared nano titanium dioxide phases in conjunction with clay on brightness and opacity of the prepared coated paper. It can be clearly seen that along with the increase in the amount of titanium dioxide in relation to clay, the paper ISO brightness and the opacity increased compared with pure clay-coated paper, because the inherent high light scattering coefficients of titanium dioxide pigment led to higher brightness and opacity as it limits the amount of light that can be transmitted through the paper. Comparing the three prepared nano titanium dioxide pigments, Table 2 shows that rutile pigment has the highest brightness value. This is in consistent with the results of UV–visible spectra in Fig. 6 which reveal that rutile pigment has the highest intensive peak. No significant difference in brightness appears upon changing the addition level of titanium dioxide from 30 to 50% for sample rutile, a mixture (Anatase + Brookite) and anatase, respectively (Table 2). The opacity of the coated paper slightly increased upon using the prepared nano titanium dioxide pigments.

Physical properties

Table 2 summarised the data obtained for optical and physical properties of coated papers having the prepared nanopigments. It shows that an increase in the addition levels of nano titanium dioxide pigments leads to substantial decrease in coated paper roughness. When

a coating mixture is applied to the paper, the dewatering or water penetration into the base paper induces the immobilisation of the coating layer. The coating layer is further immobilised during the subsequent drying process, leading to shrinkage of the structure. When nano titanium pigment is incorporated in the coating mixture, the shrinkage of the coating layer during consolidation is counteracted. Apparently, this pigment act as spacers between the clay plates decreased the overall packing density (i.e., produce coated paper with loose packing), leading to high fibre coverage and a smooth surface of the coated paper (Gullichsen et al. 2000; Camilla et al. 1994). The same effect is shown for the three types of nano titanium dioxide pigments. The effect is more pronounced at 50% additional level and greatest effect was obtained with rutile pigment, the percentage decrease reached to 40, 24 and 25% for rutile, a mixture (Anatase + Brookite) and anatase, respectively.

Test	Clay	Rutile/clay additions		(Anatase + Brookite)/clay additions		Anatase/clay additions	
		70:30	50:50	70:30	50:50	70:30	50:50
Brightness (%)	92.60	92.73	93.15	92.07	92.38	92.70	92.97
Opacity (%)	96.47	96.90	97.13	96.51	96.83	96.74	97.01
Gloss (%)	14.58	7.84	9.29	8.61	9.69	8.34	10.79
Roughness (ml/min) before calendering	84.8	84	55.4	78.4	67.7	76.2	67.2
Roughness (ml/min) after calendering	80	65	48	71	61	69	60
Porosity (ml/min)	8.3	3.7	26.4	2.6	27.6	0.3	21.1

Table 2 *Optical and physical properties of coated papers having the prepared nano TiO_2 pigments*

The gloss of the clay-coated paper is much higher than the titanium dioxide-coated paper. This may be due to the disturbance of the platy structure of the clay upon the addition of TiO_2. Table 2 shows the air permeability's (porosities) of the coated papers for clay, and clay/nano TiO_2 systems. It is evident that blend of TiO_2 with clay with percent 70:30 has the lowest air permeance value. This may be due to the nanopigments fill in the narrow pores created between clay particles. As the percent of titanium pigments increased, the porosity significantly increased. In clay coating layer the particle integrity and void network extended uniformly throughout the entire coating. This void network is truly three-dimensional, interconnecting not just in the Z direction but in the machine and cross-machine directions as well. The high level of nano TiO_2 in clay coating mixture disturbs the high packing characteristic of clay pigment providing a loose coating layer packing consequently, imparting more air flow pathway.

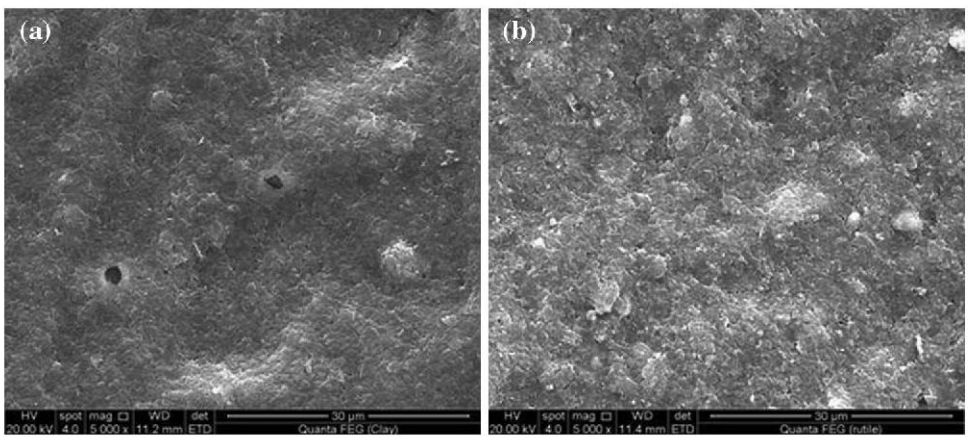


Fig. 8 *SEM micrographs of a clay and b clay/rutile coated paper at 50% additions*

Surface structures

Figure 8 is the electron micrographs of paper coated with clay-based pigment (a) and clay/rutile nano TiO_2 (b) (at 50% addition level). Figure 8 shows that the coating layer follows the tangent of the underlying fibres giving an open and rough surface. Some recesses and valleys are appeared. Upon addition of nano TiO_2, smooth and homogeneous coated paper surfaces have been obtained, this can explain the lower roughness of this coated paper sample.

Conclusions

Pure crystallographic anatase and rutile TiO_2 phase samples have been successfully prepared by hydrothermal at 120°C and hydrolysis methods, respectively. The application of the prepared nanopigments in paper coating reveals that a small amount of TiO_2 is sufficient to achieve significant gains in brightness and opacity, because of the high light scatter ability of the pigment and the refractive index contrast with the other materials in coated paper composite. Also imparting nano TiO_2 pigment into coating formula significantly decreases the surface roughness. The optimal proportion to enhance the porosity of the paper is 70:30% nano TiO_2 pigment to clay additions.

References

- Bok Y, Sig M, Duck E, Gyu H, Young W, Hee S, Lee G, Park S, Hong S (2007) Hydrothermal synthesis of titanium dioxides from peroxotitanate solution using different amine group-containing organics and their photocatalytic activity. Catal Today 124:88–93
- Camilla R, Eriksson U, Rigdah M (1994) Consolidation behavior and gloss of paper coatings based on plastic pigments. Nord Pulp Pap Res J 9:254
- Dahlvik P, Lohmander S, Lason L, Rigdahl M (2000) Relations between the rheological properties of coating colour and their performance in pilot-scale coating. Nord Pulp Pap Res J 15:106
- Deorsola FA, Vallauri D (2008) Synthesis of TiO_2 nanoparticles through Gel Combustion process. J Mater Sci 43:3274–3278
- Fumin W, Zhansheng S, Feng G, Motonarib A (2007) Morphology control of anatase TiO_2 by surfactant-assisted hydrothermal method. China J Chem Eng 15:754–759
- Gullichsen J, Paulapuro H, Lehtinen E (2000) Papermaking science and technology. Fapet/Tappi Series, part 11
- Inagaki M, Nakazawa Y, Hirano M, Kobayashi Y, Toyoda M (2001) Preparation of stable anatase-type TiO_2 and its photocatalytic performance. Inter J Inorg Mater 3:809–811
- Jiaguo Y, Jimmy Y, Bei C, Xiujian Z (2003) Preparation and characterization of highly photoactive nanocrystalline TiO_2 powders by solvent evaporation induced crystallization method. Sci in China 46(6) series B
- John MC (2006) Chemistry of TiO_2 nanoparticles. Puplished PhD thesis, Proquest
- Jun W, Gang Z, Zhaohong Z, Xiangdong Z, Guan Z, Teng M, Yuefeng J, Peng Z, Ying L (2007) Relations between the rheological properties of coating colour and their performance in pilot-scale coating. Dyes Pigm 75:335–343
- Kobayashi M, Tomita K, Petrykin V, Yoshimura M, Kakihana M (2008) Direct synthesis of brookite-type titanium oxide by hydrothermal method using water-soluble titanium complexes. J Mater Sci 43:2158–2162
- Kumar S, Sahoo T, Mohapatra M, Anand S, Yu Y (2009) Polyolassisted synthesis of TiO_2 nano particles in a semi-aqueous solvent. J Phys Chem Solids 70:147–152

- Mahshid S, Askari M, Sasani M (2007) Synthesis of TiO_2 nanoparticles by hydrolysis and peptization of titanium isopropoxide solution. J Mater Process Tech 189:296–300
- Murray H, Elzea J (2005) Engineered clay products for the paper industry. Appl Clay Sci 29:199–206
- Ninness BJ, Bousfield DW, Tripp CP (2003) Formation of a thin TiO_2 layer on the surfaces of silica and kaolin pigments through atomic layer deposition. A: Physicochem Eng Aspect 214:195–204
- Qiong H, Xianming W, Peihua M, Xiaochuan D, Wuha UJ (2008) Alkali induced morphology and property improvements of TiO_2 by hydrothermal treatment. J Wuhan Univ Tech Mater Sci Ed 23:503–506
- Smook GA (1997) Handbook for pulp and paper technologists, 2nd edn. Angus Wilde Publications Inc., Bellingham
- Wang H, Liu P, Cheng X, Shui A, Zeng L (2008) Effect of surfactants on synthesis of TiO_2 nano-particles by homogeneous precipitation method. Powder Tech 188:52–54
- Yamamoto K, Tomita K, Fujita K, Kobayashi M, Petrykin V, Kakihana M (2009) Synthesis of TiO_2 using glycolatotitanium complex and post-synthetic hydrothermal crystal growth of TiO_2. J Cryst Growth 311:619–622
- Zhang S, Liu C, Liu Y, Zhang Z, Mao L (2009) Room temperature synthesis of nearly monodisperserodlike rutile TiO_2 nanocrystals. Mater Lett 63:127–129

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

A Review of Natural Fibres and Processing Operations for the Production of Binderless Boards

Decreasing wood supplies and the need for formaldehyde-free particleboard have become important issues. This has led to studies about the use of raw materials other than wood, along with the manufacture of particleboard without using any synthetic adhesives. This paper presents an overview of the development of binderless boards from natural fibres using a diverse range of manufacturing processes, such as heat and steam treatments. The features of binderless boards produced with various parameters, such as pressing parameters, particle sizes, and additional substances, under various manufacturing processes, are discussed. Based on the availability of natural fibres, binderless boards are typically evaluated for their physical, mechanical, and thermal properties. This review is approached with an understanding of the processes and contributing factors in producing binderless boards, helping to overcome some critical issues that are necessary for the development of future new “green” binderless boards through value addition to enhance their usage.

Maisarah Tajuddin,a Zuraida Ahmad,a,* and Hanafi Ismail b

Contact information:
a: Department of Manufacturing and Materials Engineering, Kuliyyah of Engineering, International Islamic University Malaysia (IIUM), P.O. Box 10, 50728 Kuala Lumpur, Malaysia;
b: Department of Materials and Mineral Resources, Faculty of Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia;
*Corresponding author: zuraidaa@iium.edu.my

Article submitted: August 4, 2015; Peer review completed: November 4, 2015; Revisions accepted: March 23, 2016; Published: March 25, 2016.

www.bioresources.com *BioResources* 11(2)
DOI: 10.15376/biores.11.2.Tajuddin

INTRODUCTION

Particleboard is a wood-based composite consisting of various shapes and sizes of lignocellulosic particles bonded with an adhesive and consolidated under heat and pressure. Particleboard makes up about 57% of total consumption of wood-based panels consumed, and demand is continuously growing, at 2% to 5% annually. Uses include housing construction, furniture manufacturing, and interior decoration of wall and ceiling panelling (Drake 1997). The main source of fibre material for the particleboard and furniture industries in Malaysia is rubberwood, which is estimated to be 2,000,000m^3 annually, leading to a shortage of rubberwood (Anonymous 2009). Wood normally takes a long time to grow to useable sizes, and processing wood as a material is difficult. Thus, it is essential to find alternatives for wood, as the raw wood supply has diminished because of deforestation and forest degradation activities, along with high demand for wood-based panels (Ashori and Nourbakhsh 2008). Research has been carried out on a wide variety of non-wood plant fibres and agricultural residues, such as bagasse, coconut husks, bamboo, and a few more cheap raw materials from many different regions of the world, all of which may serve as a replacement for conventional woods (Miki et al. 2003).

Currently, most commercial particleboard is bonded using formaldehyde-based adhesives made from non-renewable sources. Urea formaldehyde is the most common resin used because of its fast curing time, clear colour, and low cost compared with other synthetic resins (Hashim et al. 2012). Nonetheless, formaldehyde emissions from urea formaldehyde-bonded panels have been subjected to strict legislation and gained attention as a public health concern in the last 30 years. The 10% usage of urea formaldehyde resin from the total dry weight of particleboard makes up about 60% of the overall cost of particleboard production. Also, synthetic adhesives may have effects on human health, such as cancer and irritation of the eyes, nose, and throat, and may lead to environmental pollution (Okuda and Sato 2004).

The manufacturing of binderless board by utilising lignin present in the lignocellulosic fibre raw material is a good substitution solution for expensive synthetic resin used in current particleboards. Because there is no synthetic adhesive used, it is possible that no curing period is needed, and it is economical. Lignin is a complex phenolic amorphous polymer that plays roles in cell wall development and serves to bond individual cells in plants. Lignin has been reported to play an important role in self-bonding boards, acting as a natural binder for fibres (Okuda and Sato 2004). When heat is applied to the fibres, lignin melts to the surface of fibres, and as pressure is applied to the fibres, lignin binds the fibres together. Previous studies have reported that the glass transition values in a dry state for lignin, cellulose, and hemicelluloses were 200, 220, and 170°C, respectively (Hashim et al. 2011).

Research on binderless boards has attracted interest because of its excellent physical and mechanical properties, environmental friendliness, and renewable sources, and because it is both recyclable and economical. It is highly trusted as a competitive wood supplement in the wood-based industry, as the manufacturing processes for binderless boards are simple; it is hoped that it can be easily applied to commercial production (Panyakaew and Fotios 2011). Binderless boards are still in the research stage. This has left room for development since their introduction in the early 1980s (Baskaran et al. 2012). There have been various materials used in manufacturing binderless boards, such as kenaf (Okuda and Sato 2004, 2006; Widyorini et al. 2005a; Xu et al. 2006; Aisyah et al. 2013), oil palm (Suzuki et al. 1998; Hashim et al. 2010, 2011a,b, 2012; Baskaran et al. 2012), date palm (Saadaoui et al. 2013), bamboo (Bahari et al. 2008), coconut husk (van Dam et al.

2004a,b; Panyakaew and Fotios 2011), bagasse (Panyakaew and Fotios 2011), banana bunch (Quintana et al. 2009), durian peel (Charoenvai 2013), wheat straw (Luo and Yang 2011), rice straw (Luo and Yang 2012), wood (Angles et al. 1999, 2001 Miki et al. 2003;), waste paper (Li and Liu 2000), and a few other materials (Velasquez et al. 2002, 2003a; Hunt and Supan 2006; Zhou et al. 2010; Marashdeh et al. 2011; Xie et al. 2012). These boards were manufactured using processes such as heat treatment, steam treatment, compression, and extrusion. Most of the targeted applications for these boards involve interior furniture and insulation board for building.

This article briefly reviews the development of binderless boards from various natural fibres. It follows by presenting the manufacturing processing of binderless boards and the effects of section-manufacturing processing parameters on the properties of binderless boards. Then, the properties of binderless boards produced are described, and the last section mentions the current uses of binderless boards.

DEVELOPMENT OF BINDERLESS BOARDS FROM VARIOUS NATURAL FIBRES

Fundamental knowledge of natural fibres and binderless board properties will provide a broader view of the development of binderless boards with specific properties for specific applications. Natural fibres are normally lignocellulosic, mostly consisting of cellulose microfibrils in an amorphous matrix of lignin and hemicelluloses, together with other contents such as pectin, waxes, and fats (Joseph et al. 1999; Mohanty et al. 2000, 2005). Table 1 summarises the advantages and disadvantages of natural fibres. Table 2 shows the chemical composition of various types of natural fibres, as reported by several researchers.

Advantages	Disadvantages
Low specific weight results in higher specific strength and stiffness than glass	Lower strength, especially impact strength
Renewable resources, production requires little energy, low CO_2 emissions	Variable quality, influenced by weather
Friendly processing, no wear of tools, and no skin irritation	Poor moisture resistance, which causes swelling of fibers
Production with low investment at low cost	Restricted maximum processing temperature
Good electrical resistance	Lower durability
Good thermal and acoustic insulating properties	Poor fire resistance
Biodegradable	Hydrophilic – low wetting with hydrophobic polymers

Table 1. Advantages and Disadvantages of Natural Fibres (Sreekumar 2008)

Per Table 2, researchers have studied various types of lignocellulosic waste material for fibreboard production. Among the natural fibres used in manufacturing binderless boards are kenaf, oil palm, coconut husk, banana bunches, and bagasse. These materials will be discussed briefly in this review. Waste materials such as durian peel, date palm, bamboo, paper, corrugated board, and agricultural waste also have a strong potential to be used as raw materials; however, further research is needed.

Fibers	Lignin (%)	Cellulose (%)	Hemicellulose (%)	Ash (%)	Reference
Flax	2.2	71.0	18.6-20.6	1.7	Li *et al.* 2007
Jute	12.0-13.0	61.0-71.5	13.6-20.4	0.8	
Kenaf	15.0-19.0	31.0-57.0	21.5- 23.0	2.0-5.0	
Sisal	7.0-11.0	47.0-78.0	10.0-24.0	0.6-1.0	Bismarck *et al.* 2005
Coir	40.0-45.0	32.0-43.0	25.0-25.0	2.0-10.0	
Coconut Husk	36.7-45.1	51.1-48.2	67.6-58.8		Panyakaew and Fotios 2011
Bagasse	19.2	56.9	76.3		
Date Palm	31.9	50.6	8.1	6.8	Saadaoui *et al.* 2013
Durian Fiber	10.1		48.6	3.9	Charoenvai 2013
Miscanthus sinensis	19.9	42.6	10.1	0.7	van Dam *et al.* 2004
Banana Bunches	5	63	10	0.8	Mohanty *et al.* 2000
Oil Palm	17.2	60.6	32.5	5.4	Hill and Abdul Khalil 2000

Table 2. Chemical Composition and Moisture Content of Natural Fibres

Kenaf

Kenaf (*Hibiscus cannabinus L.*) is a fast-growing annual plant. The kenaf stem comprises two major parts of fibre, with a ratio of 30:70 of the fibrous outer-bast and the woody inner core; these differ greatly in fibre morphology and chemical composition (Voulgaridis et al. 2000). The kenaf core is lighter and more porous compared to the bast, with a density of 0.10 to 0.20g/cm^3. It has the potential to become a sustainable lignocellulosic raw material. It is rich in hemicellulose content, although the lignin content of kenaf is low. A few studies (Okuda and Sato 2004, 2009; Widyorini et al. 2005; Xu et al. 2006) have been performed on kenaf to produce binderless boards using the heat and steam processes.

Okuda and Sato (2004) manufactured binderless boards using kenaf core through a hot-press method to investigate the properties of the boards using various manufacturing conditions. Results showed that the optimum pressing pressure, temperature, and time were 5.3MPa, 180°C, and 10 min, respectively, with a board density of 1.0g/cm^3. The boards' properties exceeded minimum requirements (JIS – A 5908 2003). In another study (Okuda and Sato 2006), the researchers investigated the water resistance properties of binderless boards. They were able to produce binderless boards with higher water resistance compared to boards produced with synthetic resins. Also, Okuda et al. (2006a,b) examined the chemical changes in kenaf binderless board using various pressing temperatures and by adding extra materials such as acetic acid during board production. Chemical changes occurred, as some of the lignin and hemicelluloses decomposed during the hot press process. These extra materials, although optional, helped to accelerate chemical changes as well as improve board properties.

Xu et al. (2004) produced low-density binderless boards using kenaf core for thermal and sound insulation purposes. The boards produced exhibited good mechanical properties and reached similar values of thermal conductivity as insulation materials. Although the boards showed good internal bond performance, they experienced high water absorption because of their porous characteristics. Xu et al. (2006) furthered the investigation by producing boards via a refining process, in which it was discovered that high steam pressure and long cooking time would lead to improved internal bond strength and lower

thickness swelling of the boards, but resulted in low strength values. Binderless boards with a higher moisture content could have better properties because the process enables a faster heat transfer to the board's core and lowers the melting point of lignin.

Widyorini et al. (2005a) carried out a study of the chemical changes to kenaf core binderless boards manufactured via steam-injection pressing and hot-press processes. Mild steam injection caused significant degradation of chemical components, resulting in a dark brown board with high dimensional stability values. It is important to obtain the optimum conditions of steam treatment through proper control of steam pressure and pressing time to get the best board properties. Widroyini et al. (2005b) also tried to produce binderless particleboards from bagasse using steam-pressing injection to study the effect of raw materials, storage method, and manufacturing process. It was shown that steam-pressed boards were higher in mechanical and internal bond strength than hot-pressed boards.

Oil Palm

Oil palm is a lignocellulosic material (in the bark, leaves, fronds, and trunks) rich in sugar and starch and contains cellulose, hemicelluloses, and lignin. According to Anis et al. (2007), Malaysia generates approximately 13.9 million tons (dry weight) of oil palm biomass annually, including the trunk, fronds, and empty fruit bunches. This agricultural biomass is reasonably cheap, abundant, and sustainable, but it is not used effectively and large quantities of these palms are left in the field as underutilised resources. Open burning and landfills are common practices to eliminate oil palm residues, causing environmental problems. Abundance, sustainability, and carbohydrate richness make the oil palm an ideal raw material for the production of value-added, environmentally friendly, binderless composite panels.

Suzuki et al. (1998) manufactured binderless boards from steam-exploded pulps of oil palm fronds. The mechanical strengths of the binderless boards produced met the board standard requirements (JIS - A 5908 2003). The binderless boards produced had a dark brown colour with smooth surfaces, which resulted from the degradation of chemical components of oil palm fronds. Rigorous conditions of severe explosion caused great damage, which conferred poor quality on the binderless boards. Hashim et al. (2011a,b, 2012) utilised oil palm biomass consisting of bark, leaves, fronds, mid parts, and core parts of trunks to make binderless boards. All parts of this oil palm biomass consisted of high holocellulose, lignin, starch, and sugar required for self-bonding adhesion. The boards had acceptable properties based on the standard (JIS - A 5908 2003), but were poor in dimensional stability because no pre-treatment was used. Hashim et al. (2010) also mentioned that strands showed better bonding properties characteristics, which enhanced the mechanical properties of panels compared with fine particles.

Coconut Husk and Bagasse

Coconuts are typically grown in coastal areas of tropical countries. Approximately 15 to 20 million tons of husk is generated annually, making it abundant as a cheap residue from coconut production. Coconut husk comprises 30 wt.% coir fibres and 70 wt.% pith, which must be separated through retting or mechanical decortications, for a wide variety of products such as ropes, yarns, brushes, and mattress padding reinforcement (van Dam 2002).

Bagasse is a waste product from sugarcane processing. It is rich in cellulose, which strengthens the fibre shape, thereby increasing water resistance and reinforcing the matrix

of hemicellulose-lignin due to the high degree of polymerisation of the natural cellulose (Rowell 2012, Pelaez-Samaniego et al. 2013). There are large quantities of this waste product that are still left unused or burnt. Bagasse usually contains residual sugars from cane production. These sugars may not be chemically compatible with resin binders and may interfere with bonding. Thus, to produce good quality board, the pith/core and residual sugars must be removed (Mobarak et al. 1982; Widyorini et al. 2005b).

van Dam et al. (2004a,b) conducted an experiment using coconut husk to make high-density binderless boards. The binderless boards produced showed comparable mechanical properties to commercial boards, which opens commercial possibilities for the development of cheap building materials. The composition of husk material was dependent on the maturity of the nuts. Panyakaew and Fotios (2011) used a hot press method to make low-density binderless boards from coconut husks and bagasse. Both binderless boards produced met all standard board requirements (JIS - A 5908 2003), except for thickness swelling, as the bagasse binderless board provided superior properties compared to coconut husks. The boards produced were suitable for use as insulation materials.

Other Materials

Approximately 88.8% of the total biomass from bananas is discarded. This biomass, which comes from various parts of the banana, such as the bunch, pseudo-stem, and leaves, is classified as high content fibrous materials (Zuluaga et al. 2007). Quintana et al. (2009) produced binderless boards by performing pre-treatment on banana bunches via optimum condition values of 3.55 for severity, 200°C for pressing temperature, and 1.4MPa for pressing pressure, respectively. Severity values are related to high pressure and longer time practice during pre-treatment process that change nature of fibres used.

Bamboo has high cellulose and lignin contents, as well as a short maturation period. It is easy to grow in forests or plantations. There are many types of bamboo, and it is sufficiently cheap to meet the extensive need for making boards. Bahari et al. (2008) managed to produce binderless bamboo fibreboards through the digesting process. The bending strength of binderless board exhibited a positive correlation with density and lignin content. Strength increased with bamboo age because of an increase in lignin.

Charoenvai (2013) produced new insulating binderless particleboards from durian peels as a green alternative material for insulating products. He replaced formaldehyde based resin as an adhesive in binderless board with durian peel powder. These binderless boards possessed the best physical properties while yielding the lowest thermal conductivity. Meanwhile, Saadaoui et al. (2013) developed a binderless board using four diverse date palm lignocellulosic by-products via a hot-pressing process. Fibrillum, as one of the oil palm parts, has become a promising fibrous by-product, with high internal bond strength and low water absorption, as fibrillum has a high lignin content and good mechanical resistance. Lu et al. (2011; 2012) utilised wheat straw and rice straw with steam-explosion and liquid hot-water pre-treatments, respectively, to evaluate the influence of pre-treatment on the properties of panels. The results showed that pre-treatment using both methods was amongst the best ways to increase the degradation of chemical components, leading to excellent properties. The effects of pre-treatment are discussed in the next section.

Angles et al. (1999) stated that pre-treated material leads to better strength and a smooth appearance. They produced binderless composites from pre-treated residual softwood via hydrolytic pre-treatment at a density of 1.0g/cm^3. Angles et al. (2001) expanded their study

to investigate the effect of pre-treatment severity and lignin addition. They concluded that the addition of 20% lignin caused no significant changes in density and dimensional stability, but improved internal bonds and strength properties of boards. Geng et al. (2006) treated black spruce bark with an alkaline treatment to manufacture binderless fibreboard. The treated board produced showed lighter colour with higher mechanical properties than the untreated board produced.

Velasquez et al. (2002) ground *Miscanthus sinensis* fibres and placed the fibres in a digester for a steam-explosion process. The boards with ground pulp were of better quality than those obtained with non-ground pulp. Velasquez et al. (2003a,b) advanced their study by exploring the optimum pre-treatment and pressing conditions as well as the effect of lignin addition. The boards were of high quality and satisfied the requirements of standard board specifications.

Cotton stalks contain high lignin content with very good flexibility and Runkel fibre ratios. Zhou et al. (2010) manufactured an environment-friendly thermal insulation material from cotton stalk fibres. They explained that thermal conductivity increased with board density because of a decrease in voids within and between fibres. Thus, this binderless cotton stalk fibreboard was excellent as an insulating component for building applications.

MANUFACTURING PROCESS OF BINDERLESS BOARDS

In this article, treatment term refers to the method applied to the fibres during the manufacturing process. Meanwhile, the pre-treatment term refers to the method applied before fibres were used in the manufacturing process; the pre-treatment method changed some properties of fibres. Heat treatment is a common manufacturing process in binderless board development. There are, however, binderless boards that have been produced through the extrusion and compaction processes. Pre-treatment processes such as steam explosion and a few others are important to produce better quality binderless boards, particularly in terms of dimensional stability. Meanwhile, pre-heating and grinding processes, which are simpler processes than steam treatment, are often used as another alternative for the pre-treatment process.

Heat Treatment Process

It is clear from previous studies of binderless board production that hot-pressing is widely accepted because of its simplicity compared with other methods (Okuda and Sato 2004; Xu et al. 2004; Hashim et al. 2012). The basic principle of hot-pressing is the application of heat, which activates the chemical components of the raw materials used. The raw material is basically put inside a mould, and the mould is then placed inside a hydraulic hot-pressing machine. After that, the material inside the mould is pressed depending on the parameters set up. It is necessary to apply enough heat and pressure to melt lignin through the entire board, allowing good distribution of lignin between the fibres during the manufacturing process (Mancera et al. 2008; Zhou et al. 2010). Cellulose and hemicelluloses are partially hydrolysed to simple soluble sugars that contribute to self-bonding (Shen 1991; Rowell et al. 2000; Widyorini et al. 2005a; Panyakaew and Fotios 2011). Several factors, such as pressing temperature, implemented during the manufacturing process of binderless board, have a great impact on the mechanical and physical properties of the boards produced. However, degradation of chemical components for the hot-press process has been found to be much less effective than a steam treatment (Laemsak and Okuma 2000; Okamoto et al. 1994; Widyorini et al. 2005a). The best properties obtained from this process were under a pressing temperature

of 180°C, a pressing pressure of 5.3MPa, a pressing time of 10 min, 5.0-mm board thickness, and a board density of 1.0g/cm^3, using kenaf (Okuda and Sato 2004).

Compaction Process

In addition to the heat and steam processes, binderless boards can be produced through extrusion. Extrusion occurs when the material undergoes the compaction process, in which the compaction device is heated while the compaction loads are poured into the device. Then, the loads are extruded through the die under various conditions. Miki et al. (2003) evaluated the effects of extrusion temperature, extrusion ratio, and moisture content, as well as particle size of wood. They found that increasing the extrusion temperature and moisture content of powders increased the fluidity of extruded products up to 200°C. Extrusion needs a specific machine that might not be appropriate for small industries because of the high cost involved and the particular handling knowledge required to operate the machine. Jain and Handa (1982) also produced binderless boards from agricultural wastes of straw and paper liner particles through the extrusion process. These boards can be used for interior partitions of ceiling and lining. Li and Liu (2000) investigated the process for developing high-density binderless logs from waste paper using the compaction process. Moisture content plays an important role in the compaction process. Reasonably high-quality and cost-effective logs were produced with a compaction pressure of 70% and moisture content of 15%. Hunt and Supan (2006) developed binderless boards from recycled corrugated containers and refined small diameter treetops. Both panels surpassed minimum commercial hardboard standards through this process.

Steam Pre-Treatment Process

Steam pre-treatment has been known to be effective for improving the dimensional stability of wood-based composites, depending on variables such as pressing temperature and chemical composition of lignocellulosics (Mobarak et al. 1982; Widyorini et al. 2005a). This process works by injecting high-pressure saturated steam into a reactor filled with material used, where the temperature rises up to 200°C and suddenly the pressure is reduced, resulting in an explosive decompression of the fibre material. The explosion causes an increase in surface area of the fibres, with degradation of hemicelluloses, low crystallinity of cellulose, and disruption of the lignin matrix. Widyorini et al. (2005a) managed to manufacture kenaf cores binderless boards via steam-injection treatment. The results showed that the bonding properties of these binderless boards were relatively strong, compared with binderless boards produced by hot-press treatments or even other binderless boards from different processes with the same density.

Angles et al. (2001) discovered that the hygroscopicity characteristics of hemicelluloses are responsible for moisture absorption. This means that boards with lower hygroscopicity have smaller values of water absorption and thickness swelling. Some authors (Angles et al. 2001; Widyorini et al. 2005a; Mancera et al. 2008) have attained similar results, in which decreasing hemicelluloses content during pre-treatment leads to improved dimensional stability, but does not lead to any increase in mechanical properties. The presence of cellulose in the crystalline structure helps to prevent water from penetrating the boards and leads to an increase in dimensional stability, as it makes the structure of the boards compact without voids. At the same time, cellulose is also degraded through the steam treatment process, which causes a reduction in the quality of boards (Widyorini et al. 2005a,b).

Lignin, which provides rigidity and stiffness to plant cell walls, is much more stable and resistant to steam treatment than hemicellulose (Widyorini et al. 2005a; Mancera et al. 2008). Steam treatment is considered to facilitate lowering the softening point of lignin and exposure of the more accessible lignin on the surface of the fibre, which contributes to self-bonding (Angles et al. 2001). Luo and Yang (2012) reported that hemicellulose and cellulose contents decreased with increasing lignin content from liquid hot water pre-treatment. Mancera et al. (2008) stated that pre-treatment temperature and time have no effect on lignin contents.

Other factors, such as the severity parameter, are important during the steam treatment process. The severity parameter is the expression based on calculation of steam temperature and residence time of the steam temperature. Previous studies (Suchsland et al. 1987; Geng et al. 2006) mention that steam treatment severity clearly have a significant influence on internal bond, as high severities produced higher surface area with high lignin contents. A few previous studies (Angles et al. 2001; Widyorini et al. 2005a; Mancera et al. 2008) also reported the same results, in that high severity led to improved internal bond strength and dimensional stability of boards, although it decreased the mechanical strength properties.

The effect of longer steam treatment resulted in excess steam and caused a rigorous degradation of chemical components. Increased severity not only reduces hygroscopicity, but also greatly reduces abrasive materials that are unnecessary for board manufacturing. The removal of wax and pectin from the surfaces contributed to a significant effect on the wettability of fibre surfaces (Suchsland et al. 1987). The manufactured boards turned dark brown, indicating a high degree of hydrolysis or modification of chemical components during steam treatment. Previous research (Suchsland et al. 1987; Velasquez et al. 2003b) has reported that superior mechanical properties of binderless fibreboards can be gained from steam treatment with low severity, compared with binderless fibreboards obtained from steam treatment with high severity. Low temperature, low steam pressure, and long treatment time were used to protect the structure of fibres and carry out lignin modifications to enhance the adhesive behaviour.

Pre-heating and Grinding Process

For lab-scale preparation, another process to improve binderless board is pre-treatment using pre-heating and grinding. The simplest pre-treatment is microwave preheating of the fibres before hot-pressing. This helps improve the internal bond strength and properties of manufactured boards. Okuda et al. (2006a) reported that pre-heating fibres in a microwave for one minute could accelerate thermal softening of lignin, which resulted in better strength properties. When pre-heating time increased to two minutes, there was no obvious change observed because of the influence of excessive drying, and part of raw material was burned black with very low moisture content.

One of the easiest ways of preparing pre-treatments for fibres is milling or grinding. According to previous studies (Velasquez et al. 2002, 2003a; Saadaoui et al. 2013), grinding the material before the hot-press process considerably improves the internal bond strength without affecting other physico-mechanical properties of binderless boards. This process, however, does affect the density of the boards, as grinding gave lower density than non-grinding materials because of an increase in compression resistance and more air in milled pulp. Grinding did not cut the fibres, but helped separate the bundles of fibres. This segregation leads to more spaces for inter-fibre bonding, leading to an increase in the strength of the bonds (Velasquez et al. 2002). The nature of the bonds did not change,

thus it did not affect the dimensional stability of the board. Nevertheless, the particle shape and size have an important impact on the properties of binderless boards, so the degree of crushing in grinding becomes a limiting factor, as it affects particle geometry.

EFFECTS OF MANUFACTURING PROCESS PARAMETERS ON PROPERTIES OF BINDERLESS BOARDS

During the manufacturing process of binderless board, there are a few factors that can affect the properties of boards produced. These factors include the pressing parameters in terms of temperature, pressure, and time, as well as particle sizes and the presence of additional substances.

Effects of Pressing Temperature, Pressure, and Time

Pressing temperature is one of the most important parameters influencing board properties. Past studies (Widyorini et al. 2005a; Hashim et al. 2011a) have indicated that the yield of extractives increased at a higher pressing temperature. It has been shown in Fourier transform infrared (FTIR) spectra that there were slightly smaller chemical changes during the hot-press process, where part of lignin and hemicelluloses experienced decomposition. Quintana et al. (2009) revealed that fibres could be fused together by mechanical entanglement of the softened lignin molecules, possibly accompanied by the formation of a covalent bond. Thermogravimetric analysis (TGA) also shows thermal decomposition of hemicelluloses and cellulose at temperatures around 300°C. These results are supported by Zhou et al. (2010), who suggested that the lignin fluidity of fibres increases with higher temperatures, improving lignin distribution in fibreboards and inter-fibre bonds. The chemical changes described above contribute to self-bonding and improved board properties. The reduction of hygroscopicity resulting from the degradation of hemicelluloses was observed in studies by Xu et al. (2006) and Xie et al. (2012). They emphasised that high pressing temperature was beneficial for fibre plasticising. Fibres' lignin melts and flows resulted in full fusion among fibres; the fibre contact thus became closer.

A significant increase in board density and pressing pressure resulted in an improved internal bond strength and mechanical properties, along with greater dimensional stability of the boards. Nevertheless, the thickness swelling of the board was only affected by pressing pressure, while water absorption of the board was affected by all pressing variables, such as pressing temperature, pressing time, and pressing pressure; these properties are closely related, however. Mobarak et al. (1982) reported that an increase in pressing pressure during manufacturing of bagasse pith boards had an influence on board strength, attributed to the morphological structure of pith, which mostly consists of parenchyma cells. A study by Quintana et al. (2009) demonstrated that mechanical entanglement of the softened lignin molecules was accompanied by formation of covalent bonds, as fibres with lignin-rich surfaces fused together under a high pressing pressure. Conversely, fibres are more distant with lower contact points at a low pressing pressure. Despite that, high pressure means a high process cost, although the superior properties produced by such boards are appreciated.

Li and Liu (2000) discovered no noticeable effect of pressing time when a board was pressed under high pressure. Similar trends can be seen where pressing time has less of an effect on log quality when the board is pressed at the closest moisture content to the optimum. Okuda et al. (2006; 2006a) claimed that either a one-step or a three-step pressing schedule could be selected without affecting board properties. Zhou et al. (2010) stated that prolonging pressing time resulted in an increased strength of the board. The

fibres need to be heated for longer times to make sure the heat is transferred to the core of the binderless board; hence, the lignin is plasticised and flows well.

Effects of Particle Sizes

It is well known that particle size and geometry significantly influence the development of binderless board properties in terms of bonding quality among particles, compared to mechanical strength properties of the fibres themselves. Previous studies (Munawar et al. 2007; Hashim et al. 2010) have shown that smaller particles improved the qualities of the board with superior internal bond strength. This is because smaller particles were more compressed with fewer overlapping areas, producing uniform homogeneous cells, which had lower voids. Interestingly, this leads to better dimensional stability and gives a smoother surface for binderless boards compared to larger particles (Mobarak et al. 1982; Hashim et al. 2010). Additionally, smoother surfaces and appearances are energy saving, as no sanding stage is required. The smaller particles, particularly in powder form, need more energy to manufacture and are difficult to handle during the fabrication process (Okuda and Sato 2004).

Studies conducted by Hashim et al. (2010) and Juliana et al. (2012) reported that strands led to higher internal bond and mechanical strength compared with particles. Strands are thinner, longer, and have a larger surface contact area with a better glue line, which leads to better strength characteristics. Longer particles are high in aspect ratio (fibre length over width) or adhesive content per unit particle surface area. The roughness value of strands is higher because strands are coarser and have a rigid structure of vascular bundles. Juliana et al. (2012) again stated that more slender (length over thickness) particles usually provide better bonding than bigger particles because of a greater amount of contact surface. Slender particles require more adhesive to sufficiently bond the particles. Admixture boards consisting of kenaf and rubberwood gave better strength than using 100% of the same materials. Particles of rubberwood were stronger and more slender than the kenaf particle. These results were supported by a study by Charoenvai (2013), in which the manufacturing of particleboard using durian-peelpowder-based adhesive gave similar properties when compared with synthetic adhesives.

Effects of Additional Substances

Numerous studies (Velasquez et al. 2003a; Okuda et al. 2006b; Ashori and Nourbakhsh 2008; Baskaran et al. 2012) have been performed by adding extra materials to binderless boards for the purpose of comparison. A study conducted by Ashori and Nourbakhsh (2008) reported that wax addition in binderless board reduced strength properties, but it helped to improve the dimensional stability of the boards. Moreover, further treatments such as coating or laminates are required for binderless boards without using wax or any hydrophobic substance. Therefore, a small amount (approximately 1%) of wax can be used in binderless particleboard manufacturing.

Velasquez et al. (2003a) investigated the effects of replacing fibre with different kinds of technical lignin recovered directly from pulping liquor, without further purification or treatment. The lignin was added in two conditions, which were prior to the steam explosion process and just before the hot-press process, after the material had gone through a steam-explosion process. They discovered that substituting 20% of *Miscanthus sinensis* with lignin had superior effects on board properties. Boards with kraft lignin added before the steam explosion process had superior properties, resulting from the elimination and reduction of low-molecular weight substances during the steam explosion, leading to

better homogenisation and a good mixture between kraft lignin and the chips. This is applicable for low pressing temperatures only.

It is essential to find the optimum parameters and factors of pressing temperature, pressing pressure, pressing time, and particle geometry and size to produce binderless boards that meet all standard requirements, while consecutively contributing to the internal bond and strength properties of boards. Adding particular materials such as 1% wax or technical lignin can help improve the board properties if the optimum amount is used.

PROPERTIES OF BINDERLESS BOARDS

Table 3 shows the density, strength, and dimensional stability of binderless boards made from various natural fibres and manufacturing processes (Velasquez et al. 2003b; Okuda and Sato 2004; Van Dam et al. 2004a; Quintana et al. 2009; Hashim et al. 2010; Luo and Yang 2011, 2012; Xie et al. 2012; Saadaoui et al. 2013). The binderless boards were produced within a density range of 0.8 to 1.3g/cm^3 using nine types of materials adapted for various processes. The common tests were conducted according to available standards (JIS - A 5908 2003) to see if the boards met the recommended requirements, which are a minimum modulus of rupture (MOR) of 18MPa, minimum internal bond (IB) strength of 0.3MPa, and maximum thickness swelling (TS) of 12%. From Table 3, it can be concluded that high-density boards turned out to have the highest strength. Most of the binderless boards met the minimum requirement of MOR and IB, except for date palm (Saadaoui et al. 2013), and a few others (Quintana et al. 2009; Luo and Yang 2011, 2012), which did not meet the minimum requirement for IB. However, only wood (Xie et al. 2012) and coconut husk (Van Dam et al. 2004a) met the requirement of maximum TS of 12%.

It can be seen that the modulus of rupture (MOR) value of *Miscanthus sinensis* board is the highest. It is assumed that the *Miscanthus sinensis* board has gone through a steam process that changed the chemical compounds and improved the internal bond, as well as strength of the board. The second highest MOR value is the board made of wood, followed by the board made from coconut husk and kenaf. These three boards - wood, coconut husk, and kenaf - were manufactured via a hot-press process. It is clearly shown in the table that these three boards have high values compared with other boards made from the steam process, except for *Miscanthus sinensis* board. The internal bonds (IB) have a great influence on the dimensional stability of boards. From the dimensional stability in the Table 3, boards made of date palm have high values of thickness swelling (TS) and water absorption (WA) because they have the lowest IB value. Conversely, the IB of kenaf is the highest. Also, the dimensional stability of kenaf board is almost 3 to 5 times higher than that of wood board and coconut husk board. The board produced from oil palm has the lowest value in density, which also affects its MOR value. It also has a low dimensional stability compared with other boards. This is in agreement with the theory stating that the hot-press process only causes small chemical changes in boards, which does not help to improve the TS and WA values.

In conclusion, there are a large number of factors that affect board properties, such as material type, manufacturing process, parameters used, and parts and sizes of materials, which must be considered and given particular attention when developing binderless boards.

Process	Author(s)	Natural fiber(s)		Density (g/cm^3)	MOR (MPa)	IB (MPa)	TS (%)	WA (%)
Hot-press (HP)	Hashim *et al.* (2010)	Oil Palm	OP	0.8	24.95	0.95	41.6	80.0
Hot-press	Okuda and Sato (2004)	Kenaf	KF	1.0	36.10	5.70	19.6	40.9
Hot-press	Saadaoui *et al.* (2013)	Date Palm	DP	1.0	12.90	0.03	150.0	275.0
Hot-press	Xie *et al.* 2012	Wood	W	1.2	52.80	0.92	7.6	-
Hot-press	Van Dam *et al.* (2004)	Coconut Husk	CH	1.3	50.00	-	8.0	8.0
Steam + HP	Luo *et al.* (2011)	Wheat Straw	WS	1.0	19.80	0.26	-	61.0
Liquid hot-water + HP	Luo *et al.* (2012)	Rice Straw	RS	1.0	18.10	0.24	-	63.7
Steam + HP	Quintana *et al.* (2009)	Banana Bunch	BB	1.2	24.14	0.14	60.0	55.5
Steam + HP	Velasquez *et al.* (2003)	*Miscanthus sinensis*	MS	1.3	61.00	3.76	23.0	8.9

Table 3. Properties of Binderless Boards Made of Various Natural Fibres

Most of the reported binderless boards produced using different natural fibres were prepared at laboratory scale and these boards' properties have considerable room for improvements, mainly with respect to dimensional stability attributes. These developed binderless boards are suitable to be used for internal furniture, decorative partition walls, and insulation boards either for sound or thermal. For exterior usage, some extended studies might be required to improve dimensional stability performance of binderless boards. The ideas of surface coating or wrap with waterproof materials or to make these boards as the core for sandwich panels can be considered for future research so that these binderless boards can be used as interior and exterior furniture. On the other hand, the evaluation of health-environment impact and insect fungal resistance seem relevant and necessary for future tests on these binderless boards produced.

CONCLUSIONS

1. This review of binderless boards provides a big picture of previous research on the development of binderless boards conducted worldwide, focusing on the manufacturing process and properties of binderless board.
2. The prospect of natural fibres gives ideas for utilisation of lignocellulosic waste materials that have been abundantly left around the world into value-added products, although there are some constraints because of the fibres themselves.
3. The various manufacturing processes for binderless boards also have been reviewed, including optimum parameters needed to obtain the best quality boards.
4. Boards made from kenaf and *Miscanthus sinensis* have the best qualities among boards that have been manufactured using the hot-press and steam processes, respectively. These two boards may be used as good references for future studies.
5. The properties of binderless boards are affected by many factors, and the main one is on divergence of different materials, which agrees with the theory studied in previous research.

6. Further research on health-environment impacts, insect fungal resistance, along with coating or wrapping binderless boards produced are important for exterior and interior usage.
7. It is essential to understand the basic structural components of natural fibres and their effects on the physical, mechanical, and thermal properties to manufacture binderless boards. More studies are required on the manufacturing process, especially for largescale end products, as well as product commercialisation, which has not been discussed here.

ACKNOWLEDGEMENTS
The researchers would like to thank International Islamic University Malaysia (IIUM), Selangor for providing guidelines that have made this work possible.

REFERENCES CITED

- Aisyah, H. A., Paridah, M. T., Sahril, M. H., Anwar, U. M. K., and Astimar, A. A. (2013). "Properties of medium density fibreboard (MDF) from kenaf (Hibiscus cannabinus L.) core as function of refining conditions," Composites: Part B 44(1), 592-596. DOI: 10.1016/j.compositesb.2012.02.029
- Anglès, M. N., Reguant, J., Montané, D., Ferrando, F., Farriol, X., and Salvadó, J. (1999). "Binderless composites from pre-treated residual softwood," Journal of Applied Polymer Science 73(2), 2485-2491. DOI: 10.1002/(SICI)1097-4628(19990919)73:12<2485::AID-APP17>3.0.CO;2-G
- Anglès, M. N., Ferrando, F., Farriol, X., and Salvadó, J. (2001). "Suitability of steam exploded residual softwood for the production of binderless panels. Effect of the pretreatment severity and lignin addition," Biomass and Bioenergy 21(3), 211-224. DOI: 10.1016/S0961-9534(01)00031-9
- Anis, M., Kamaruddin, H., and Wan Hasamuddin, W. H. (2007). "Current status of oil palm biomass supply," in: Proceeding of the 7th National Seminar on the Utilization of Oil Palm Tree, Oil Palm Tree Utilization Committee (OPTUC), Kuala Lumpur, Malaysia, pp. 3-11.
- Anonymous. (2009). NATIP: National Timber Industry Policy 2009-2020, Ministry of Plantation Industries and Commodities Malaysia.
- Ashori, A., and Nourbakhsh, A. (2008). "Effect of press cycle time and resin content on physical and mechanical properties of particleboard panels made from the underutilized low-quality raw materials," Industrial Crops and Products 28(2), 225-230. DOI: 10.1016/j.indcrop.2008.02.015
- Bahari, S. A., Jamaludin, M. A., Ahmad, M., Subardi, S. A., Saad, M. J., and Nordin, K. (2008). "Characterization on bending strength of binderless bamboo fibreboard" (BBF), Proceeding of 9th Pacific Rim Bio-based Composites Symposium, CSIRO and SCION, New Zealand, pp. 238-246.
- Baskaran, M., Hashim, R., Said, N., Raffi, S. M., Balakrishnan, K., Sudesh, K., Sulaiman, O., Arai, T., Kosugi, A., Mori, Y., et al. (2012). "Properties of binderless particleboard from oil palm trunk with addition of polyhydroxyalkanoates," Composites: Part B 43, 1109-1116. DOI: 10.1016/j.compositesb.2011.10.008
- Bismarck, A., Mishra, S., and Lampke, T. (2005). "Plant fibers as reinforcement from green composites," in: Natural Fibers, Biopolymers and Biocomposites, A. K. Mohanty, M. Mishra, and L. T. Drzal (eds.),Taylor & Francis, Boca Raton, FL. DOI: 10.1201/9780203508206.ch2
- Charoenvai, S. (2013). "New insulating material: Binderless particleboard from durian peel," Advances in Civil Engineering and Building Materials, CRC Press, pp.119-123. DOI: 10.1201/b13165-26

- Drake, P. A. (1997). “The composite panel industry: A global market assessment,” in: Proceedings of 31st International Particleboard/Composite Materials Symposium, Washington State University, Pullman, WA.
- Geng, X., Zhang, S. Y., and Deng, J. (2006). “Alkaline treatment of black spruce bark for the manufacture of binderless fibreboard,” Journal of Wood Chemistry and Technology 26(4), 313-324. DOI: 10.1080/02773810601076857
- Hashim, R., Saari, N., Sulaiman, O., Sugimoto, T., Hiziroglu, S., Sato, M., and Tanaka, R. (2010). “Effect of particle geometry on the properties of binderless particleboard manufactured from oil palm trunk,” Materials and Design 31(9), 4251-4257. DOI: 10.1016/j.matdes.2010.04.012
- Hashim, R., Said, N., Lamaming, J., Baskaran, M., Sulaiman, O., Sato, M., Hiziroglu, S., and Sugimoto, T. (2011a). “Influence of press temperature on the properties of binderless particleboard made from oil palm trunk,” Materials and Design 32(5), 2520-2525. DOI: 10.1016/j.matdes.2011.01.053
- Hashim, R., Wan Nadhari W., Sulaiman, O., Kawamura, F., Hiziroglu, S., Sato, M., Sugimoto, T., Seng, T. G., and Tanaka, R. (2011b). “Characterization of raw materials and manufactures binderless particleboard from oil palm biomass,” Materials and Design 32(1), 246-254. DOI: 10.1016/j.matdes.2010.05.059
- Hashim, R., Wan Nadhari, W. S., Sato, M. O., Hiziroglu, S., Kawamura, F., Sugimoto, T., Seng, T. G., and Tanaka, R. (2012). “Properties of binderless particleboard panels manufactured from oil palm biomass,” BioResources 7(1), 1352-1365. DOI: 10.15376/biores.7.1.1352-1365
- Hill, C. A. S., and Abdul Khalil, H. P. S. (2000). “Effect fibre treatments on mechanical properties of coir or oil palm fibre reinforced polyester composites,” Journal of Applied Polymer Science 78(9), 1685-1697. DOI: 10.1002/1097-4628(20001128)78:9<1685::AID-APP150>3.0.CO;2-U
- Hunt, J. F., and Supan, K. (2006). “Binderless fibreboard: Comparison of fibre from recycled corrugated containers and refined small-diameter whole treetops,” Forest Products Journal 56(7/8), 69-74.
- Jain, S. K., and Handa, S. K. (1982). “A press for producing binderless boards from agricultural wastes,” Research and Industry 27(2), 121-123.
- JIS - A 5908 (2003). “Particleboards,” Japanese Standards Association, Tokyo, Japan.
- Joseph, K., Filho, L. D. T., James, B., Thomas, S., and Carvalho, L. H. (1999). “A review on sisal fibre reinforced polymer composites,” Revista Brasileira de Engenharia Agricola e Ambiental 3(3), 367-379.
- Juliana, A. H., Paridah, M. T., Rahim, S., Azowa, I. N., and Anwar, U. M. K. (2012). “Properties of particleboard made of kenaf (Hibiscus cannabinus L.) as function of particle geometry,” Materials and Design 34, 406-411. DOI: 10.1016/j.matdes.2011.08.019
- Laemsak, N., and Okuma, M. (2000). “Development of boards made from oil palm frond II: properties of binderless boards from steam exploded fibers of oil palm frond,” Journal of Wood Science 46(4), 322-326. DOI: 10.1007/BF00766224
- Li, X., Tabil, L. G., and Panigrahi, S. (2007). “Chemical treatments of natural fibre for use in natural fibre-reinforced composites: A review,” Journal of Polymers and the Environment 15(1), 25-33. DOI: 10.1007/s10924-006-0042-3
- Li, Y., and Liu, H. (2000). “High-pressure binderless compaction of waste paper to form useful fuel,” Fuel Processing Technology 67(1), 11-21. DOI: 10.1016/S0378-3820(00)00092-8

- Luo, P., and Yang, C. (2011). "Binderless particleboard from steam exploded wheat straw," Applied Materials Research 179-180, 807-811. DOI: 10.4028/www.scientific.net/amr.179-180.807
- Luo, P., and Yang, C. (2012). "Production of binderless particleboard using rice straw pre-treated with liquid hot water," Applied Mechanics and Materials 200, 331-334. DOI: 10.4028/www.scientific.net/AMM.200.331
- Mancera, C., Ferrando, F., and Salvado, J. (2008). "Cynara cardunculus as raw material for the production of binderless fiberboards: Optimization of pretreatment and pressing conditions," Journal of Wood Chemistry and Technology 28(3), 207-226. DOI: 10.1080/02773810802347024
- Marashdeh, M. W., Hashim, R., Tajuddin, A. A., Bauk, S., and Sulaiman, O. (2011). "Effect of particle size on the characterization of binderless particleboard made from Rhizophora spp. mangrove wood for use as phantom material," BioResources 6(4), 4028-4044. DOI: 10.15376/biores.6.4.4028-4044
- Miki, T., Takakura, N., IIzuka, T., Yamaguchi, K., and Kanayama, K. (2003). "Possibility of extrusion of wood powders," JSME International Journal Series A 46(3), 371-377. DOI: 10.1299/jsmea.46.371
- Mobarak, F., Fahmy, Y., and Augustin, H. (1982). "Binderless lignocellulose composite from bagasse and mechanism of self-bonding," Holzforschung 36(3), 131-135. DOI: 10.1515/hfsg.1982.36.3.131
- Mohanty, A. K., Misra, M., Drzal, L. T., Selke, S. E., Harte, B. R., and Hinrichsen, G. (2005). "Natural fibers, biopolymers and biocomposites: An introduction," in: Natural Fibres, Biopolymers and Biocomposites, A. K. Mohanty, M. Misra, and L. T. Drzal (eds.), Taylor & Francis, Boca Raton, FL. DOI: 10.1201/9780203508206.ch1
- Mohanty, A. K., Misra, M., and Hinrichsen, G. (2000). "Biofibres, biodegradable polymers and biocomposites: An overview," Macromolecular Materials and Engineering 276(1), 1-24. DOI: 10.1002/(SICI)1439-2054(20000301)276:1<1::AIDMAME1> 3.0.CO;2-W
- Munawar, S. S., Umemura, K., and Kawai, S. (2007). "Characterization of the morphological, physical and mechanical properties of seven non-wood plant fibre bundles," Journal of Wood Science 53(2), 108-113. DOI: 10.1007/s10086-006-0836-x
- Okamoto, H., Sano, S., Kawai, S., Okamoto, T., and Sasaki, H. (1994). "Production of dimensionally stable medium density fiberboard by use of high-pressure steam pressing," Mokuzai Gakkaishi 40(4), 380-389.
- Okuda, N., and Sato, M. (2004). "Manufacture and mechanical properties of binderless boards from kenaf core," Journal of Wood Science 50(1), 53-61. DOI:10.1007/s10086-003-0528-8
- Okuda, N., and Sato, M. (2006). "Water resistance properties of kenaf core binderless boards," Journal of Wood Science 52(5), 422-428. DOI: 10.1007/s10086-005-0785-9
- Okuda, N., Hori, K., and Sato, M. (2006a). "Chemical changes of kenaf core binderless boards (I): Influence of the pressing temperature condition," Journal of Wood Science 52(3), 244-248. DOI: 10.1007/s10086-005-0761-4
- Okuda, N., Hori, K., and Sato, M. (2006b). "Chemical changes of kenaf core binderless boards during hot pressing (II): Effects on binderless boards properties," Journal of Wood Science 52(3), 249-254. DOI: 10.1007/s10086-005-0744-5
- Panyakaew, S., and Fotios, S. (2011). "New thermal insulation boards made from coconut husk and bagasse," Energy and Buildings 43(7), 1732-1739. DOI: 10.1016/j.enbuild.2011.03.015

- Pelaez-Samaniego, M. R., Yadama, V., Lowell, E., Espinoza-Herrera, R. (2013). "A review of wood thermal pretreatments to improve wood composite properties," Wood Science and Technology 47, 285-1319. DOI 10.1007/s00226-013-0577-0
- Quintana, G., Velasquez, J., Betancourt, S., and Ganan, P. (2009). "Binderless fibreboard from steam exploded banana bunch," Industrial Crops and Products 29(1), 60-66. DOI: 10.1016/j.indcrop.2008.04.007
- Rowell, R. M., Han, J. S., and Rowell, J. S. (2000). "Characterization and factors effecting fibers properties," in: Natural Polymers and Agrofibers Composites, Preparation, Properties and Applications, F. Elisabete, L. L. Alcides, and H. C. Mattoso (eds.), Emrapa Instrumentacao Agropecuaria, Brazil, pp. 115-134.
- Rowell, R. M. (ed.) (2012). Handbook of Wood Chemistry and Wood Composites, CRC press. ISBN: 9781439853801.
- Saadaoui, N., Rouilly, A., Fares, K., and Rigal, L. (2013). "Characterization of date palm lignocellulosic by-products and self-bonded composite materials obtained thereof," Materials and Design 50, 302-308. DOI: 10.1016/j.matdes.2013.03.011
- Shen, K. C. (1991). "Method of making composite products from lignocellulosic materials," United States Patent # 5017319.
- Sreekumar, P. A. (2008). "Matrices for natural fibre reinforced composites," in: Properties and Performance of Natural-Fibre Composite, K. L. Pockering (ed.), Woodhead Publication Limited, Birmingham, UK, pp. 67-126.
- Suchsland, O., Woodson, G. E., and McMillin, C. W. (1987). "Effect of cooking conditions on fibre bonding in dry-formed binderless hardboard," Forest Journal Products 11(12), 65-69.
- Suzuki, S., Shintani, H., Oark, S. Y., Saito, K., Laemsak, N., Okuma, M., and Iiyama, K. (1998). "Preparation of binderless boards from steam exploded pulps of oil palm (Elaeis guineensis Jaxq.) fronds and structural characteristics of lignin and wall polysaccharides in steam exploded pulps to be discussed for self-bindings," Holzforschung 52(4), 417-426. DOI: 10.1515/hfsg.1998.52.4.417
- van Dam, J. E. G. (2002). "Wet processing of coir – drying, bleaching, dyeing, softening and printing," CFC/FAO Techno-economic Manual, No. 6.
- van Dam, J. E. G., van der Oever, M. J. A., Teunissen, W., Keijsers, E. R. P., and Peralta, A.G. (2004b). "Process of production of high density/high performance binderless boards from whole coconut husk. Part 1: Lignin as intrinsic thermosetting binder resin," Industrial Crops and Products 19(3), 207-216. DOI: 10.1016/j.indcrop.2003.10.003
- van Dam, J. E. G., van der Oever, M. J. A., and Keijsers, E. R. P. (2004a). "Production process from high density high performance binderless boards from whole coconut husk," Industrial Crops and Products. 20(1), 97-101. DOI: 10.1016/j.indcrop.2003.12.017
- Velasquez, J. A., Ferrando, F., and Salvado, J. (2002). "Binderless fibreboard from steam exploded Miscanthus sinensis: The effect of a grinding process," Holz als Roh-und Werkstoff 60(4), 297-302. DOI: 10.1007/s00107-002-0304-2
- Velasquez, J. A., Ferrando, F., and Salvado, J. (2003a). "Effects of kraft lignin addition in the production of binderless fibreboard from steam exploded Miscanthus sinensis," Industrial Crops and Products 18(1), 17-23. DOI: 10.1016/S0926-6690(03)00016-5
- Velasquez, J. A., Ferrando, F., and Salvado, J. (2003b). "Binderless fibreboard from steam exploded Miscanthus sinensis: Optimization of pressing and pre-treatment conditions," Wood Science Technology 37(3), 279-286. DOI: 10.1007/s00226-003-0186-4

- Voulgaridis, E., Passialis, C., and Grigoriou, A. (2000). “Anatomical characteristics and properties of kenaf stem (Hibiscus cannibus),” IAWA Journal 21(4), 435-442. DOI: 10.1163/22941932-90000259
- Widyorini, R., Xu, J., Umemura, K., and Kawai, S. (2005b). “Manufacture and properties of binderless particleboard from bagasse. I: Effects of raw material type, storage methods, and manufacturing process,” Journal of Wood Science 51(6), 648-654. DOI: 10.1007/s10086-005-0713-z
- Widyorini, R., Xu, J., Watanabe, T., and Kawai, S. (2005a). “Chemical changes in steampressed kenaf core binderless particleboard,” Journal of Wood Science 51(1), 26-32. DOI: 10.1007/s10086-003-0608-9
- Xie, L., Liu, J., and Du, A. (2012). “Effect of hot-pressing factors on binderless fibreboard properties,” in: 2012 International Conference on Biobase Material Science and Engineering (BMSE), pp. 8-11. DOI: 10.1109/BMSE.2012.6466168
- Xu, J., Sugawara, R., Widroyini, R., Han, G., and Kawai, S. (2004). “Manufacture and properties of low-density binderless particleboard from kenaf core,” Journal of Wood Science 50, 62-67. DOI: 10.1007/s10086-003-0522-1
- Xu, J., Widyorini, R., and Yamauchi, H. (2006). “Development of binderless fibreboard from kenaf core,” Journal of Wood Science 52(3), 236-243. DOI: 10.1007/s10086-005-0770-3
- Zhou, X., Zheng, F., Li, H., and Lu, C. (2010). “An environment-friendly thermal insulation material from cotton stalk fibres,” Energy and Buildings 42(7), 1070-1074. DOI: 10.1016/j.enbuild.2010.01.020
- Zuluaga, R., Putaux, J-L., Restrepo, A., Mondragon, I., and Gañán, P. (2007). “Cellulose microfibrils from banana farming residues: Isolation and characterization,” Cellulose 14(6), 585–592. DOI: 10.1007/s10570-007-9118-z

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Solenis' Total Mill Perspective Helps Mills Stay Competitive

When Ashland Water Technologies needed a new name after the company was sold in August 2014, it didn't have to look far for inspiration. Drawing on its rich heritage of delivering excellent customer service and solving complex problems, it found an appropriate name in Solenis, which combines the words solution and genesis and reinforces the company's mission to be the source of solutions for its customers.

Nowhere is this mission more clearly demonstrated than in the pulp and paper industry. Over the years, Solenis and its legacy companies (Betz Laboratories, Drew, Stockhausen, Hercules and Ashland Water Technologies) have built a reputation on delivering a full range of functional, process and water treatment chemistries to paper mills all over the world.

"We've been in business for nearly a hundred years, and we've always provided solutions to myriad challenges that paper and pulp companies face, whether functional, process or water. We've even led the way in anticipating challenges and innovating ahead of the curve," says Ludwig Krapsch, Vice President, Pulp and Paper EMEA at Solenis.

According to Krapsch, taking a "total mill perspective" enables Solenis to deliver unparalleled results to its customers. "We have the technology, the people and the science to be the water resource for our clients," he says. "We don't just solve problems as they come up — we help mills proactively address challenges by delivering comprehensive and integrated solutions that improve operational efficiency and product quality."

Every Drop of Water, Every Step of the Way

Solenis' water-treatment solutions start at the influent water system and carry through to the waste-treatment area, supporting every aspect of a mill's operations and enhancing its reliability, efficiency and profitability. The company's line-up of water treatment products for the pulp and paper industry is both state of the art and comprehensive.

"We're thinking about how water can be used to maximise production and minimise costs from when the first drop of water enters the facility. We follow it through until the last drop leaves as wastewater making sure as much as possible has been reused and has the lowest environmental impact" says Malcolm Turvey, Market Manager EMEA. "At every step, we're doing whatever it takes to ensure that your water is being fully utilised as an essential integrated element of your system."

For influent water, for example, Solenis has developed a wide portfolio of coagulants and flocculants for water clarity, and a range of processes and chemistries that address water temperature, pH, alkalinity, turbidity and colour. The company also specialises in corrosion protection and microbiological control chemicals for cooling water and boiler systems, including recovery boilers. And for effluent water, Solenis offers an extensive array of bio-augmentation technologies, antifoams, odour control chemicals, and dilution and feeding systems to help mills remove pollutants, minimise sludge handling and disposal costs, recycle effluent or improve wastewater quality.

When they integrate these products with Solenis' complete family of OnGuard™ monitoring and control equipment, mills can prevent water treatment problems altogether or make rapid course adjustments to minimise their impact. Either way, Solenis' end-to-end approach helps mills protect their assets, their products and their profits.

Solenis Chemistries

- Anti-scalants
- Corrosion inhibitors
- Coagulants
- Flocculants
- Defoamers
- Bio-augmentation
- Odour control
- Microbiological control

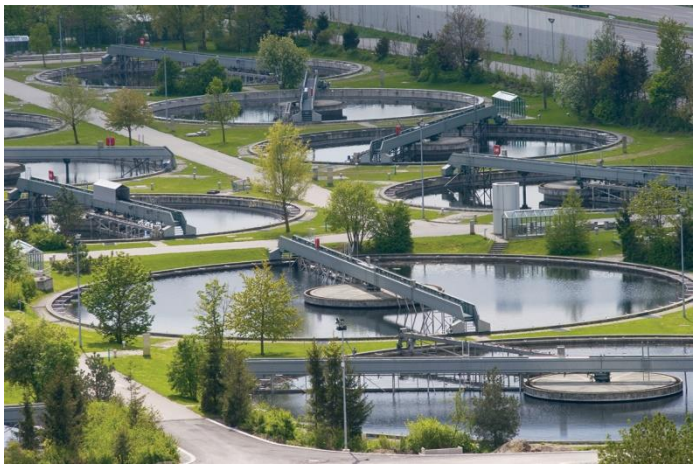
The Best Products, Backed by the Best People

A Solenis solution goes far beyond a portfolio of chemicals and process and control equipment. “We’re proud of the innovative technologies and chemistries we’ve created,” Turvey says, “but it’s our pulp and paper specialists who make us such a valuable resource for our clients. They’re the true foundation of what we do.”

It starts with a far-reaching network of field specialists, who work at sites all over the world and who serve as ambassadors of Solenis’ total mill approach. They visit their clients’ mills whenever called upon and work closely with personnel to understand the mill’s needs, conduct investigative diagnostics, and brainstorm comprehensive solutions that are specifically tailored to the mill’s particular challenges (and advantages).

Often, these field specialists are able to create and implement fully effective solutions before leaving the mill. Sometimes, though, there’s a particularly difficult challenge that requires even more highly focused expertise, whether to diagnose an elusive problem or engineer a new and customised solution. That’s when the field specialists call for backup, tapping Solenis’ elite pulp and paper applications experts. The field specialist may call on a number of applications experts with the refined expertise necessary to solve any problem a mill might face. And all of these hands-on problem-solvers work downstream from Solenis’ R&D scientists, who are hard at work developing the next generation of innovative technologies for the pulp and paper industry.

Armed with this total mill perspective, Solenis now strives to be more than solely a purveyor of chemicals or a provider of technological systems — or even an on-call consultant.



“We’re a partner to our clients,” Turvey concludes. “It’s our job to know each water system in every detail, and make use of every opportunity to boost the mill’s operational efficiency, improve the quality of their products, and help them protect their plant assets and minimise their environmental impact.”

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Energy Management: Lowering energy prices by managing supply and demand

ABB

(Presented at DITP 2015)

The ABB Energy Management helps customers in all industries monitor, manage and optimise their energy usage for maximum efficiency and cost savings. It addresses the business side of energy management by producing accurate energy demand plans and taking advantage of them in energy supply planning and optimisation. Being able to accurately plan the energy requirements a day-ahead provides significant financial advantages, especially in the open electricity market, and ultimately lowers energy costs.

Energy Manager also includes reporting and analysis tools that evaluate the energy use patterns of all processes and pinpoint areas for improvement.

A key element in any company's energy management program, Energy Manager offers dramatic cost savings for customers in all industries, especially for processes that are particularly energy intensive. Opportunities for cost reduction are greatest when both electricity consumption and prices vary over time, which is common in the process industries and in the open electricity market environment. Energy Manager clearly indicates the cost of electricity and provides support to schedule electricity consumption for off-peak hours. It coordinates electricity purchases and sales with its own generation capacity, then schedules this generation during on peak hours, when purchased electricity is most expensive, to provide additional cost savings.

ABB Energy Manager has been assessed by UL DQS for ISO 50001:2011 conformity. ISO 50001:2011 is an International Standard for Energy Management Systems and can reliably present the results of the software's proper use to support their conformity with elements 4.4 and 4.61 of the ISO 50001:2011 standard. Organisations that choose to seek certification to management system standards other than the ISO 50001 standard may also use this software along with continual improvement processes similar to Plan, Do, Check, and Act to demonstrate Best Practices."

Typically, the ABB Energy Manager can help customers achieve overall cost reductions of 2 to 5 per cent of their total electricity cost. For some process manufacturers, this can translate into millions of dollars saved annually.

Energy Manager is completely scalable; this modular solution can start with basic energy monitoring and reporting at a single facility, and later expand to include multiple sites, or be implemented throughout the entire company to optimise energy use and manage energy supply costs. A key component of this strategy is to tie in to sources of energy consumption, many of which are already captured in a plant level historian, others which require an OPC connection.

Energy Manager includes planning and scheduling tools to optimise energy use and supply, energy balance management tools to support the real-time monitoring and control of the energy balance, and reporting tools to evaluate and report energy consumption, costs, efficiency and other energy-related information.

Key features include:

- Manage electricity purchase and sales transactions, monitor and control peak-loads, energy balance and efficiency
- Identify energy requirements using sophisticated planning tools for planning electricity and steam demand and planning energy use
- Meet energy needs at minimum cost with resource optimisation and production scheduling

- Support electricity sales and purchase in the open market, including timing and pricing transactions
- Avoid peak tariffs through load planning, tie line monitoring and load shedding
- Enhance awareness of energy generation, use and purchases for improved cost effectiveness
- Support decision making with simulation and “what-if” analysis capabilities

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Salvtech UK – Company Profile

Salvtech is a specialist process engineering and waste plastic recycling company located in North Wales. They supply a diverse range of services and branded products to the Pulp & Paper, Waste Management & Recycling industries and now the Automotive industry.

Martin Christmas
General Manager
Salvtech Ltd
Unit 12 Engineer Park
Babbage Road
Sandycroft
Flintshire
CH5 2QD

Office Phone: 01244 638900
Mobile: 07789 583602

www.salvtech.com

Salvtech is owned by a family with two generations of experience in the Paper Industry. Peter Christmas worked for St. Regis and M-Real in production roles and his son Martin, worked for the major OEMs in service, project management and sales. As a company therefore we understand the challenges of a 24/7 operation and the financial pressures the mills face. Our aim is to make it easy for mills to get their hands on new process equipment and spare parts to operate their processes efficiently. We are proud to represent some of the best equipment suppliers in the industry as well as offering our own branded, high quality, screen baskets and rechromes. Combining our experience and the supplier's products and knowledge means that we can help our customers save energy and costs through process improvements.

SALVTECH LTD - Exclusive UK supplier for:

Paper and Tissue Machine System Solutions

As a worldwide supplier to the paper and pulp industry and the worldwide partner for paper machine optimisation, IBS specialise in a wide range of system solutions for this industry as well as many others.

Dewatering elements	Doctors & Showers
Fabric guides and tensioners	Special Products
Technological services	Engineered consumables

Stock Preparation Equipment

Cellwood Machinery have over 100 years' experience manufacturing high quality equipment, specialising in stock preparation machinery to give you the highest quality pulp at the lower cost per tonne. They own the brand names Grubbens, Krima and Algas.

Pulpers	Pumps
Reject separators	High density cleaners
Deflakers	Refiner
Screw dewaterer	Screw press
Dispersing system	Fibre recovery

Materials Handling

SICMA provides a complete system package for the handling of all raw materials through to the finished product. SICMA is able to build and supply the machines for the following systems:

Pulper feeding systems	Roll handling systems
Jumbo rolls storage	Wire Winder
Roll wrapper machinery	Jumbo rolls handling systems
Pallet Handling	Roll splitting lines
Pulper reject presses	

Clean Air Solutions

Rotamill is the specialist for clean air and one of the world's leading providers of exhaust gas purification systems, as well as industrial fans. Economic and resource efficient factors are important in all building and service performances of Rotamill.

Industrial radial fans	Exhaust gas purification systems
Recuperators	Waste heat boilers

Cutters and Cutting Accessories

The Gavo Meccanica company has been working in the industrial field for about 30 years, designing and building high quality machines, systems and industrial cutters.

Core cutters	Deburring systems
Trimming stations	

Polyurethane Products

Uretec manufactures bespoke polyurethane products in applications which require high chemical corrosion resistance and are subject to too high wear.

Cleaner cones	Slide bearings
Dewatering elements	Drum screen wheels

Paper Carrier Ropes

Standard and speciality ropes to suit each paper position, such as dryers and coaters. Lanex ropes boast durability, with high abrasion and temperature resistance.

Screen Baskets & Rechromes

The Salvtech MAXIscreen™ screen baskets are made to replace your existing OEM baskets. Remove the hassle and reduce the costs of managing your screen baskets by switching to Salvtech's MAXIscreen™. The MAXIscreen™ has a high slot accuracy and excellent wear properties, with multiple recoats possible. A skilled engineer is available to inspect your existing screen baskets.

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 2, Number 1, 2016

Paper Industry Technical Association

5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Improved Performance with INDUSTRIAL INTERNET – already today

From Valmet's FORWARD customer magazine, edition 1/2016

http://www.valmet.com/Valmet/products/Vault2MP.nsf/BYWID/WID-160314-2256E-CB73A/$File/valmet_forward_1-16_eng_spreads.pdf?OpenElement

Improved performance with INDUSTRIAL INTERNET – already today

Industrial Internet is a topic that is widely discussed today as something that will come in the future. However, Valmet has already today a strong infrastructure and technical expertise to serve its customers on a daily basis with the help of Industrial Internet.

For Valmet, Industrial Internet means the ability to capture and share data and information from the pulp, paper and energy production machines and processes, and to utilize it for the benefit of our customers.

Together with our customers we move their performance forward by utilizing the data to adjust operations and to plan preventive maintenance. We have already implemented hundreds of solutions utilizing our Industrial Internet capabilities.

"As an example, we have today over 400 online connections with over 70,000 I/O tags monitored. We have been offering advanced remote analysis services to our customers for a long time," confirms **Johan Pensar**, Director of Digital Services and Analytics at Valmet.

The future is already there.

Long history in the digitalization of process industries

Valmet's background in Industrial Internet lies in 1960's when the first automation solutions came to the market. In 1980's, Valmet launched the first distributed controls and monitoring systems, and in the 1990's was already able to embed intelligence and advanced information into the production processes.

"In early 2000, we started to provide our customers with 24/7 remote services for troubleshooting and for preventive maintenance. Already since 2010 our customers have been able to utilize our information services and remote analysis to increase their productivity, end product quality and raw material efficiency," Pensar says.

Customers are extensively utilizing Valmet's Industrial Internet capabilities.

Today, our customers can enjoy solutions that enable them to improve their performance by utilizing benchmark data and best practices regarding, for example, energy consumption optimization, fleet analytics and next generation process applications.

Industrial Internet impacts all stages of the production process and brings clear benefits. It enables a more efficient supply chain, enhances asset management and makes both the process and operations more effective.

"Industrial Internet for Valmet means the ability to capture and share data and information from machines and processes, and to utilize it to adjust operations and plan predictive maintenance for the benefit of the customers."

Clear roadmap in Industrial Internet

Today, enabled by advanced communication technology and big data analysis, Industrial Internet is already moving to the next level– outside the production facilities. We believe that in the future we will see networks of different systems impacting each other, connecting different value chains, and thus changing the whole society we live in, in ways that we can hardly envision today.

Valmet has a clear roadmap forward in Industrial Internet and intends to be a frontrunner in this field also in the future. The unique combination of intelligent process technologies, services and automation is a strong platform for further development projects that are currently ongoing.

In the coming few years, more advanced automation technologies and more diagnostics will be embedded into customers' processes, keeping information security a high priority at the same time. Furthermore, mobile and remote services will be developed to the next level, ensuring the customers a fully mobile access to all information anytime and anywhere.

Valmet wants to be a game changer in utilizing Industrial Internet, bringing new opportunities to its customers. ■

CONTACT PERSON
Johan Pensar
Director, Digital Services and Analytics
johan.pensar@valmet.com
Tel. +358 50 463 1268

Serving our customers with Industrial Internet

Possibility to use more biomass fuels

Kuopion Energia Oy produces district heat for the residents of the city of Kuopio in Finland, thus the production reliability is in high priority. They have had Valmet's FuelDiet KCL corrosion control system in use since 2013 at their Haapaniemi 3 power plant. The FuelDiet solution enables to use more biomass fuel without increasing the risk of superheater corrosion.

Jaani Silvennoinen, Valmet's Product Manager for FuelDiet explains: "With the performance agreement and remote connection, we can give stability to the customer's energy production process. As a result, they can now use 100% biomass and get real time measurement of the sulfur/chlorine ratio and hence react immediately if the ratio goes too low. Automatic control helps and guides the operator to run the power plant optimally and they have been able to increase the boiler's maximum load."

Virtual connection, remote diagnosis add to Burgo mill results

A Valmet bleach plant optimization project at Burgo's Ardennes kraft pulp mill in Belgium achieved the customer's expectations and a good ROI. However, this was not the end of the task to maintain and improve the results. The control performance has actually improved under the watchful, remote surveillance of Valmet engineers. As an example, Valmet staff has diagnosed and corrected a temperature regulation problem. Valmet's solution reduced the chemical consumption.

Through daily and monthly reporting and proactive follow-up, control solutions continue over the long term. A Performance Service Agreement includes remote system and process monitoring though a data link to Valmet which includes refined key process indicators (KPIs) and performance triggers. As a result, the Burgo process is virtually 24/7 in Valmet offices where the process performance is analyzed and diagnosed and recommendations can be made about how to correct a problem and improve the results of the controls. The bleaching process performance is monitored stage by stage and regular control performance reports are provided to the customer.

Eric Bazzoni, fiber line production manager, finds this a useful tool as it gives a concise report on key control objectives and uncovers any problems. **Pierre Carnevali**, projects manager, adds: "The reports tell us if we are in a good control range or not, and if we are consuming the right amount of chemicals."

Industrial internet supports process improvement at CMPC Guaíba

In 2013, when Valmet and CMPC signed a contract to supply the main technology to Line 2 at CMPC's Guaíba Mill in Brazil, the delivery included a major part of automation systems for the plant operations, such as Distributed control systems (DCS), Operation training simulator (OTS) and Advanced process control (APC).

Embedded in this supply, Valmet delivery also included the possibility to remote access to operation data, allowing process improvement and system check-outs even when Valmet crew are not physically at the mill.

"The remote access to the DCS and mill data has always to be agreed with the client, due to security reasons, but it has shown to be a powerful tool to support customer operations whenever upset conditions take place. It allows us to provide fast support even during the night or when the problem can't wait for a process engineer to travel to the site. It allows us also to analyze historical data to better understand the changes in process conditions along the time and find ways to further improve the plant", says **Dimas Rodrigues**, Valmet's process manager.

Technical assistant Rafael Santos (on the right) and process service engineer Filipe Centenaro of Valmet viewing the operation data together with CMPC's machine crew.

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Green Marketing; Initiatives for green marketing; Need of green marketing; Importance of green marketing

This article gives an overview of green marketing as a concept, and highlights some initiatives undertaken by various companies in India. Given the sustainable nature of our main raw material, the Paper Industry is ideally situated to use Green Marketing concepts.

Neeraj Kumar Sharma*

Baba Ramdas Udaseen Shikshan Sansthan, Hapur, Uttar Pradesh, India

Tel: 0091-9756966938
E-mail: brdudc@gmail.com

Citation: Neeraj Kumar S (2015) Industry Initiatives for Green Marketing in India. Bus Eco J 7:192.
doi: 10.4172/2151-6219.1000192

Introduction

According to the American Marketing Association, green marketing is the marketing of products that are presumed to be environmentally safe. Thus green marketing incorporates a broad range of activities, including product modification, changes to the production process, change in packaging, as well as modifying advertising [1]. Yet defining green marketing is not a simple task where several meanings intersect and contradict each other; an example of this will be the existence of varying social, environmental and retail definitions attached to this term [2]. Other similar terms used are Environmental Marketing and Ecological Marketing.

Evolution of green marketing

The first wave of Green Marketing came into the picture in the 1980s. Corporate Social Responsibility (CSR) Reports started with the ice cream seller Ben and Jerry's where the financial report was supplemented by a greater view on the company's environmental impact.

In 1987 a document prepared by the World Commission on Environment and Development defined sustainable development as meeting "the needs of the present without compromising the ability of future generations to meet their own need"; this became known as the *Brundtland Report* and was another step towards widespread thinking on sustainability in everyday activity [3].

Two tangible milestones for the wave of green marketing came in the form of published books, both of which were called Green Marketing. They were by Kinnear [4] in the United Kingdom and by Jacquelyn Ottman [5] in the United States of America.

In the years after 2000 a second wave of Green marketing emerged. By now CSR and the Triple Bottom Line (TBL) were widespread. Such publications as a 2005 United Nations Report, then in 2006 a book by Al Gore and the UK Stern Report brought scientific-environmental arguments to a wide public in an easy to understand way.

Objective

The objective of this paper is to examine the need, importance and problems of green marketing and also to evaluate the initiatives taken by Indian companies for green marketing in their core business values.

Importance of green marketing

Companies that develop new and improved products, and services with environmental inputs in mind give themselves access to new markets, increase their profit sustainability and enjoy a competitive advantage over the companies that are not concerned for the environment [6].

Some of the advantages of green marketing are as follows

1. It ensures sustained long-term growth along with profitability.
2. It saves money in the long run, although initial cost is more.
3. It helps the companies to market their products and services keeping the environment aspects in mind. It helps in accessing new markets and enjoying a competitive advantage.
4. Most of the employees also feel proud and responsible to be working for an environmentally responsible company.
5. It promotes corporate social responsibility.

Reasons for Adopting Green Marketing

1. Opportunities available and competitive advantage.
2. Corporate social responsibility on the part of companies.
3. Government regulations.
4. Competition with other responsible companies.
5. Goodwill of the company.
6. Environmentally conscious consumers.
7. For conserving scarce natural resources.

Green Marketing Mix

Every company has its own favourite marketing mix. Some have 4 P's and some have 7 P's of marketing mix. The 4 P's of green marketing are that of a conventional marketing but the challenge before marketers is to use 4 P's in an innovative manner [7]:

Product

The ecological objectives in planning products are to reduce resource consumption and pollution and to increase conservation of scarce resources [8].

Price

Price is a critical and important factor of green marketing mix. Most consumers will only be prepared to pay additional value if there is a perception of extra product value. This value may be improved performance, function, design, visual appeal, or taste. Green marketing should take all these facts into consideration while charging a premium price.

Promotion

There are three types of green advertising:

a. Ads that address a relationship between a product/service and the biophysical environment
b. Those that promote a green lifestyle by highlighting a product or service
c. Ads that present a corporate image of environmental responsibility

Place

The choice of where and when to make a product available will have significant impact on the customers. Very few customers will go out of their way to buy green products.

Challenges of Green Marketing Ahead - Problems of green marketing

Many organisations want to turn to green, as an increasing number of consumers want to associate themselves with environmentally friendly products. Alongside, one also witnesses confusion among the consumers regarding the products. In particular, one often finds distrust regarding the credibility of green products. Therefore, to ensure consumer confidence, marketers of green products need to be much more transparent, and refrain from breaching any law or standards relating to products or business practices [9-12].

Examples of green marketing in Indian companies

Wipro and Infosys: Wipro and Infosys's are going green. Wipro launched desktops, laptops are known as Wipro green wares. It was the first company in India who developed eco-sustainability in the form of energy, water efficiency and waste management. Wipro are actively seeking to become a very green company. Wipro has taken various initiatives

to be green and the main objective of this is to become a carbon natural, water positive and energy saving in business organisation. Wipro designs products and solutions that can minimise hazardous waste [13]. For the purpose of enhancing ecological sustainability, Wipro is continuously offering green products.

Wipro has adopted a number of steps for ecological-sustainability at its corporate level also. Wipro wants to become fully carbon natural and to achieve zero carbon emission by balancing the carbon released by the firm with equalling quantity offset. Wipro and Infosys reduced its *per capita* consumption of electricity and procured renewable energy. In future, every new building on campus will follow integrated design methods for the purpose of maximising daylight and reducing heat [14]. It will construct energy efficient buildings, at present also, in Wipro 18 building are certified to the international green standard. It replaced older office equipment with new energy saving equipment. Wipro and Infosys also installed solar panels in their campus. We know that solar power is 70% cheaper than power generated by diesel. Solar energy has no adverse impact on our surrounding also. Products manufactured by these firms are less harmful to the environment.

Tata Metaliks Limited: This deals in the mining and metal sector. It has given a green view to reduce its carbon footprint. The objective of Tata Metaliks Limited is to increase the green cover through plantation, ground water, power generation and use of natural fertilisers etc. The major green initiative of this company is related to water utilisation. It depends entirely on groundwater and no municipal supply and it will perform completely water neutral operations [15].

Suzlon Energy: Suzlon energy is also going green. Suzlon is the world's fourth largest wind power company and is among the greenest and best companies in India. It is a renewable company, manufacturer and producer of wind Turbines; now Suzlon produces 30% of the renewable energy in India. It meets the need of present without compromising the capacity of future generations to meet their needs. Its total revenue was $4.18 billion in 2011 [16].

Electronics sector: The consumer electronics sector provides room for using green marketing to attract new customers. One example of this is HP's promise to cut its global energy use 20% by the year 2010. To accomplish this reduction below 2005 levels, The Hewlett-Packard Company announced plans to deliver energy-efficient products and services and institute energy-efficient operating practices in its facilities worldwide [17].

Introduction of CNG in Delhi: New Delhi, capital of India, was being polluted at a very fast pace until Supreme Court of India forced a change to alternative fuels. In 2002, a directive was issued to completely adopt CNG in all public transport systems to curb pollution [18].

Maruti Udyog Ltd: Greening of Supply Chain: The company has remained ahead of regulatory requirements in pursuit of environmental protection and energy conservation at its manufacturing facilities, and in development of products that use fewer natural resources and are environment friendly [19].

The company credited the 'Just-in-Time' philosophy adopted and internalised by the employees as the prime reason that helped to excel in this direction. The company has been promoting 3R since its inception. As a result the company has not only been able to recycle 100% of treated waste water but also reduced fresh water consumption. The

company has implemented rain water harvesting to recharge the aquifers. Also, recyclable packing for bought out components is being actively promoted.

The company has been facilitating implementation of Environment Management System (EMS) at its suppliers' end. Regular training programs are conducted for all the suppliers on EMS. Surveys are conducted to assess the vendors who need more guidance. The systems and the environmental performance of suppliers are audited. The green co-efficient of this system is much better than the conventional system.

Important rules of green marketing

Marketers should grow their green marketing plan. How they can create new opportunities for selling their products and face threats of competitors in the market. The marketing firm should know its strong and weak points also. Make plans how the firm can make its customers' lives better and how it can differentiate its offering from competitors. The firm should provide assurance to customers that they are safe and the environment should be kept in mind in all aspects from production to supply of products [20,21].

The firms should do the right thing and reassure customers that they are doing the right things: they are making a good quality of product and service by hard working and caring. Firms should consider people, profit and planet while taking marketing decisions if a firm wants to supply a green product to customers. First of all it needs to decide that the consumer is aware about the issues the product attempts to address. The product should have some value added benefits. The firms should make sure that customers feel delight when they use the particular product and it is different from other alternative products existing in the market. Firms should consider pricing policies also, if they are charging more than competitors. Then make sure that product cost is more due to use of higher quality ingredients and economies of scale. Always continue efforts to improve over existing products and adopt new types of Eco-products to do a great job of winning the trust of consumers; it means that the producer should not only concentrate on functional benefits but they should also think what they are making. Their products and services are green or not; if not then how they can make products green and whom they are working with. To capture advantages and opportunities that green marketing represents to engage customers on an emotional level.

Conclusion

Green marketing should not neglect the economic aspect of marketing. Marketers need to understand the implications of green marketing. If we think customers are not concerned about environmental issues or will not pay a premium for products that are more eco-responsible, think again. We must find an opportunity to enhance our product's performance and strengthen our customer's loyalty and command a higher price.

Nowadays, green marketing has become necessary to save the world from environmental pollution. From the marketing point of view, a good marketer will not only satisfy the consumer needs but also produce and supply products according to the choice of the consumers. But the business firm should know the benefits of selling green products [22]. Consumers are also ready to pay more to maintain a greener and cleaner surroundings. Consumers are also aware about initiatives taken by corporations about the attributes and use of products; that's why they demand green products. Making green products has to be achieved throughout the complete supply chain. The firms should work constantly to find the green material and methods of making green finished products which are commercially viable.

Suggested Solution

a. Environmentally responsible organisations should attempt to minimise their waste
b. Organisation policy
c. Employee Awareness Program
d. Effective and Transparent Communication
e. Constantly Refine the Product and Processes

Green marketing is still in its infancy and a lot of research is still to be done on green marketing to fully explore its potential. Think of a refrigerator for example. While we may have had to be convinced in the 1950s to buy a refrigerator, we would have wanted the great white box to look cool in the 1970s, but in today's uncertain world we might ask ourselves about the impact of the chlorofluorocarbons (CFCs) that our refrigerator is emitting and demand a more environmentally friendly refrigerator. So, if today's successful marketing is about appealing to personal values and delivering consumer empowerment, then surely the time is right to inject sustainable development into the marketing mix to help address some of the gritty issues currently facing our planet. Green marketing methods produce highly effective results. They apply all of the steps you need to cut costs, raise response rates and increase growth so that in the most important marketing metric we are all held accountable for-the bottom line.

References

1. Fernandez RD, Bhandarkar SM (2004) *Green Marketing: An Indian Perspective*.
2. Mathur LK, Mathurl (2000) An Analysis of the wealth effect of green marketing strategies. *Journal of Business Research* 50: 193-200.
3. Kilbourne WE (1998) Green Marketing A Theoretical Perspective. *Journal of Marketing Management* 14: 641-655.
4. Kinnear TC, Taylor JR (1973) The Effect of Ecological Concern On Brand Perception. *Journal of Marketing Research* 10: 191-197.
5. Ottman JA, Stafford ER, Hariman CL (2006) Avoiding Green Marketing Myopia: Ways to Improve Consumer Appeal for Environmentally Preferable Products. *Environment Science and Policy for Sustainable Development* 48: 22-36.
6. Chitra K (2007) In search of the Green Consumers: A perceptual study. *Journal of Services Research* 7: 173-191.
7. Zimmer MR, Stafford TF, Stafford MR (1994) Green Issues dimensions of environmental concern. *Journal of Business Research* 30: 63-74.
8. Kotler P (2000) *Marketing Management - The Millennium Edition* Prentice Hall of India Private Limited, New Delhi.
9. Ginsberg JM, Bloom PN (2004) Choosing the Right Green Marketing Strategy. *MIT Sloan Management Journal*.
10. Welling, Anupam CS (2010) Analyzing the Feasibility of Green Marketing in SME? Asia-Pacific *Journal of Research in Business Management*.
11. Joshi NM, Chitale AK (2009) An Investigation Of Customers Awareness With Reference To Green Marketing Of Automobiles. *Indian Journal of Marketing*.
12. Gurmeet Kaur (2006) Role of Socio-Demographics in segmenting and profiling green consumers: An exploratory study of consumers in India. *Journal of International Consumer Marketing* 18: 107-146.
13. www.wipro.com
14. www.greenenergy.wisein.org
15. www.livestrong.com
16. www.sulzon.com
17. www.economicstimes.indiatimes.com
18. Narendra, KP (2013) *Successful Adoption of CNG and Emerging CNG-H2 Program in India*.
19. www.greenpeace.org
20. www.greenmarketing.com
21. (2010) *Green Marketing. Business Practices*.
22. Lakshmi CS (2007) *Turning Over a New Leaf. Indian Management*.

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 2, Number 1, 2016

Paper Industry Technical Association

5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Top Ten Communication Skills

Communication – both written and verbal – is fundamental to all forms of human interactions. This short piece gives ten proven ways to improve communication skills.

The ability to communicate effectively with superiors, colleagues, and staff is essential, no matter what industry you work in. Workers in the digital age must know how to effectively convey and receive messages in person as well as via phone, email and social media.

Here are the top 10 communication skills that will help you stand out in today's job market.

1. **Listening -** Being a good listener is one of the best ways to be a good communicator. No one likes communicating with someone who only cares about putting in her two cents, and does not take the time to listen to the other person. Instead, practice active listening. Active listening involves paying close attention to what the other person is saying, asking clarifying questions, and rephrasing what the person says to ensure understanding ("So, what you're saying is…"). Through active listening, you can better understand what the other person is trying to say, and can respond appropriately.

2. **Nonverbal Communication -** Your body language, eye contact, hand gestures, and tone all colour the message you are trying to convey. A relaxed, open stance (arms open, legs relaxed), and a friendly tone will make you appear approachable, and will encourage others to speak openly with you. Eye contact is also important; you want to look the person in the eye to demonstrate that you are focused on the person and the conversation (however, be sure not to stare at the person, which can make him or her uncomfortable).

   Also pay attention to other people's nonverbal signals while you are talking. Often, nonverbal signals convey how a person is really feeling. For example, if the person is not looking you in the eye, he or she might be uncomfortable or hiding the truth.

3. **Clarity and Concision -** Try to convey your message in as few words as possible. Say what you want clearly and directly, whether you're speaking to someone in person, on the phone, or via email. If you ramble on, your listener will either tune you out or will be unsure of exactly what you want. Think about what you want to say before you say it; this will help you to avoid talking excessively and/or confusing your audience.

4. **Friendliness -** Through a friendly tone, a personal question, or simply a smile, you will encourage your coworkers to engage in open and honest communication with you. This is important in both face-to-face and written communication. When you can, personalise your emails to coworkers and/or employees - a quick "I hope you all had a good weekend" at the start of an email can personalise a message and make the recipient feel more appreciated.

5. **Confidence -** It is important to be confident in all of your interactions with others. Confidence ensures your coworkers that you believe in and will follow through with what you are saying. Exuding confidence can be as simple as making eye contact or using a firm but friendly tone (avoid making statements sound like questions). Of course, be careful not to sound arrogant or aggressive. Be sure you are always listening to and empathising with the other person.

6. **Empathy -** Even when you disagree with an employer, coworker, or employee, it is important for you to understand and respect their point of view. Using phrases as

simple as "I understand where you are coming from" demonstrate that you have been listening to the other person and respect their opinions.

7. **Open-Mindedness -** A good communicator should enter any conversation with a flexible, open mind. Be open to listening to and understanding the other person's point of view, rather than simply getting your message across. By being willing to enter into a dialogue, even with people with whom you disagree, you will be able to have more honest, productive conversations.

8. **Respect -** People will be more open to communicating with you if you convey respect for them and their ideas. Simple actions like using a person's name, making eye contact, and actively listening when a person speaks will make the person feel appreciated. On the phone, avoid distractions and stay focused on the conversation.

   Convey respect through email by taking the time to edit your message. If you send a sloppily written, confusing email, the recipient will think you do not respect her enough to think through your communication with her.

9. **Feedback -** Being able to appropriately give and receive feedback is an important communication skill. Managers and supervisors should continuously look for ways to provide employees with constructive feedback, be it through email, phone calls, or weekly status updates. Giving feedback involves giving praise as well - something as simple as saying "good job" to an employee can greatly increase motivation.

   Similarly, you should be able to accept, and even encourage, feedback from others. Listen to the feedback you are given, ask clarifying questions if you are unsure of the issue, and make efforts to implement the feedback.

10. **Picking the Right Medium -** An important communication skill is to simply know what form of communication to use. For example, some serious conversations (layoffs, changes in salary, etc.) are almost always best done in person. You should also think about the person with whom you wish to speak - if they are very busy people (such as your boss, perhaps), you might want to convey your message through email. People will appreciate your thoughtful means of communication, and will be more likely to respond positively to you.

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 2, Number 1, 2016

Paper Industry Technical Association

5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

How can you make a good presentation even more effective?

Ten top tips on how to improve presentation skills.

This article draws on published advice from expert presenters around the world, which will help to take your presentations from merely 'good' to 'great'. By bringing together advice from a wide range of people, the aim is to cover a whole range of areas. Whether you are an experienced presenter, or just starting out, there should be ideas here to help you to improve.

1. **Show your Passion and Connect with your Audience -** It's hard to be relaxed and be yourself when you're nervous. But time and again, the great presenters say that the most important thing is to connect with your audience, and the best way to do that is to let your passion for the subject shine through. Be honest with the audience about what is important to you and why it matters. Be enthusiastic and honest, and the audience will respond.

2. **Focus on your Audience's Needs -** Your presentation needs to be built around what your audience is going to get out of the presentation. As you prepare the presentation, you always need to bear in mind what the audience needs and wants to know, not what you can tell them. While you're giving the presentation, you also need to remain focused on your audience's response, and react to that. You need to make it easy for your audience to understand and respond.

3. **Keep it Simple: Concentrate on your Core Message -** When planning your presentation, you should always keep in mind the question:

   - What is the key message (or three key points) for my audience to take away?

   You should be able to communicate that key message very briefly. Some experts recommend a 30-second 'elevator summary', others that you can write it on the back of a business card, or say it in no more than 15 words. Whichever rule you choose, the important thing is to keep your core message focused and brief. And if what you are planning to say doesn't contribute to that core message, don't say it.

4. **Smile and Make Eye Contact with your Audience -** This sounds very easy, but a surprisingly large number of presenters fail to do it. If you smile and make eye contact, you are building rapport, which helps the audience to connect with you and your subject. It also helps you to feel less nervous, because you are talking to individuals, not to a great mass of unknown people. To help you with this, make sure that you don't turn down all the lights so that only the slide screen is visible. Your audience needs to see you as well as your slides.

5. **Start Strongly -** The beginning of your presentation is crucial. You need to grab your audience's attention and hold it. They will give you a few minutes' grace in which to entertain them, before they start to switch off if you're dull. So don't waste that on explaining who you are. Start by entertaining them. Try a story (see tip 7 below), or an attention-grabbing (but useful) image on a slide.

6. **Remember the 10-20-30 Rule for Slideshows -** This is a tip from Guy Kawasaki of Apple. He suggests that slideshows should:
   - Contain no more than 10 slides;
   - Last no more than 20 minutes; and
   - Use a font size of no less than 30 point.

This last is particularly important as it stops you trying to put too much information on any one slide. This whole approach avoids the dreaded 'Death by PowerPoint'.

As a general rule, slides should be the sideshow to you, the presenter. A good set of slides should be no use without the presenter, and they should definitely contain less, rather than more, information, expressed simply. If you need to provide more information, create a bespoke handout and give it out after your presentation.

7. **Tell Stories -** Human beings are programmed to respond to stories. Stories help us to pay attention, and also to remember things. If you can use stories in your presentation, your audience is more likely to engage and to remember your points afterwards. It is a good idea to start with a story, but there is a wider point too: you need your presentation to act like a story. Think about what story you are trying to tell your audience, and create your presentation to tell it.

8. **Use your Voice Effectively -** The spoken word is actually a pretty inefficient means of communication, because it uses only one of your audience's five senses. That's why presenters tend to use visual aids, too. But you can help to make the spoken word better by using your voice effectively. Varying the speed at which you talk, and emphasising changes in pitch and tone all help to make your voice more interesting and hold your audience's attention.

9. **Use your Body Too -** It has been estimated that more than three quarters of communication is non-verbal. That means that as well as your tone of voice, your body language is crucial to getting your message across. Make sure that you are giving the right messages: body language to avoid includes crossed arms, hands held behind your back or in your pockets, and pacing the stage. Make your gestures open and confident, and move naturally around the stage, and among the audience too, if possible.

10. **Relax, Breathe and Enjoy -** If you find presenting difficult, it can be hard to be calm and relaxed about doing it. One option is to start by concentrating on your breathing. Slow it down, and make sure that you're breathing fully. Make sure that you continue to pause for breath occasionally during your presentation too. If you can bring yourself to relax, you will almost certainly present better. If you can actually start to enjoy yourself, your audience will respond to that, and engage better. Your presentations will improve exponentially, and so will your confidence. It's well worth a try.

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

A SOLDIER LOOKS AT BUSINESS

An Address by FIELD-MARSHALL THE VISCOUNT SLIM K.G., G.C.B., G.C.M.G., G.C.V.O., G.B.E. Joint Meeting with the Canadian Club of Toronto Monday, April 22, 1963

CHAIRMAN: President of the Canadian Club of Toronto, Dr. W. Harvey Cruickshank. Dr. Cruickshank introduced Viscount Slim.

This enlightening article was highlighted at a seminar I attended recently, and is something the presenter uses as an exemplar of 'Leadership' in all forms. For those of you who do not recognise the name, Field-Marshall Slim was the leader of the successful Burma Campaign during WWII, which included the infamous bloody Battle of Kohima, arguably one of the greatest and most important defensive actions ever because failure here would have led to a Japanese invasion of India, which was of strategic importance to the Allied Campaign. After leaving the Army, Field-Marshall Slim was decorated with many honours, held various Civil positions and served on the Boards of many large international companies. The observations in this piece from half-a-century ago still hold true today, and form the bedrock of the necessary attributes for successful leadership.

VISCOUNT SLIM: There was, not very long ago, an author of very amusing literary trifles, who said that he had occasion to consult the encyclopaedia on the subject of intelligence and he opened it and he found a long article which started something like this. It said: "Intelligence can be considered under three headings: human intelligence, animal intelligence and military intelligence."

Well, although I served several years in industry at both ends-the bottom and the top-and while I have had certain intimate connection for a considerable time, with government in civic administration, most of my working life has been spent as a soldier and I am, basically, a soldier and my approach to situations and problems and persons is still and remains that of a soldier. So it is not surprising if some of you think, even if you are too polite to say so, that this self-confessed soldier is rather presumptuous, possibly impertinent, to think that he has got anything to say about industry which can be of value. But, a soldier might have something to say.

After all, industry and military affairs really are close together; the larger industrial organisations become, the wider they spread their work, the more the problems that confront them, become similar to those that are met with by a general in a campaign. They are so similar that quite frequently I find myself very much at home in a board room. At times they become extremely remarkable, like when we were ready to take over Cordeau.

Then, too, soldiers have been engaged in these great enterprises for several thousand years longer than the business people and we might have picked up something in the course of that time. And, therefore, it might be possible that these problems, the big problems of organisation, transportation, finance, communication, choices between technical methods, the choice of subordinates and, above all, the problems of human relations - they are all the same problems that face either large industry or military commanders. And we of the Army have not only been engaged in these problems for a very long time, but we have always been engaged in them on a much larger scale than business, and that head start we have always kept. For instance, there is no commercial or industrial organisation that has ever attempted an enterprise as large, as complicated or as important as the D-Day landing in Normandy, and yet that was conceived, planned, directed and carried through to a successful conclusion by regular officers of the services. So, it is possible that a soldier might, looking at industry, have something not completely without value and I hope that will be the case with me.

Now, no man's experience, of course, covers everything and mine is very, very far from that. Before I say anything else, I would like to make it quite clear that I am not going to teach anybody his job, because we all have different jobs, nor am I, when I talk about industry, talking particularly about Canadian industry, because the whole purpose of my visit to Canada is to learn something about it and I am extremely ignorant of it now.

Now, industry, whatever its nature, really depends for its success, very largely, on its management. I would prefer to use the word "leadership", rather than "management". Leadership is a much more elementary and basic human relationship than management. I am always inclined to think that leadership is an art dealing much more with the spirit of a man and management is much more a science. And, anyway, I think any man would rather be led than managed. Wouldn't you?

Now, leadership - or management, if you like to call it that - is the combination of persuasion, compulsion and determination. All those three elements must be present in it.

Even in an army, much more is done by persuasion, by gaining the confidence of your soldiers, than by barking harsh orders at them. Persuasion is a tremendous element in all this. Then there must be, in reserve, a determination that, when it is necessary, the unpleasantness and worse of using this compulsion must be accepted. The example is the purest form of leadership and, in many ways, the most effective because example, instead of saying "go on", says "come on" and men will always respond to that very much better.

If you asked me to define leadership, I should say that it is an extension of personality. Leadership is an extremely personal thing and everybody exercises it a little bit differently from everybody else. But it is, essentially, making people do what you want them to do even when sometimes they do not want to do it very much, by an extension of your personality.

Well, all right. If you are going to be a leader, leadership is the extension of personality. What sort of a personality does the chap have to have to become a leader?

It is very important to decide what the qualities of a leader should be, first of all, because we want to develop it in ourselves and, equally important, especially in industry and in the Army we want to be able to recognise those qualities very early in those who serve under us so that we can train them and bring them up and mark them for leadership.

Of course, if you want to list the qualities of a leader, you could go on with a list as long as your arm; but to my mind there are six basic qualities that a leader must have and which we must look for, and the first of these is courage. A leader must have **courage**. Courage is not so much a virtue, it is the virtue, because without courage there are no virtues. Faith, hope and charity and all the rest of them, are not virtues until it takes courage to exercise them. But a leader wants not so much physical courage, perhaps, as moral courage and that is a much harder thing to get. He must be prepared to do what he thinks is right, even if the consequences to him are not going to be very pleasant. Every man must be as big as his job and a real test of being as big as your job is to be prepared to give it up if people are trying to force you to do something which you believe so strongly is either morally or materially, if you like, wrong. But, courage is an essential of any kind of leadership.

Then, next to courage I would put **will-power** because if you want to lead, you will always find plenty of opposition and the most difficult opposition to deal with does not always come from your enemy or from your competitor in business; it very often comes from your own people and it is, very often, very genuine opposition and you have got to have sufficient determination and will-power and tenacity to overcome that opposition. So, it is not much good trying to be a leader unless you have got will-power.

Next, I would put **judgment**, the power of balancing alternative courses and choosing the right one or, at any rate, a reasonable one. Now, if you select a leader who has not got judgment, the greater his courage, the stronger his will-power, if he lacks judgment, the more disastrous will be his leadership. So, judgment is an absolutely essential quality. As far as judgment is concerned, I always used it to tell my people, when I was in the Army, that when they had two courses of action open to them and the arguments appeared to be pretty equally balanced and they were in doubt as to which they should pursue, I always told them to choose the bold one.

Now, we are getting on where we have got courage and will-power and judgment, but the world is a very rapidly changing place these days and there is a quality of leadership which

is becoming more and more important and that is **mental flexibility**. Any organism that survives in nature is able to adapt itself to new conditions; otherwise, it just fades out. Conditions are changing so rapidly and in every direction that, unless we have this mental flexibility, it is rather difficult to survive.

There is this struggle always in leadership between determination, so that it does not become just obstinacy, and flexibility, so that it does not become vacillation. Now, if you can hold the balance between determination and flexibility, I think anybody who can do that is well on the way to being a real leader. But it is not easy to do. Very often one changes one's mind and when I have done that, which I have done frequently, I have found a quotation from Emerson very useful. As far as I remember, Emerson at one time wrote: "A foolish consistency is the hob-goblin of a little mind." You try that when you want to change your mind; it is great company.

Then, of course, a leader must have **knowledge**. After all, unless you know more about the thing which you are telling other people to do than they do, you have no right to lead them. That does not mean that you have to know the details of the work of every man who serves under you. You can't expect an Army commander to drive a tank as well as a professional tank driver, to take a wireless set to pieces and to put it together as well as a signaller or preach a sermon as well as an Army Chaplain or take out an appendix as well as an Army doctor, or something like that. But, he must have knowledge of all the conditions under which those things are done and how long they take and the strain that they entail on the men who do them and in what ways they can be helped in their tasks. And, of course, if he is down on the low level, if you are a section commander or a platoon commander you ought to be able to do everything that any man in your section or your platoon does at least as well as he can and if you can't, get out behind the hut and practise till you can; but as you go up, your detail knowledge must, of course, inevitably grow less.

Now, I have given you five qualities: courage, will-power, judgment, flexibility and knowledge, and there is one more that I think the real leader ought to have. If you have those five qualities, you will be a leader. Nothing will stop you from being a leader. But if you are to be a leader for me, then I think you must have one more and this is not so much of a quality as an element in which all the other qualities work, and that is what I would call **integrity**.

Integrity is a little more than just plain honesty. It is really the old, Christian virtue of loving your neighbour even before yourself, and "your neighbour", for a leader, is the people he leads and he must always think of them and put their well-being actually before his own: That is not only, I think, good ethics, but it is good business because one will find then that when your leader has integrity, even if things do not go very well with him, people will stand by him. If he hasn't got integrity, he will be a fair-weather leader and there are very few of us who have ever tried to lead anything who have not run into some pretty bad weather sometime.

In this exercise of leadership in any field, there are three elements. There is, first of all, the commander. In the Army, he is usually a General. In business, he may be a chairman or a board. But it is, whatever you like to call it, the top man or the top men. Then there are subordinates who are his subordinate commanders, divisional commanders or regimental commanders; in business, his managers, and so on. That is the second element.

Then, the third element is the communications system by which ideas pass from the top right through every individual in the whole organisation. Now, the job of the top man or the board is really to make decisions and, having made those decisions on high matters of policy, it is an awful pity if they waste their time doing things that are not important. Having made their decision on it, it is their job to see that it is clearly expressed and it is very funny how well our education is alleged to be increasing. I really believe that our command of plain, simple, easily understandable English is growing less and everybody who sets out to be a leader, in any walk of life, wants to be able to express himself plainly, shortly, and clearly.

Now, beginning at the top with our commander or leader or chairman or board, one of the first things that they have got to do is to get themselves known. It is a very distressing thing, but in a great many firms and organisations the head man can go around his organisation and, unless he is trailed around by a lot of other people, the ordinary fellow on the workshop floor won't know who he is. Now, a general or the head of any organisation ought to be able to go into any camp, barrack, bivouac or any workshop, office, in his organisation, and be recognised as the top man. That is, I think, the thing in which the Army is rather better than a good deal of industry. I think we in the Army usually achieve that. I know I used to walk into somewhere, unannounced, and I would hear the whisper go around, 'Here's the old bugger, what's he doing now?" Well, it was much better to be recognised than to be popular, and also, soldiers, and I think workers in all walks of life, have a habit of using words beginning with "b" almost as a term of endearment. But the head man must be known because he can't know everybody. But they must know him. And never laugh at a general who wears a pair of breeches and puts two patches on them, because he is fulfilling one of the outstanding requirements of leadership. He is getting himself known to the men he leads.

The temptations that assail the head of any organisation to remain at your desk are increasing because the problems pile up and you have to keep in the centre of things; but do not let that become too strong. Get out and about. After all, if you are running the show properly you will have somebody that can take your place. If you have got a really good organisation, it will run quite well for a week without your being there. If it runs as well when you are away for a month or more, well then you may as well stay away.

The second element in the exercise of leadership is the subordinate commanders, all the managers and the heads of areas, or whatever your organisation has. Now, what they want, first of all, is a clear directive of what they are supposed to be doing. They ought to be fully in the mind of the top man or top board and it is necessary that they should understand very clearly what his object is, what he is trying to do. Now, I have had an immense number of orders and directives sent out in my name and those of you who remember the military order, there is one thing in it which is called the "intention". It is usually the shortest paragraph in the order and I had a lot of very, very good Staff Officers who could write orders much better than I could, but I always wrote the intention paragraph myself. It was usually the shortest in the order, but I think it is the most important because if the intention of the directive is known, then you can allow your subordinates a great deal of flexibility and a great deal of room in what they do to obtain it, so long as they keep well within the bounds of the directive. We are a little inclined to breathe down the necks of our subordinates and when we do it is, very largely, for one of two reasons: (1) because we are not quite sure we have chosen the right man, and that is our fault, and (2) we have not really made our intentions to him clear and we are not quite sure that he will keep within the bounds of the intention.

Another thing about subordinates is sometimes the subordinate fails. In the Army, he may lose a battle or do something wrong. Well, I have always found that it was not a good thing to rush to him and sack him on the spot; it was much wiser to find out why he had failed because sometimes, especially in war, men fail because things happen of which they could not possibly have any foreknowledge and in an attack somewhere there happened to be two enemy divisions that just arrived the night before, or the weather might suddenly have changed, and it was always a good thing, I found, to go down and find why he had failed. But, do not be in too big a hurry to sack a chap until you know why he went wrong. If he did it because he was clod-footed or plumb-stupid or something like that, well, you can't get him out quick enough. But give him a chance to find out why.

Now, one of the most difficult things in leadership, especially in industrial leadership, is what I think we can call "communications", which means how you get the intention of the top man right to the boy with the oily rag, right down through the whole organisation. And it sounds stupidly simple but I have always found if you want to get people to understand something you want to tell them, the simplest thing is to go and tell them. Now, I have a belief that occasionally - not very often, but occasionally - the top man, he may be the top of a great organisation or he may be the manager in the factory, he ought to assemble the people. Now, of course, if you run an organisation with one hundred and twenty thousand workers in it, you can't do this all at once. You will have to split them up. But what I believe in very much is collecting the whole of one bloc, the managers, sub-managers, the foremen and workers, right down to the old boy who sweeps out the workshop floor, and get them all together in one place. There are advantages in that. It makes them feel a team. Then tell them what you are trying to do. You do not have to be an orator to do that. Only two things are required. One is to know what you are trying to do and the other is to believe in it yourself, because if you try to tell people things you do not believe in yourself, unless you are a very clever politician, you will be found out. I think that should be done sometimes.

Another thing which sometimes I have noticed some firms - not any with which I am connected - the thing some firms are not very good at: they get a little bit confused on the channel by which you would pass down your instructions. You must, of course, keep your trade unions and your trade union representatives very closely in touch with you, well aware of what you are trying to do and of the effects it will have to pass your information down through what I would call the proper channel of command and let your foreman know about it at least as soon as your shop stewards. You know, sometimes in industry we are not very good in making what I would call the N.C.O.s of industry feel that they really are part of the management. In the Army, we have our non-commissioned officers, but you will notice that we call them "officers". They have something on their sleeve. I may have something on my shoulder, but we are both officers and if you have got any sense, when you are commanding a regiment, you impress very much on your N.C.O.s that they are non-commissioned "officers". I think very often in the lower ranks of the administration of industry we would be well advised to do that a little more than we do and make them realise that they really are a welcome part of the management.

Now, industry gets more and more complicated and to me, a soldier, it grows more and more like a campaign and I think, looking at it as a soldier, on the many, many fronts of it at home and abroad, there are two or three to which we might possibly pay a little more attention or even look at the Army and see if there is anything there that we might pick up.

Now, first of all, there is the technical front. It is absolutely essential that whatever industry we are in, we should keep well in the forefront technically. If we don't, we shan't survive. That, of course, entails a very close study of the proportion of your resources you will spend on research and of the amount that you spend on research, or devote to research, how much you will devote to developing lines that you are already working on, improving your capacity for turning out things you are turning out, and how much you will devote to what is much more fundamental in research and that is a problem much greater and, having settled that, it is one on which the future prospect of our industry depends very much. Another thing is the continuation of progress, technical progress of his education which starts long before a man comes to join an industry, and we are very much inclined, I think - certainly in Great Britain, and we certainly were in Australia - to have this idea that you have got to shove everybody through university. Perhaps I am prejudiced because I never went to university. But they used to tell me in Australia that we must have five thousand more scientists. Well, believe me, if they had had five thousand more scientists the next morning, they would not have known what to do with them. They have got scientists - at any rate, fellows with B.Sc. degrees - watching dials in control rooms and, honest to God, I believe I could learn to do that in a week. When your needle goes into the red, you pick up a telephone and say, "Number five furnace is getting too hot." What we want, I think, even more than these very large numbers is quality, and you will make more progress if you have five hundred really first-class technicians or scientists than you will if you have five thousand ordinary ones, and we ought to go in our education systems, I think, very much more for quality. If you will repeat that to anybody, I shall get a lot of letters tomorrow morning telling me I do not know anything about it - but, that is what I believe.

Another thing, I think, in which industry lags is long-range planning. We get mixed up between what is planning and what is development. To me, a soldier, planning is something you do quite a long way ahead and a lot of it you never use. But, you take, for instance, when the Common Market, two or three years ago, burst on an astonished British industry. The damn thing had been going on about five years and had been talked about for about fourteen years, but you found there were a large number of British in the United Kingdom ran about saying: "What the hell is this Common Market and what are we going to do about it?" They would have been very much better off if four years earlier they had got down to planning what the Common Market meant to them and the effect it would have, if it came, on their business. In that, I really do think that the services, the Army, can teach industry something.

I believe, however, large industry should have a small group of planners. The planners would be quite young men. They would be taken from various parts of the industry in which they had already distinguished themselves. They would be relieved of all executive authority. They would be put directly under the control of the Chairman or one of the Vice-Chairmen and their job would be to go around the organisation, with the authority of the Chairman, and ask any questions they liked, find out about things, produce ideas and work on any ideas that were given to them. I think that would produce a dividend. Don't keep them out too long or else they get swell-headed, but send them back to the grind-stone every two years, or every eighteen months, if you like, and pick new ones. But, I do think every organisation should have a small planning section, responsible to the top management, with no executive authority, whose job is simply to discover and examine ideas. I think, very often, the sections of industry are not terribly good at that; planning is a bit muddled.

Then, the other that we have to do is to recognise, select and train subordinate leaders. Now, an Army in which the only leaders are the Generals will never win any victories at all. You have to get leaders the whole way down and it is the same in industry. You have to spot them quite early because it is no good having a fellow in the ranks for fifteen years and then expecting him to become an officer - he won't. We have to have some organisation in industry, like you have in the Army, that begins to look for potential leaders as soon as they join. You know, when we had National Service in the Army, the boy came in and from the day he joined he was being looked at either as a potential N.C.O. or as a potential officer, because we only had him two years and we wanted to use the potential officers for eighteen months as officers, and we had jolly good officers that way. But I think very often in industry we are not quick enough to spot the fellow who could become a good executive. We know the qualities that we ought to look for but we haven't got a good system of looking for them or reporting them when we find them. But, to go even higher, I think when you want a senior executive, sometimes there isn't a very good method of selecting him. You see, in the Army, if I wanted a Divisional Commander, I would very likely pick one that I knew and he would, I hope, do a good job; but the military executive furnish and put on my desk four names with a little history of what they were and what they had done and they would say: "Any one of these four will do the job, but some of them have such and such faults and some of them have lack of qualifications, and so on." In industry, one is awfully inclined to miss a chap who has been working in another section of a large industry and go to the chap he knows very well. But I think we ought to have organisation which will put every man in front of whatever does the selection. We have, in industry, to a very large extent, copied the methods of training in the Army and I think that is very wise. We have our staff colleges and they are modelled completely on the ordinary Army life. They run the same way and their methods of instruction are the same and I think that is very good and it works very well. But there is one thing a good many industries are not totally good on and that is, having got a fellow who is likely to be a potential executive, very often his career is not planned; he is not given the wide experience that he should have. People are obviously reluctant: if you were the manager of a factory or a department and you have got a good chap under you, you are in no hurry to send him away. But, there should be some organisation which looks for a man in ten years' time to be one of our leading executives. He has the qualities and now he has spent all his time in one line. They will shift him over to another because he will need that when he gets up. I do not think we plan careers of our most promising chaps in industry as well as we should.

Now, I have talked a good deal too much, but one of the things is that industry is changing - the world in changing, politically and materially, morally and in every way the world all around us is changing. But it is not changing like it used to fifty or sixty years ago when I was a boy. The world is changing now as if somebody had his foot down hard on the accelerator of a sports car and we have got to be alive to that. But, it is not good, and it is quite wrong to go about shaking one's head saying, "Oh, things are changing." Of course they are changing; anything that lives changes and the thing to remember is that change is only another name for opportunity. And why shouldn't it be our opportunity?

THANKS OF THE MEETING were expressed by Mr. J. Palmer Kent, Q.C.

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Eight Steps To Continuous Self-Motivation

Ian McKenzie

Hints and tips on keeping self-motivated.

Many of us find ourselves in motivational slumps that we have to work to get out of. Sometimes it's like a continuous cycle where we are motivated for a period of time, fall out and then have to build things back up again.

Keep a positive attitude: There's is nothing more powerful for self-motivation than the right attitude. You can't choose or control your circumstance, but can choose your attitude towards your circumstances. [That is – we are all 'response able'.]

How I see this working is while you're developing these mental steps, and utilising them regularly, self-motivation will come naturally when you need it.

The key, for me, is hitting the final step to Share With Others. It can be somewhat addictive and self-motivating when you help others who are having trouble.

My 8 Steps

1. Start simple. Keep motivators around your work area – things that give you that initial spark to get going.

2. Keep good company. Make more regular encounters with positive and motivated people. This could be as simple as chats with peers or a quick discussion with a friend who likes sharing ideas.

3. Keep learning. Read and try to take in everything you can. The more you learn, the more confident you become in starting projects.

4. Stay Positive. See the good in bad. When encountering obstacles, you want to be in the habit of finding what works to get over them.

5. Stop thinking. Just do. If you find motivation for a particular project lacking, try getting started on something else. Something trivial even, then you'll develop the momentum to begin the more important stuff.

6. Know yourself. Keep notes on when your motivation sucks and when you feel like a superstar. There will be a pattern that, once you are aware of, you can work around and develop.

7. Track your progress. Keep a tally or a progress bar for ongoing projects. When you see something growing you will always want to nurture it.

8. Help others. Share your ideas and help friends get motivated. Seeing others do well will motivate you to do the same. Write about your success and get feedback from readers.

What I would hope happens here is you will gradually develop certain skills that become motivational habits.

Once you get to the stage where you are regularly helping others keep motivated – be it with a blog or talking with peers – you'll find the cycle continuing where each facet of staying motivated is refined and developed.

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 2, Number 1, 2016

Paper Industry Technical Association

5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Beyond Competencies: What About the Leader's Mind?

New ideas about how the 'inner world' of our minds affects every day behaviour.

Behaviour-based competencies have been the foundation for developing leaders — a reasonable approach. Behaviours are the most tangible, visible and measurable aspects of leadership.

But what happens in a leader's mind also plays an important role in effective leadership.

In a new white paper, *Leadership Development Beyond Competencies: Moving to a Holistic Approach*, CCL suggests it's time we take a closer look at leaders' inner experiences as well as visible actions.

Our complex inner worlds influence and are influenced by our behaviours and external outcomes. A more honest, holistic approach to leader development acknowledges the interplay between behaviours and actions and our thoughts, emotions, memory, and other internal elements.

In the CCL paper, Marian Ruderman, Cathleen Clerkin, and Carol Connolly draw on brain-based science and contemplative practices to add 3 additional elements to a model of leadership development:

- **Circuitry** — the physical, chemical and neurological functioning of our bodies. Much of our behaviour is influenced by the basic network of interconnected neurons in the brain and nervous system. This internal wiring affects how we develop as leaders. Self-awareness, the core of effective leadership, should also include awareness of the body's neural circuitry.

- **Inner content** — our raw emotions, gut reaction and inner dialogues. These inner experiences define our relationships with ourselves, as well as shape our beliefs and emotional reactions to thoughts and situations. Inner content includes the constant "mind chatter" going on in our heads, as well as the narratives we create in relationship to other people and the culture around us.

- **Conscious engagement** — our ability to observe, modify and regulate mental processes. With awareness and practice, we can learn to direct much of our thoughts, emotions and inner processes. This is the area that has the most potential for development in leaders, as we can learn to choose a more mindful response to difficult situations and promote healthier physical and psychological responses in ourselves and others.

Increasingly, these ideas are moving from research or fringe interest toward actions that can be implemented broadly. From David Rock's SCARF model to mindfulness practices at General Mills, Google, and Target, many people are starting to recognise that the mind is important and that cognitive health matters.

Janice Marturano, a former vice president and deputy general counsel at General Mills and author of *Finding the Space to Lead: A Practical Guide to Mindful Leadership*, says mindfulness is a powerful way for leaders to make a difference in their organisations and communities.

When asked what is driving the interest in mindfulness and cognitive health, Marturano said, "It's not about mindfulness. It's about the incredible challenge and complexity of

being a leader today. People are sensing that we need more capabilities than we have right now."

By taking a holistic approach to leadership development, CCL agrees, we have the opportunity to expand our capabilities, boost our effectiveness, and improve leadership outcomes.

What's the Big Difference?
The traditional behavioural competencies approach and the "Beyond Competencies" approach are rooted in different assumptions:

Behavioural Competencies Assumptions	Behaviours & Inner World Assumptions
• Behaviours are a result of deliberate and conscious processing.	• State of mind and body influence how leadership is enacted; behaviours can reflect automatic processing, emotions, thought patterns, past experiences, and level of self-awareness.
• Leadership is the function of explicit behaviours.	• Leadership is a function of circuitry, inner content, conscious engagement and external behaviours. The four are inherently interconnected.
• Holding leaders accountable for certain behaviours helps them to become better leaders.	• Helping leaders understand their inner world leads to increased self-awareness, adaptive behaviours and responses, and more effective leadership.

Read *Leadership Development Beyond Competencies: Moving to a Holistic Approach* for more insight into the limits of the behavioural competencies approach to leadership development, the 3 additional elements, valuable resources for more information — and the challenges involved in taking a new "inner worlds" approach.

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Products & Services

Page 2	Advanced Whitening Concept	**Archroma**
Page 3	Bearing AP & Heater / Grease Injector	**SKF**
Page 5	Beat the Warehouse Shortage	**M. P. Trucks**
Page 6	Coating Permeability Tester	**Versaperm**
Page 7	Coriolis Family Offers Smart Flow Measurement	**ABB**
Page 8	Effective Monitoring of Vibration	**Sensonics Ltd**
Page 9	Flow Meters Reduce Energy Costs	**Gardner Denver**
Page 10	Interactive Webinar Calendar	**Henkel**
Page 11	LED-based Colour Sensor Measurement	**ABB**
Page 12	Pigging Technology for Chemical Transfer	**ABB**
Page 14	Safety Switch – Pilz - PSENM-LOCK	**Pilz**

ADVANCED WHITENING CONCEPT

Providing papermakers with truer whites and customisable formulations
Archroma, a global leader in colour and specialty chemicals, has developed a new concept that gives papermakers the ability to produce truer, cleaner whites with improved print contrast and appearance while reducing consumption of optical brightening agents (OBAs) by up to 20%.

Five years in development, this new, patent-pending concept – called ADVANCED WHITENING – allows users to optimize both OBA and shading components when producing their printing, writing and office papers.

The new concept features a two-component package that combines Archroma's Cartawhite XL liq – a surface shading solution – with its Leucophor® optical brightening agents. By allowing the separate dosing of these two components, ADVANCED WHITENING provides papermakers with the means to reduce their whiteness costs across all grades.

Archroma had already raised the bar a few years earlier when it developed its innovative Leucophor XL whitening system. This range allowed papermakers to break through their whiteness ceiling to reach previously unattainable levels. The Leucophor XL range improved whiteness build-up without destroying brightness for coated and uncoated papers and board.

Now, notes Archroma, its new ADVANCED WHITENING process retains these benefits while providing even more advantages, including:

- Good compatibility with size-press and coating systems;
- Reduced two-sidedness compared with 100% pigment shading systems;
- Comparable lightfastness to conventional whiteness solutions; and
- REACH-compliance.

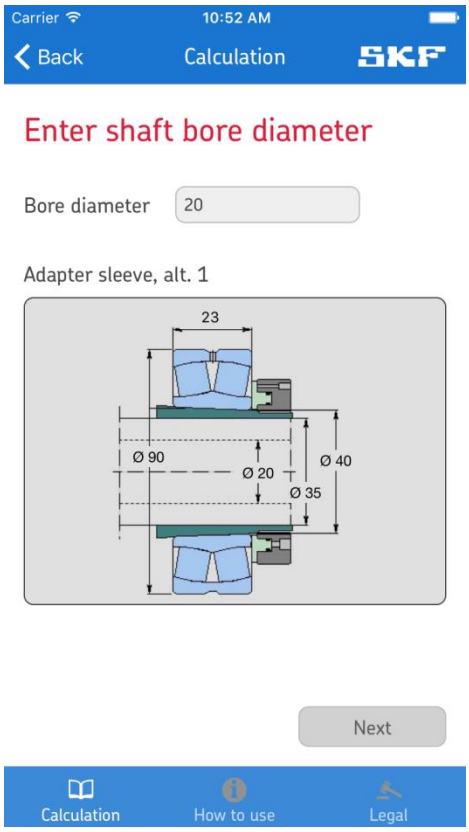
"The new concept can save costs across all grades while retaining the advantages of the original whitening approach, not to mention the reduced OBA dosage which means less chemicals in the process and a reduced environmental footprint," says Andrew Jackson, Global Head Product Management OBA for Archroma. "We're excited to bring ADVANCED WHITENING to the global market, and provide papermakers with levels of flexibility they have never seen before," said Jackson.

For more information see: **http://archroma.com/**

BEARING AP & HEATER / GREASE INJECTOR

SKF offers new app for mounting bearings

SKF has announced the introduction of a new app for its proven SKF Drive-up Method for mounting bearings. Developed for ease of use in the field, the app is offered in both iOS and Android formats and can be used on smartphones and tablets. Complementing SKF's recognized SKF Drive-up Method PC software, the app is available for download from the Apple app store and from Google Play.



Unique to SKF, the app enables the user to achieve accurate adjustment of spherical roller and CARB toroidal roller bearings mounted on tapered seatings. The correct fit is attained by controlling the axial drive-up of the bearing from a predetermined starting position. The method incorporates the use of an SKF hydraulic nut fitted with a dial indicator, as well as a highly accurate digital pressure gauge mounted on the selected pump.

When utilizing the app on either a smartphone or tablet, the user selects the bearing designation and seating arrangement, and the values required for optimal mounting are displayed. In addition, the app provides step-by-step working instructions. Both the required values and instructions can be saved in the convenient PDF format.

For more information on the app, please visit: **http://www.skf.com/group/products/maintenance-products/hydraulic-tools-for-mounting-and-dismounting/skf-drive-up-method/index.html**

SKF offers new online heater selection tool

SKF has announced the introduction of its online heater selection tool for bearings and similar workpieces. Accessible via the Group's website: www.skf.com, this convenient tool makes it quick and easy for SKF customers and distributors to find the right heater for various applications.

In standard cases, the versatile selection tool utilises an SKF bearing designation to determine the appropriate heater. However, for other bearing or annular components, a suitable heater can be found by defining the application and by specifying the dimensions and weight of the bearing or workpiece. The new heater selection tool chooses from SKF's comprehensive offering, including the electric hot plate, induction heaters and fixed induction heaters.

Hot mounting and dismounting of bearings and workpieces reduce the risk of damage to the bearing, shaft or workpiece and help to increase bearing service life and machine reliability. Suitable for most SKF bearings with a cylindrical bore, hot mounting is also used with many annular components.

The online heater selection tool is available via the following link: **http://www.mapro.skf.com/heaterselect/**

SKF launches Lincoln high-vent injectors

SKF has introduced its new Lincoln SL-32HV high-vent injectors for applications requiring faster venting. In addition, these injectors provide improved functionality in cold temperatures and enable the use of heavier greases.

Designed for indoor or outdoor applications, the SL-32HV high-vent injectors can lower system installation costs, because less-expensive, smaller-diameter supply lines can be utilized. Compatible with all existing Lincoln Centro-Matic grease injectors, the SL-32HV injectors also can be used to upgrade an entire lubrication system.

The new injectors have a high venting capability of 400 psi (28 bar) and can pump viscosities up to and including NLGI 2 greases. Multiple manifold configurations are available ranging from one to 10 injectors per manifold, and individual injectors can be removed easily for inspection or replacement.

Developed for use in a wide range of industries, these injectors are suitable for food and beverage, industrial automation, machine tool, oil and gas, steel, pulp and paper, marine and forestry applications, as well as construction, wind energy, mobile on-road, metal removal equipment and more.

For more information on all products contact:

SKF (UK) Ltd, Sundon Park Road, Luton, Bedfordshire, LU3 3BL

Tel: 01582 490049 Email: marketing.uk@skf.com www.skf.com

BEAT THE WAREHOUSE SHORTAGE

According to a logistics market report the UK's warehouse property stock will have vanished by the end of the decade, due to demands from internet retailers. Midland Pallet Trucks, one of the UK's leading providers of pallet and pump trucks, is urging businesses to make the most of the space they have available by investing in good-quality equipment for use in warehouses.

The report suggests that warehousing space fell to a record low last year, despite the predicted increase in online sales. Following on a similar path to the last five years, online sales are expected to significantly rise again to reach £182.80 bn in 2016 (+16.7%) and £215.38 bn in 2017. As retailers attempt to satisfy consumer demand more quickly and efficiently, there is an unprecedented demand for warehouse space right across the country. And although this year will see elevated levels of new developments, consultancy Lambert Smith Hampton (LSH) said that retailer and distributor requirements for logistics warehouses will exceed the country's available stock by 2020 by around 7.6 million m2.

Phil Chesworth, Managing Director of Midland Pallet Trucks said, "It's quite concerning that despite ongoing development, the country may see a lack of available storage. Warehouses are often over 30 feet high, meaning there's ample space for companies to expand upwards instead of outwards and utilise the space they have available. By investing in quality equipment such as aerial work platforms and stacker trucks, warehouse staff are able to store products safely and effectively to make the most of their space."

The news comes as it's also revealed that high street bricks and mortar stores suffered during March. Thought to be as a consequence of the early timing of Easter and the heavy rain brought on by Storm Katie, the number of visitors through retailers' doors fell by 3.9 per cent – lower than the 2.9 per cent dip reported in February.

To find out more about Midland Pallet Trucks and its range of pallet and pump trucks, visit the website: **http://www.midlandpallettrucks.com**

Midland Pallet Trucks are pallet truck specialists, with a diverse range of models and specifications held in stock for immediate shipping. The company is based in the West Midlands, England, importing high-quality pump trucks and lift tables directly from the manufacturer. It carries sufficient stocks in its 60,000 square feet warehouse to supply the whole of the UK market with any kind of hand-operated truck or lift.

COATING PERMEABILITY TESTER

Versaperm

Permeable Coating Measurements that Improve Products from Paper to Oil Rigs
Paper is one of the most widespread materials on earth, and despite falling oil prices, oil rigs are quite common as well! Both make use of an extremely wide range of coatings that protect or enhance their surfaces. As does a huge range of products.

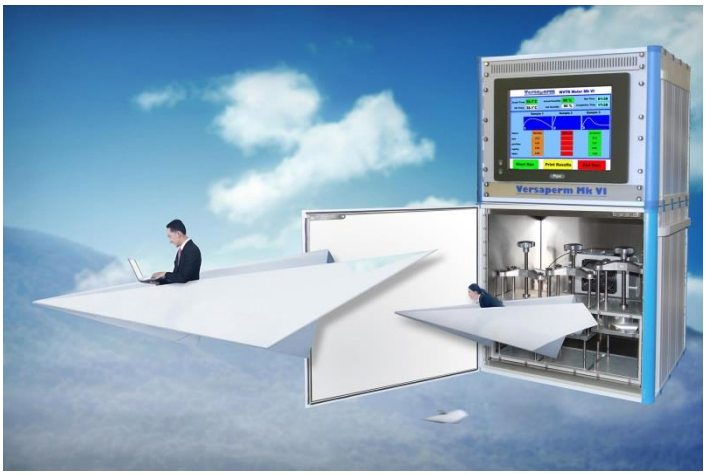
Coatings do this by controlling permeability – which is responsible for everything from rust through to paper's printability and from keeping food fresh to a home's watertightness. Measuring permeability is critical for both for development and QC, which is where Versaperm comes in. Their latest systems are capable of independently testing the vapour permeability of up to six coatings, samples, components or products at a time, sometimes in as little as 30 minutes.

In 90 per cent of real world products the key is water vapour permeability, but in some cases (such as with food) it can be Oxygen, Carbon Dioxide, Hydropcarbons or various other gasses. Fortunately the equipment can optionally measure permeability for all of the world's common gasses. Small changes to a material or a coating's composition often lead to substantial changes in the finished performance.

This isn't just important for writing paper, packaging and oil rigs – but with food, pharmaceuticals, seals, clothes, plastics, engineering and even space shuttles. In all these cases critical performance characteristics are controlled by the permeability.

Versaperm measurement are typically accurate in the parts per million range, (parts per billion with some gasses).

As well as manufacturing the instruments, Versaperm offers laboratory and consultancy services for companies that only need to test samples on an irregular basis.



Please send any sales enquiries to:

Versaperm Ltd, 10 Rawcliffe House, Howarth Road, Maidenhead, Berkshire, SL6 1AP, UK

Tel: +44 1628 777668
www.versaperm.com
e.mail: info@versaperm.com

CORIOLIS FAMILY OFFERS SMART FLOW MEASUREMENT

Expanded ABB Coriolis mass flowmeter family includes a new electronics platform that features self-configuration, integrated accuracy verification, built-in valve control and many other smart tools

ABB has expanded its range of Coriolis flowmeters with the addition of the FCB400, featuring a totally new electronics platform offering users the option of up to five, freely-configurable communication outputs. The entirely digital, internal communication ensures maximum accuracy for compact and remote devices without the need for special cabling.

Using the innovative sensor and application technology "SensorApplicationMemory", FCB400 saves not only all calibration data but also all measuring point parameters and totalizers, which are linked to the sensor in a non-detachable way. This includes an automatic self-configuration function, which synchronizes the configuration data in the sensor and the transmitter after power has been switched on. The "SensorApplicationMemory" duplicates the configuration data storing it in a permanent memory and ensures safe data synchronization during maintenance, i.e. when the transmitter is replaced.

Application-specific software packages enable the FCB400 to offer a solution for an expanded range of installations. In filling processes, the "FillMass" function directly controls the downstream valve via a special digital output. By means of predefined characteristics e.g. for alcohols, sugar solutions or starch "DensiMass" enables the precise determination of the concentrations of liquid mixtures through high-precision density measurement. Moreover, the "net mass or volume flow rate" can be determined, too.

Another novelty is the integrated verification function "VeriMass". Using this function FCB400 carries out a self-diagnosis and can test, whether the device is still operating within the specified range. Thus, the user can detect possible erosions or deposits inside the sensor without interrupting the measurement and without removing the device. This ensures the permanent monitoring of the metering tube loop, reduced measuring accuracy can be detected, test cycles can be optimised and critical conditions can be prevented at an early stage. Hence plant availability and safety increase.

The proven, common and intuitive operation concept of all ABB meters enables great ease of use and commissioning. The robust design expands usability at ambient temperatures of -40°C to +70°C and desensitizes the device to excessive vibrations.

The device features an exceptionally low pressure loss and an extremely compact design. It is therefore about 50 % lighter and smaller than many similar devices on the market. The compact metering tube and device design sets new standards for device dimensions and weights solving the space constraints of the process industry. Of course, all relevant Namur recommendations are fulfilled as well as the SIL2 requirements.

ABB’s Measurement & Analytics business is among the world's leading manufacturers and suppliers of instrumentation and analyzers. With thousands of experts around the world and high-performance technology, ABB's team is dedicated to making measurement easy for its customers. For further information, please visit **www.abb.com/measurement**.

EFFECTIVE MONITORING OF VIBRATION

Slow speed rotating machinery (typically, less than 300 RPM) is commonplace in many industrial applications, for example; cooling towers, hydro-electric turbines and wind power generation. To ensure this type of machinery and plant is functioning at optimal levels it's essential to measure vibration, as much as it is a critical requirement for standard speed machinery applications. In all cases the focus should be; understand the dynamic behaviour, establish a baseline vibration performance, and then to detect the early onset of failure in rotating parts which if left un-checked has the potential to result in more serious damage affecting overall performance.

Whilst the use of accelerometers is common place on standard speed machinery (i.e. 1500 RPM) this becomes problematic at lower speeds as the absolute accelerations measured are much smaller in value for similar vibration displacements. Condition monitoring specialists SENSONICS have recognised the need for a sensor which can meet these requirements and has developed the VEL/GLF, a new LOW FREQUENCY VELOCITY VIBRATION SENSOR. The VEL/GLF is an electro dynamic sensor which offers a superior performance compared to piezo-electric devices by combining high measurement sensitivity with a frequency response down to 0.5 Hz and is therefore ideally suited to measuring velocity vibration on equipment with speeds below 300 RPM.

The sensor offers a standard IEPE type interface to enable easy integration with existing plant protection and monitoring equipment. Furthermore, the VEL/GLF provides advantages over traditional piezo-electric based velocity vibration sensors which are susceptible to many forms of interference in low frequency applications that can result in spurious readings and alarms. Typical causes include; base strain effects due to temperature changes amplified through the internal signal processing, high frequency and high g vibration events caused by auxiliary machine items resulting in transducer saturation and also mains voltage interference due to a combination or poor local plant earth and insufficient transducer internal isolation.

Thanks to its robust design, the VEL/GLF combats these effects, offering high noise immunity due to the low impedance electro dynamic nature of the sensor assembly. In addition to the filtering of high frequency events and since no electronic integration is required, the design is immune to the saturation problems that impair the reliability of piezoelectric devices.

Typical applications for the VEL/GLF will be found in cooling towers, hydroelectric and wind power generation, slow speed pumps and also structural monitoring.

Further details on VEL/GLF sensors are available from: **Russell King, Sensonics Ltd, Berkhamsted, Hertfordshire, UK.**

Tel: +44 (0) 1442 876833 Email: sales@sensonics.co.uk www.sensonics.co.uk

FLOW METERS REDUCE ENERGY COSTS

Leading vacuum pump and compressor manufacturer Gardner Denver has launched a new range of measurement equipment to identify compressed air energy lost through pipework leakages.

With the Carbon Trust reporting that a leak as small as 3mm could cost more than £700 a year in wasted energy, Gardner Denver's new Insertion and In-Line Flow Meters offer a reliable means of evaluating compressed air generation and the associated costs from any downstream inefficiencies.

For pipework over an inch and a half thick, offers a trusted solution to measure compressed air efficiency, while the In-Line Flow Meter has been developed for pipes with a smaller diameter.

Flow, pressure and temperature can all be monitored at a glance, ensuring any costly air leaks can be quickly identified and remedied. Only one flow meter is needed to measure each of these factors, simply by fixing the equipment directly to the pipework.

Sites that cannot afford any production downtime will benefit from Gardner Denver's hot tap drill installation process, which enables the innovative flow meters to be fitted within 30 minutes without isolating the system.

Keith Findlay, Northern Europe Aftermarket Sales Manager at Gardner Denver, explains: "Generating compressed air accounts for 10 per cent of total energy costs in industry, so ensuring wastage is kept to an absolute minimum should be a key concern for all operators. Our new flow meters guarantee that flow, pressure and temperature in compressed air is constantly monitored, so companies can implement a reliable energy management programme to reduce overall energy costs.

"For guaranteed assurance, we recommend combining our flow meters with our leak detection devices, which use ultrasound technology to locate and evaluate the intensity of leaks. A report is then generated, highlighting potential energy savings in further detail.

"We are committed to delivering high-quality and low-maintenance energy management solutions, which make a difference to a business' bottom line."

About the Gardner Denver Industrials Group
Gardner Denver Industrials Group delivers the broadest range of compressors and vacuum products, in a wide array of technologies, to end-user and OEM customers worldwide in the industries it serves.

For more information visit:
http://www.gardnerdenver.com/.

INTERACTIVE WEBINAR CALENDAR

Food Safety is one of the key topics of the food & food related industries. Our webinars allow you to communicate directly with our Henkel food safety experts from the corresponding fields. Gain further knowledge and interactively deepen your personal expertise on food safe packaging!

Get to know all the advantages of our interactive live-seminars and benefit from:

- first-hand expert knowledge
- clear and easy presentations of complex matters
- direct contact to our experts
- lively question and answer sessions
- convenient ways to deepen your personal expertise

Forthcoming dates to the end of the year are as follows:

June 23 9AM & 4PM CEST
Mineral Oil Components in Food Packaging Adhesives – Essentials you need to consider

June 30 10AM CEST
Coldseal coatings in direct and indirect food contact applications

15 September 3PM CEST
Food Safe Packaging Hotmelts - Everything you need to know *

30 September 10AM CEST
Risk assessment of NIAS in food contact adhesives

28 October 10AM CEST
Plasticizers in Food Packaging – Everything you need to know

11 November 10AM CEST
Aliphatic Laminating Adhesives – Safe and highly productive solutions for retortable packaging

30 November 9AM & 4PM CEST
Primary Aromatic Amines – Everything you need to know

2 December 10AM CEST
Food Contact Statements – How to read and apply.

For more information see:
http://www.henkel-adhesives.com/packaging/webinars-48155.htm.

LED-BASED COLOUR SENSOR MEASUREMENT

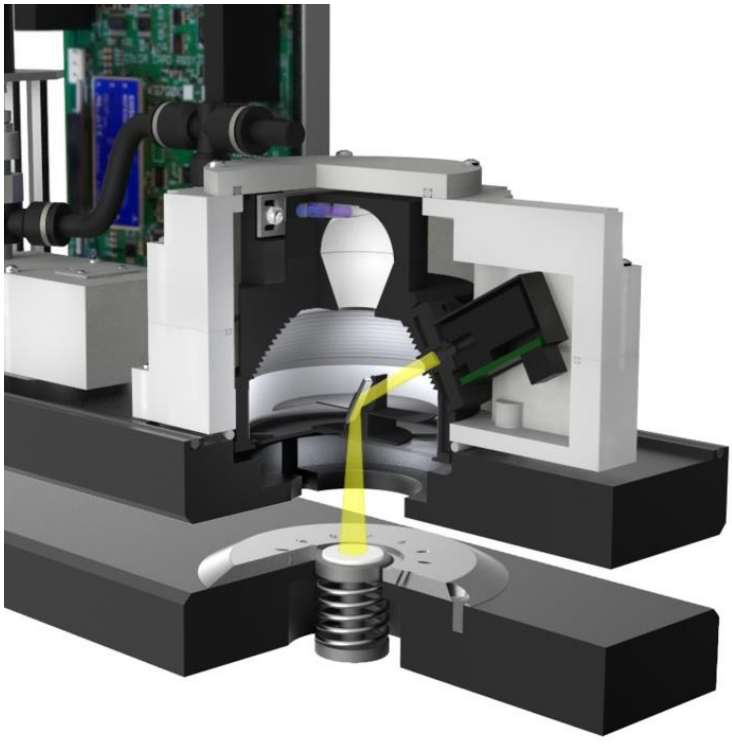
Discrete light emitting diodes (LEDs) provide continuous on-line colour measurement for more accurate paper web analysis, at a lower cost of ownership

ABB High Performance Colour Measurement is a completely new sensor design that incorporates LED technology for superior on-line measurements of colour, brightness, florescence, opacity and whiteness.

Capable of taking up to 60 measurements per second from the moving web, the sensor offers greater accuracy with lower short-term variability. With more frequent and continuous measurement, paper manufacturers benefit from increased precision leading to more consistent colour and improved final product quality. The sensor enables manufacturers to precisely control colour while minimizing off-specification production and improving shade consistency as well as reducing the use of expensive fluorescent whitening agents, dye and pigments.

By replacing traditional Xenon and Halogen illumination sources, the LEDs modulate between UV-included and UV-excluded illumination at high speed and without the use of filters. This enables continuous UV-corrected colour measurements, reducing colour variation, and improving laboratory correlation. LEDs also provide a stable and repeatable illumination leading to better measurement stability.

The sensor features a compact modular design and has no moving parts in the measurement module, thereby enhancing its reliability with lower maintenance and lifecycle costs. It can be applied the top or bottom of the web, or to both sides.



High-Performance Colour Measurement is designed for a quick and easy upgrade path. The new measurement module can replace ABB Smart Colour sensors in existing ABB QCS systems as part of ABB's stepwise evolution options for ABB QCS systems.

For further information, please visit **www.abb.com/measurement**.

PIGGING TECHNOLOGY FOR CHEMICAL TRANSFER

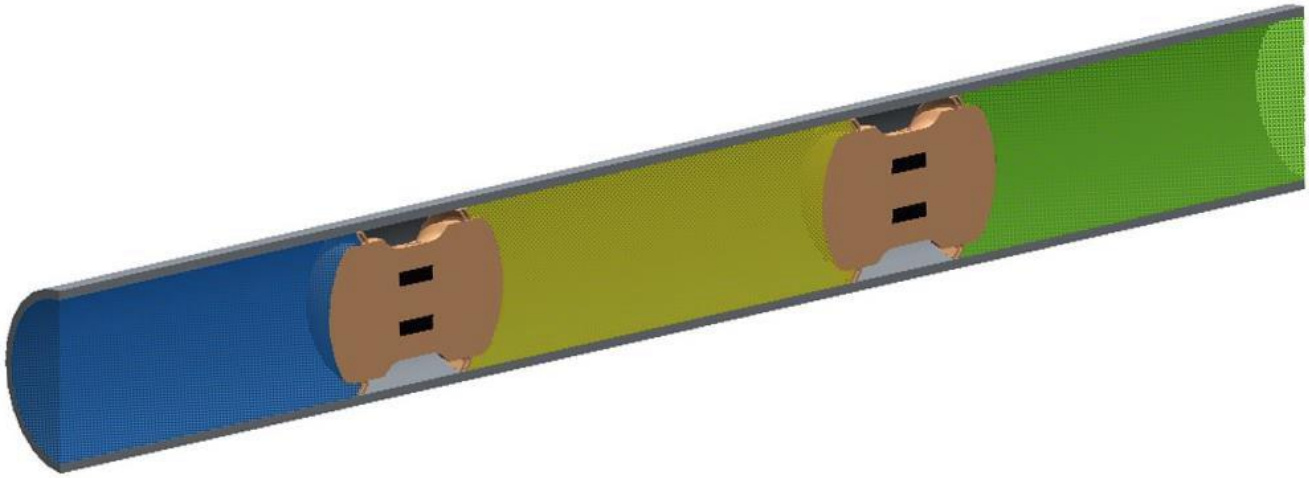
As technology provider for formulation industries such as lubricant and paint manufacturing, Cellier Activity of ABB France has developed pigging technology as a standard for the transfer of liquid raw materials and finished products. Considering that paper manufacturing could benefit from this technology in terms of production flexibility as well as reduction of operational costs and effluents, Cellier Activity now enhances its offer of chemical delivery systems with the pigging technology.

The pigging technology consists in moving a scraper inside a pipe. The scraper, otherwise known as a pig, fits exactly the internal surface of the pipe in order to:

- completely empty the pipe of all the liquid contents,
- clean the pipe with a quantity of cleaning fluid transferred through the pipe between two scrapers,
- transfer different fluids through the same pipe without cross-contamination.

Implementing this technology leads to the reduction of the number of installed pipes by using the same line for both product transfer and product recovery and yields a reduction in the quantity of flushing water. In the paper industry it can be used for the transfer of liquid raw materials, slurries and coating colours over short or long distances.

With more than forty years' experience in various formulation industries, ABB offer a wide range of patented components enabling the design and supply of a pigging system adapted to your plant specifications and budget. Of sturdy construction and designed without retention zones, the pigging components are easy to install, operate and maintain.



Picture 1 – Two scrapers separating different fluids through the same pipe

In addition to a simplified piping network with much less space requirement inside the mills, the ABB pigging technology enables improved operation efficiency by a modular and easy layout, automated and safe operations, minimised maintenance and efficient pipe flushing (operation with forward and backward pigging). Secondly, it helps to lower the environmental impact by recovering 100% of the transferred product, avoiding cross-contamination and reducing the quantity of effluents and cleaning agents.

The pigging technology is the complementary solution to cutting-edge systems developed by Cellier Activity for the paper industry such as continuous coating colour preparation, continuous starch cooking, in-line dynamic mixing, coating effluent centrifugation, etc. With this technology, Cellier Activity offers optimised chemical delivery units, based on a design aiming at improving operational and environmental performance.

Picture 2 – Pigging line with distribution valves serving storage tanks

For more information please contact:

ABB France – Process Automation Division - Cellier Activity
700 bd. Jean-Jules Herbert, 73100 Aix-Les-Bains, France

Tel.: +33 (0)4 7935 0565 - E-Mail: info.cellier@fr.abb.com

Contact: Jean-Christophe Bussolaro - E-Mail: jean-christophe.bussolaro@fr.abb.com

SAFETY SWITCH - PILZ- PSENM-LOCK

Pilz is adding PSENmlock to its range of safety switches.
PSENmlock offers safety gate monitoring (also known as interlocking) and safe guard locking for the protection of personnel and processes to the highest levels up to PL e (of EN ISO 13849) in one device. It fully satisfies the requirements of the latest interlocking standard EN ISO 14119. The slimline yet robust design and the many different installation options make PSENmlock both flexible to use and easy to install.

PSENmlock is a reliable door guard switch both for small or large, light or heavy, swinging or sliding doors, gates, covers and flaps. Above and beyond these possible applications the flexibly mounted actuator ensures high tolerance compensation and unrestricted functionality even with sagging gates. Thanks to a bi-stable solenoid, the currentless guard locking system reduces the energy consumption of the safety gate system. Diagnostic data is easily identifiable in many installation positions: LEDs on three sides of the housing support user-friendly diagnostics whatever the installation situation.

Extremely strong, with a holding force of 7500 N and the integrated latching force of 30 N, the safety gate system prevents the guard from opening inadvertently. This makes PSENmlock particularly suitable for machines with a hazardous overrun that makes guard locking up to PL d or PL e absolutely essential, such as rotating knives, flywheels or robots. In addition, an integrated mechanical restart interlock prevents the guard locking system from being activated inadvertently, without the need for separate accessories. Not only does the restart interlock make operating the machine safer, it also prevents an inadvertent restart during maintenance operations!

The integration of RFID into the tongue actuator means that, in the unlikely event that it breaks off in the switch, such a failure is detected and a safe state is preserved. The outputs of the switch are cross-monitored semi-conductor types with short-circuit detection built in.

3 levels of coding are available, and a high level of protection against manipulation is assured. Mounting plates and brackets are available for 40mm profile structural systems.

For more information please visit:
https://www.pilz.com/en-CZ/eshop/00106002227123/PSENmlock-safety-gate-system

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Installations

The following pages contain a summary of the various installations and orders from around the world of papermaking, wood panel and saw mills, and bio-power generation, received since November 2015.

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Anon China	Valmet	Supply board machine key technology and control systems for two container board machines	
Anon Denmark	Cellwood	Supply a High Consistency Pulper and a High Density Cleaner for processing old newsprint & journals	
Anon Ukraine	Papcel	Reconstruct the stock preparation line and wet end of a tissue machine	
Arkhangelsk Pulp and Paper Mill Novodvinsk Russia	Valmet	A recausticizing upgrade	2017
Asia Kraft Paper Bangkok Thailand	Allimand Group	Supply a hydraulic headbox	
Atlantic Packaging Toronto Canada	Precision Energy Services	Supply sludge-to-energy plant	
BillerudKorsnäs Gruvön Sweden	Pöyry	Awarded engineering services contract for a new board machine project	
BillerudKorsnäs Skärblacka Sweden	Pöyry	Awarded engineering services contract for machine glazed (MG) paper machine relocation project from Tervasaari in Finland to Skärblacka in Sweden	
Board24 (Logson Group) Preston UK	Mosca Direct	Bespoke pallet system	
Bruks Group Cramlington Estover UK	Burmeister & Wain	Supply a wood chip handling system for the renewable energy plant	2017
Cartiere Modesto Cardella Lucca Italy	Andritz	Rebuild PM3 (testliner)	2016
Cartiera di Momo Momo Italy	Bekaert Solaronics	Supply four IR (UniDryer V3) and air turn bars after each coating station	2016
Celupaper S.A. (part of Grupo Vual) Papelera Nicaragua South American	Toscotec	Supply MODULO-PLUS 65tpd tissue line (PM4)	2017
Cheng Yang Paper Mill Co., Ltd. Ho Chi Minh City Vietnam	GAW Technologies	Supply starch preparation, working station and wet end chemical preparation system for PM2	2016
CMPC Celulosa S.A. Guaíba Brazil	Voith	Rebuild of PDM1 pulp dryer	2016

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
CMPC Celulosa S.A. Laja Pulp Mill Chile	Valmet	Supply new white liquor plant	2018
Corrboard UK Ltd. Scunthorpe UK	tba	Install 500kW Anaerobic Digester	
Domtar Windsor QC Canada	PulpEye	Supply PulpEye analyser	
Fibria Grosso do Sul Pulp Mill Brazil	ABB	Supply integrated process electrification, automation and optimisation systems	
Fibria Três Lagoas Unit State of Mato Grosso do Sul Brazil	Pöyry	Supply balance of plant at the Horizonte 2 Project	
Fine Hygienic Holding (FHH) (Nuqul Group) Al Nakheel Mill Abu Dhabi UAE	Valmet	Supply Advantage DCT 200TS tissue production line	2017
Forestal y Papelera Concepcion mill Chile	Valmet	Supply Advantage NTT 5.5m tissue line	
Fujian Jinmin Reconstituted Tobacco Development Co., Ltd. Fuzhou city Fujian province China	Toscotec	Supply Steel Yankee Dryer	2017
Georgia-Pacific Alabama River Cellulose Mill USA	tba	Replacing one of the mill's two existing wood yards and upgrade the other wood yard and a major upgrade to one of the mill's machines that produces pulp	
Greenpaper (Formerly known as Propasa) San Nicolás de los Garza Mexico	Bekaert Solaronics	Supply one infrared drying system GemDryer after a rebuilt of UMV twin HSM coater on its PM3	
Grupo Hinojosa Papelera de Sarrià Mill Spain	Cadagua	Supply a new effluent treatment line including an anaerobic paper sludge treatment unit for biogas production	2016
Guizhou Chitianhua Paper Industry (Taison Group) Chishui facilities Guizhou China	A.Celli Paper	Supply 9 model AC882 5.6m shaftless tissue rewinders	2017

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Guizhou Chitianhua Chishui city Guizhou Province China	Andritz	Supply two 5.6m tissue machines (TM5 & 6)	2016 (TM5) 2017 (TM6)
Hebei Jinboshi Group Co. Ltd China	PMP	Supply two 75 tpd tissue lines	2016 (TM1) & 2017 (TM2)
Helen Salmisaari Power Plant Helsinki Finland	Valmet	Supply a 92MW wood pellet heating plant	2018
Hokuetsu Kishu Paper Bernard Dumas France	ABK Groupe	Modify PM1	
Huanggang Chenming Pulp & Paper greenfield pulp mill Hubei province China	Andritz	Supply continuous cooking plant for production of kraft pulp for paper grades	
Huhtamaki Ivanteevka Russia	tba	Expansion of egg packaging manufacture	
Jiangsu Changfeng Paper China	PMP	Supply rebuild of PM2 press section	2017
Khanna Paper Mills India	Valmet	Supply paper machine (PM5) wet end rebuild	2017
Kotkamills Kotka Mill Finland	Kemira	Awarded a start-up contract in the "Flying Eagle" project for converting PM2 into a high performance food service board (FSB) machine	2016
Kotkamills Kotka Mill Finland	Valmet	Received two orders for automation technology	2016
KRPA PAPER a.s. Czech Republic	GapCon	Rebuild PM6 press section	
Kruger Packaging L.P. Trois-Rivières Québec Canada	ABB	Complete engineering solution to the PM10 rebuild project	2017
Kruger Packaging L.P. Trois-Rivières Québec Canada	Kadant Black Clawson Inc.	Supply a recycled fibre processing line to produce lightweight, high-strength linerboard on PM10	2017
Kruger Packaging L.P. Trois-Rivières Québec Canada	Pöyry	Awarded detailed engineering services assignment for the rebuild of the PM10	2017

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Kruger Packaging L.P. Trois-Rivières Québec Canada	Valmet	Rebuild and modernise PM10, transforming from newsprint to lightweight packaging	2017
Lee & Man Chongqing Mill China	Valmet	Supply two Advantage DCT 5.6m tissue production lines	2016
LLC "Siberwood" Biorefinery complex Yenisei District Krasnoyarsk Region Russia	China CAMC Engineering Co., Ltd. Andritz Hawkins Wright NPK LCC	Construct a biorefinery	2019
Lucart Porcari facility Lucca Italy	Toscotec	Rebuilt PM4 tissue machine	2016
Marusumi Paper Ohe Mill Japan	Valmet	Rebuild press section into shoe press technology	2016
Metsä Board Husum Pulp Mill Sweden	ÅF	Modernise the control systems. The contract is for an end-to-end solution and covers conversion to new, modern Siemens control systems for the bleach, cooking and recycling plants	2016
Metsä Group Äänekoski Bioproduct Mill Finland	ABB	Supply the complete power and process electrical systems	2017
Metsä Group Äänekoski Bioproduct Mill Finland	Pöyry	Awarded EPC assignment for tall oil plant	2017
Metsä Group Äänekoski Bioproduct Mill Finland	Sulzer	Deliver an extensive process pump package	2017
Metsä Group Äänekoski Bioproduct Mill Finland	Valmet	Supply a sulphuric acid plant.	2017
Papeterie de Clairefontaine Etival France	PMT Italia	Rebuild the press section of PM5	2016
Port Hawkesbury Paper NS Canada	PulpEye	Supply PulpEye analyser	
Porvoon Energia Oy Loviisa Finland	KPA Unicon	Deliver a 10MWth biomass fired boiler plant	2016

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Porvoon Energia Oy Loviisa Finland	Valmet	Supply automation for biomass-fired boiler plant	2016
Pro-Gest Mantova site Italy	Valmet	Supply an OptiConcept M boardmaking line and mill-wide automation system	
Reno di Medici Arnsberg Germany	Voith	Installation of a new primary pumping system, state of the art headbox including an extended de-watering	2016
Rottneros Pulp Mill Sweden	tba	Install new biomass boiler	2017
Rottneros Pulp Mill Sweden	Valmet	Supply high consistency bleaching system	2016
Rottneros Bruk AB Rottneros Mill Sweden	Andritz	Upgrade flash drying capacity of CTMP pulp drying line	2016
Rottneros AB Vallvik Pulp Mill Sweden	Valmet	Deliver a new white liquor filter	2016
Sappi Kirkniemi Mill Finland	Valmet	Paper machine wet end rebuild	2016
SCA Östrand Pulp Mill Sweden	ABB	Supply engineering for the control system and optimisation of all processes at the expanded pulp mill	2018
SCA Östrand Pulp Mill Sweden	Andritz	Supply wood yard equipment	2018
SCA Östrand Pulp Mill Sweden	Head Engineering	Supply tall oil plant	2018
SCA Östrand Pulp Mill Sweden	Skanska	To refurbish and extend the mill	2018
SCA Östrand Pulp Mill Sweden	Sweco	Responsible for land use and construction planning, and parts of the process piping plan	2018
SCA Östrand Pulp Mill Sweden	Valmet	Supply cooking, fibre line and evaporation plant.	2018
Segezha Pulp and Paper Mill (Segezha PPM) Republic of Karelia Russia	Voith	Supply a complete process line for sack paper	
Siam Cellulose Ban Pong Mill Thailand	Valmet	Supply pulp cooking plant	2016
Smurfit Kappa Barbosa Mill Colombia	PMP	Supply part-rebuild to press section of PM1	2016/2017

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Smurfit Kappa Cellulose Du Pin Biganos France	Valmet	New screening and brown stock washing plant (1250adt/d)	2017
Smurfit Kappa Los Reyes Mill Mexico	PMP Group	Supply rebuild of PM6 involving a blend of repurposed and refurbished assets	2017
Södra Cell Mörrum Pulp Mill Sweden	Andritz	Supply new evaporator and modernisation of the brown stock washing system	2017
Södra Cell Mörrum Pulp Mill Sweden	Valmet	Supply the new brown washing plant in the dissolving pulp line	2017
Södra Cell Mönsterås Pulp Mill Sweden	Valmet	Supply TwinRoll press, then a recovery boiler upgrade and an evaporation line upgrade	Late 2015, then late 2016
Sofidel Delitissue Mill Ciechanóv Poland	Valmet	Supply an Advantage NTT tissue production line	2017
Sofidel Lancaster plant UK	A.Celli Paper	Supply tissue rewinder	2016
Sonoco-Alcore Karhula Paper Mill Finland	Andritz	Supply pulping and de-trashing equipment for the OCC stock preparation line	2016
Steinbeis Papier Glückstadt Mill Germany	tba	Install new drives on PM4 and an automated warehouse system	2017
Stora Enso Ostrołęka Mill Poland	tba	To commission a feasibility study with the aim of expanding containerboard production	2016
Suzano Papel e Celulose Imperatriz Brazil South America	Voith	Supply 220tpd tissue line	2017
Suzano Pulp and Paper Mucuri Unit Bahia Brazil	Savcor	Modernise the Anodic Protection System in digester 1	2015
Suzano Papel e Celulose Mucuri Brazil South America	Voith	Supply 220tpd tissue line.	2017
Vinda Group Sanjiang facility Guangdong province China	Toscotec	Supply two Ahead 2.0M tissue machine	2016

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Vinda Group Shandong facility China	Toscotec	Supply one Ahead 1.5M tissue machine	2016
WEPA Cassino Mill Italy	Toscotec	Rebuild and upgrade PM13 tissue line	2016
WEPA Professional Piechowice S.A. Piechowice Poland	Toscotec	Supply AHEAD-2.0S 2.8m tissue production line	2017
Yuen Foong Yu Ching Shui Mill Taiwan	PMP Group	Rebuild TM7 with new Yankee with cap, steam and condensate equipment	2016

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 2, Number 1, 2016

Paper Industry Technical Association

5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Research Articles

Most journals and magazines devoted to the paper industry contain a mixture of news, features and some technical articles. However, very few contain research items, and even fewer of these are peer-reviewed.

This listing contains the most recent articles from the five main journals that publish original research:

- *APPITA JOURNAL*
- *IPPTA JOURNAL*
- *J-FOR*
- *NORDIC PULP & PAPER RESEARCH JOURNAL*
- *TAPPI JOURNAL*

The Paper Industry Technical Association (PITA) is an independent organisation which operates for the general benefit of its members – both individual and corporate – dedicated to promoting and improving the technical and scientific knowledge of those working in the UK pulp and paper industry. Formed in 1960, it serves the Industry, both manufacturers and suppliers, by providing a forum for members to meet and network; it organises visits, conferences and training seminars that cover all aspects of papermaking science. It also publishes the prestigious journal *Paper Technology* and the *PITA Annual Review*, both sent free to members, and a range of other technical publications which include conference proceedings and the acclaimed *Essential Guide to Aqueous Coating*.

***APPITA JOURNAL*, Vol.69 No.1 – Jan-Mar 2016**

1. Terap, Medang and Balik angina shown to be similar to commercial fast-growing tree species used for pulp wood production
2. Impact of additives and filers on OBA effectiveness in HYP pulps is quantified
3. Obtaining true fibre property distributions from optical fibre analysers
4. Advantages and disadvantages of interstage fractionation for TMP can be managed by the ratio of energy applied to high and low consistency refining
5. Simulation studies show integrating electrolysis in a modern pulp mill (to produce hydrogen and oxygen) can decrease the operating costs when the price for electricity is low or purchased oil price is high

***APPITA JOURNAL*, Vol.69 No.2 – Apr-Jun 2016**

1. Fibre changes after interstage fractionation and LC refining
2. Factors affecting blister pack peel strength
3. Nanofibrillated cellulose additive to reduce linting
4. Differing fixing agent effects on dissolved and colloidal substances

***IPPTA JOURNAL*, Vol.27 No.4 – Oct-Dec 2015**

1. Performance and Appearance Of Packaging Grades Of Paper – Study On Quality Measurement Methods
2. Innovation In Steam Systems In Pulp And Paper Industry
3. Reducing Environmental Footprint Through Holistic Approach – A Case Study Of Pulp & Paper Mills In Kashipur Cluster
4. Total Integrated Automation For Pulp & Paper Industry
5. Performance Evaluation Of Corrugated Packaging – A Key To Success For Papermakers And Corrugators
6. Improvement In Optical And Print Properties Of Coated Recycled Board Used For Packaging
7. Retention – Drainage – Formation
8. Nanoparticles Based Biolatex: Application In Coating
9. Optimization of Fibre Properties Using Single Pass Refining vs Recirculation – A Case Study Kumar Mukesh
10. Saving Energy With The Vacuum System

***J-FOR*, Vol.5 No.2 – 2016**

1. Automatic selection of relevant data for paper machine diagnostics
2. Condenser cooling-water control strategy recovers waste heat from power generation
3. ASB dredging and odour control
4. Post-D0 tower brightness – useful or not?
5. 3D printing – a review of technologies, markets, and opportunities for the forest industry
6. Environmental evaluation of durapulp bio-composite using LCA: comparison of two applications

***NORDIC PULP & PAPER RESEARCH JOURNAL*, Vol.30 No.4 – 2015**

1. BIOREFINERY - Structural changes in softwood kraft lignin during non-oxidative thermal treatment
2. BIOREFINERY - Fractionation of rice straw for producing dissolving in biorefinery concept

3. BIOREFINERY - Can redispersible low-charged nanofibrillated cellulose be produced by the addition of carboxymethyl cellulose?
4. CHEMICAL PULPING - Investigation of manganese hydrolysis particles and decomposition of hydrogen peroxide in the pulp bleaching process
5. CHEMICAL PULPING - Improved pulp yield and strength by retained glucomannans in kraft pulping of softwood
6. MECHANICAL PULPING - Low dosage sulfite pretreatment in a modern TMP-line
7. MECHANICAL PULPING - Pulp property development Part I: Interlacing under-sampled pulp properties and TMP process data using piece-wise linear functions
8. MECHANICAL PULPING - Low consistency refining of mechanical pulp: how plate pattern and refiner operating conditions change the final properties of pulp
9. PAPER CHEMISTRY - Enhancing the performance of carboxymethyl cellulose by chitosan in producing barrier coated paper sheets
10. PAPER CHEMISTRY - Anchorage of ASA on cellulose fibers in sizing development
11. PAPER PHYSICS - The effect of blending ratio and crowding number on the yield stress of mixed hardwood and softwood pulp fibre suspensions
12. PAPER PHYSICS - A multi-scale simulation method for the prediction of edge wicking in multi-ply paperboard
13. PAPER PHYSICS - The influence of grammage and pulp type on through air drying
14. COATING - Semiconductor nanoparticles as surface coating for security papers
15. PAPERMAKING - Rewetting after high vacuum suction boxes in a pilot paper machine
16. PRINTING - Research on quality evaluation system of prints based on D-M model of micro dot
17. PAPER-INK INTERACTIONS - A novel approach for studying the effects of corona treatment on ink-substrate interactions
18. RECYCLING - Enzymatic deinking for recycling of photocopier waste papers using crude cellulase and xylanase of *Trichoderma harzianum* PPDDN10 NFCCI 2925

***NORDIC PULP & PAPER RESEARCH JOURNAL*, Vol.31 No.1 – 2016**

1. BIOREFINERY - Utilizing active pH control for enhanced hot-water extraction of wood
2. BIOREFINERY - On acoustical properties of novel foam-formed cellulose-based material
3. BIOREFINERY - Phosphorylated nanofibrillated cellulose: production and properties
4. BIOREFINERY - Life Cycle Assessment of lignin extraction in a softwood kraft pulp mill
5. Supplementary information: Life Cycle Assessment of lignin extraction in a softwood kraft pulp mill
6. BIOREFINERY - Sulfur-free pulping of hot-water-extracted spruce sawdust
7. CHEMICAL PULPING - The effect of foil rotor design on some aspects of pulp screen performance
8. CHEMICAL PULPING - On the origin of the spectroscopic signals of cellulose II-type in sulphite dissolving pulp
9. CHEMICAL PULPING - Mill tests on separating green liquor dregs with hydrocyclone
10. MECHANICAL PULPING - The relation between net power, gap, and forces on bars in low consistency refining
11. PAPER CHEMISTRY - Determination of rosin-size retention in wet-end process by quantifying the resin acid content in paper products

12. PAPER PHYSICS - Dynamic model and simulation for a high consistency refining process
13. PAPER PHYSICS - In-plane strength anisotropy and layering effects for laboratory sheets with recycled pulp and softwood kraft pulp
14. PAPER PHYSICS - Investigation of interfibre joint failure and how to tailor their properties for paper strength
15. PAPER PHYSICS - Short compression testing of multi-ply paperboard, influence from shear strength
16. PAPER PHYSICS - Multilayer assembly onto pulp fibres using oppositely charged microfibrillated celluloses, starches, and wet-strength resins − Effect on mechanical properties of CTMP-sheets
17. PRINTING - On the accuracy of shaping from shading algorithm for restoring three-dimensional model of printing dot
18. PRINTING - The effect of multilayer polyelectrolyte coating on inkjet ink water fastness and rub resistance
19. PAPER-INK INTERACTIONS - Measurements and dimensional scaling of spontaneous imbibition of inkjet droplets on paper
20. RECYCLING - Deinking by flotation under neutral condition using fatty alcohol ethoxylates

***TAPPI JOURNAL* – Vol.14, No.10, Oct 2015**

1. BIOENERGY - Effect of feedstock moisture content on biomass boiler operation
2. BIOREFINERY - Pyrolysis of hardwood soda-anthraquinone spent pulping liquor
3. PULPING - Hardwood pulping kinetics of bulk and residual phases
4. BLEACHING - Quantification of lignin-carbohydrate complexes in hardwood pulps, Part 2: Effects of bleaching chemicals
5. FIBER SUPPLY - Examination of the potential to reduce water application rates in pine wet decks

***TAPPI JOURNAL* – Vol.14, No.11, Nov 2015**

1. BLEACHING - Application of pure, thermostable, alkali-tolerant xylanase in bleaching of oxygen-delignified pine kraft pulp
2. BIOREFINERY - Applicability of electrodialysis to the separation of sodium acetate from synthetic alkaline hardwood extract
3. CORROSION - Identifying microbially influenced corrosion on surfaces contacted by mill waters
4. PROCESS CONTROL - Causality of manufacturing processes with significant time delays
5. NONWOOD PULPING - Desilication of bamboo for pulp production
6. PRINTING - An automatic method for detecting missing dots in rotogravure printing

***TAPPI JOURNAL* – Vol.15, No.1, Jan 2016**

1. PRE-WETTING - Press wetting as an enhanced wetting method for baled OCC material
2. INK DISPERSION - Factors influencing polymeric granule-assisted dispersion of ultraviolet ink
3. DRUM PULPING - Falling impact as an isolated disintegration mechanism in drum pulping for packaging board
4. MINERAL OIL REMOVAL - Removal of mineral oil during recovered paper processing
5. DEINKING - Study on neutral chemical deinking of laser printed papers

***TAPPI JOURNAL* – Vol.15, No.2, Feb 2015**

1. PULPING - Characterizing latency removal in mechanical pulping processes part I: Kinetics
2. WASTEWATER TREATMENT - Biochemical methane potential of kraft bleaching effluent and codigestion with other in-mill streams
3. PRINTING - Causes of back-trap mottle in lithographic offset prints on coated papers
4. PAPERMAKING - Effect of sheet temperature on web densification during calendering
5. PROCESS CONTROL - Support vector regression and model reference adaptive control for optimum control of nonlinear drying process
6. WASTEWATER TREATMENT - Anaerobic treatment to improve sludge recovery at a deinked fiber pulp and paper mill

***TAPPI JOURNAL* – Vol.15, No.3, Mar 2015**

1. FIBER SUPPLY - Status update on development of a eucalyptus plantation program in the southeastern United States and higher elevations of southern Brazil
2. FIBER SUPPLY - Potential of *C. citriodora* wood species for kraft pulp production
3. BLEACHING - Impact of dissolved lignin in oxygen delignification and chlorine dioxide stages
4. BLEACHING - Revised steady-state model for chlorine dioxide brightening that considers extraction washer carryover effects
5. RECOVERY CYCLE - Improving recovery boiler availability through understanding fume behavior
6. RECOVERY CYCLE - Formation of blue deposits in kraft recovery boilers
7. RECOVERY CYCLE - Ring removal in rotary kilns used by the pulp and paper industry
8. BIOREFINERY - Treating kraft mill extract using bipolar membrane electrodialysis for the production of acetic acid

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 2, Number 1, 2016

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Technical Abstracts

The general scientific and engineering press consists of several thousand journals, conference proceedings and books published annually. In among the multitude of articles, presentations and chapters is a small but select number of items that relate to papermaking, environmental and waste processing, packaging, and wood panel manufacture. The edited abstracts contained in this report show the most recent items likely to prove of interest to our readership, arranged as follows:

Page 2	*Environment* *Fibres* *Filler / Pigments* *Nano-Science*
Page 5	*Nonwovens* *Novel Paper Products*
Page 6	*Packaging Technology* *Paper Chemistry*
Page 7	*Starch*
Page 8	*Stock Preparation*
Page 9	*Testing* *Waste Treatment*
Page 10	*Wood Panels*

The Paper Industry Technical Association (PITA) is an independent organisation which operates for the general benefit of its members – both individual and corporate – dedicated to promoting and improving the technical and scientific knowledge of those working in the UK pulp and paper industry. Formed in 1960, it serves the Industry, both manufacturers and suppliers, by providing a forum for members to meet and network; it organises visits, conferences and training seminars that cover all aspects of papermaking science. It also publishes the prestigious journal *Paper Technology* and the *PITA Annual Review*, both sent free to members, and a range of other technical publications which include conference proceedings and the acclaimed *Essential Guide to Aqueous Coating*.

ENVIRONMENT

Maximizing the greenhouse gas reductions from biomass: The role of life cycle assessment, Patricia Thornley *et al*, *Biomass and Bioenergy*, 81. Biomass can deliver significant greenhouse gas reductions in electricity, heat and transport fuel supply. However, our biomass resource is limited and should be used to deliver the most strategic and significant impacts. The relative greenhouse gas reduction merits of different bioenergy systems (for electricity, heat, chemical and biochar production) were examined on a common, scientific basis using consistent life cycle assessment methodology, scope of system and assumptions.

FIBRES

Surface and thermal enhancement of the cellulosic component of thermo mechanical pulp using a rapid method: Iodomethane modification, Michael George *et al*, *Carbohydrate Polymers*, 142. The feasibility of employing chemical methods for enhancement of cellulose-based materials is dependent on the availability, price, and green index of the modifying agent. This study details the use of iodomethane, an inexpensive organo halide, to increase the hydrophobicity of thermo mechanical (TMP) samples, which renders them better structural elements for composite materials.

Preparation of reactive fibre interfaces using multifunctional cellulose derivatives, Beatriz Vega *et al*, *Carbohydrate Polymers*, 132. Cellulose fibres have poor reactivity and limited potential for surface engineering with advanced chemical functionalisation in water. In this work, cellulose fibres were decorated with azide functions by charge-directed self-assembly of a novel water-soluble multifunctional cellulose derivative yielding reactive fibres.

FILLERS / PIGMENTS

Fillers for Papermaking: A Review of their Properties, Usage Practices, and their Mechanistic Role, Martin A. Hubbe & Robert A. Gill, *Bioresources*, 11 (1). Issues of cost and product quality have caused papermakers to place increased attention on the use of mineral additives, which are the subject of this review article. Technologists responsible for the production of paper can choose from a broad range of natural and synthetic mineral products, each of which has different characteristic shapes, size distributions, and surface chemical behaviour. This article considers methods of characterisation, and then discusses the distinguishing features of widely available filler products. The mechanisms by which fillers affect different paper properties is reviewed, as well as procedures for handling fillers in the paper mill and retaining them in the paper. Optical properties of paper and strategies to maintain paper strength at higher filler levels are considered. The goal of this review is to provide background both for engineers working to make their paper products more competitive and for researchers aiming to achieve effects beyond the current state of the art. ***[Editor's note – this article would have been reproduced in this edition of PAPERmaking!, but for the fact it is 74 pages long. It is an article well worth reading and can be downloaded free of charge from www.bioresources.com]***

NANO-SCIENCE

Biodegradability and mechanical properties of reinforced starch nanocomposites using cellulose nanofibers, Mehran Babaee, *Carbohydrate Polymers*, 132. In this study the effects of chemical modification of cellulose nanofibres (CNFs) on the biodegradability and mechanical properties of reinforced thermoplastic starch (TPS) nanocomposites was evaluated. Compared with the neat TPS, the addition of nanofibres

improved the degradation rate of the nanocomposite and particularly ACNFs reduced degradation rate of the nanocomposite toward fungal degradation.

Surface grafting of cellulose nanocrystals with natural antimicrobial rosin mixture using a green process, Daniele Oliveira de Castro *et al*, *Carbohydrate Polymers*, 137. Surface functionalisation of cellulose nanocrystals (CNCs) aims to improve their properties. The main objective of this study was the esterification of the surface of CNCs using nontoxic resin acids. The antimicrobial activities of the modified and neat CNC were investigated; the rosin-grafted CNC exhibited a strong antibacterial activity against Gram-negative bacteria and a modest antibacterial activity against Gram-positive bacteria.

Extraction and comparison of carboxylated cellulose nanocrystals from bleached sugarcane bagasse pulp using two different oxidation methods, Kaitao Zhang *et al*, *Carbohydrate Polymers*, 138. Two kinds of carboxylated cellulose nanocrystals and the effects of oxidant content on the yield, carboxyl content, degree of polymerization (DPv) and morphology of the oxidised celluloses in the two oxidation methods were studied.

Nanofibrillated cellulose (CNF) from eucalyptus sawdust as a dry strength agent of unrefined eucalyptus handsheets, María Evangelina Vallejos *et al*, *Carbohydrate Polymers*, 139. Nanofibrillated cellulose has been obtained from the cellulosic fraction of eucalyptus sawdust. The obtained CNF was subsequently used as a dry strength agent on unbleached unrefined eucalyptus pulp. The addition of 3, 6 and 9wt.% of CNF increased lineally the tensile index of handsheets, compatible with papermachine runnability. The other mechanical properties also increased substantially, and porosity decreased moderately.

PLLA-grafted cellulose nanocrystals: Role of the CNC content and grafting on the PLA bionanocomposite film properties, Erlantz Lizundia *et al*, *Carbohydrate Polymers*, 142. Cellulose nanocrystals (CNC), extracted from microcrystalline cellulose by acid hydrolysis, were grafted by ring opening polymerization of l-Lactide at two different CNC:l-lactide ratios. The resulting CNC-g-PLLA nanohybrids were incorporated in poly(lactic acid) (PLA) matrix by an optimised extrusion process at two different content and obtained bionanocomposite films were characterised by thermal, mechanical, optical and morphological properties.

Microfibrillated cellulose and borax as mechanical, O2-barrier, and surface-modulating agents of pullulan biocomposite coatings on BOPP, Carlo A. Cozzolino *et al*, *Carbohydrate Polymers*, 143. Multifunctional composite coatings on bi-oriented polypropylene (BOPP) films were obtained using borax and microfibrillated cellulose (MFC) added to the main coating polymer. The deposition of the coatings yielded an increase in the elastic modulus of the entire plastic substrate, a decrease of both static and kinetic coefficients of friction, dramatically increased the oxygen barrier performance of BOPP, especially under dry conditions, and highly wettable surfaces.

Fabrication of flexible self-standing all-cellulose nanofibrous composite membranes for virus removal, Weijuan Huang *et al*, *Carbohydrate Polymers*, 143. All-cellulose nanocomposite membranes with excellent performance were successfully fabricated as novel filtration system to remove nanoparticles and virus from aqueous medium. These membranes were composed of two combined layers: an electrospun cellulose nanofabric layer treated by hot-pressing to provide mechanical support and a coating of regenerated cellulose gel with tiny inter-connected pores as barrier.

The role of heteropolysaccharides in developing oxidized cellulose nanofibrils, Qijun Meng *et al*, *Carbohydrate Polymers*, 144. A fundamental study was undertaken to determine the general role of heteropolysaccharides during the production of TEMPO-oxidized cellulose nanofibrils.

Characterisation of films and nanopaper obtained from cellulose synthesised by acetic acid bacteria, Linda Rozenberga *et al*, *Carbohydrate Polymers*, 144. Bacterial cellulose (BC) samples were obtained using two culture media and two bacteria. Nanopaper was obtained from the BC through oxidation and both were studied to determine the impact of culture media and bacteria strain on nanofibre structure and mechanical properties. It was concluded that BC is an excellent source for easily obtainable, highly crystalline and strong nanofibres.

Suitability of wheat straw semichemical pulp for the fabrication of lignocellulosic nanofibres and their application to papermaking slurries, E. Espinosa *et al*, *Cellulose*, 23 (1). The present work studies the feasibility of wheat soda pulp as a raw material for the fabrication of cellulose nanofibres and their application as an additive in papermaking.

Preparation of porous sheets with high mechanical strength by the addition of cellulose nanofibrils, Kyujeong Sim & Hye Jung Youn, *Cellulose*, 23 (2). Porous sheets with high mechanical strength were prepared with natural pulp fibres (hardwood and softwood bleached kraft pulp) and polyethylene terephthalate (PET) by adding cellulose nanofibrils (CNF) through a wet-laid forming method. The structure and mechanical properties of the porous sheets were investigated in this study depending on the type of mixed fibres, the CNF ratio, and drying methods (cylinder-drying and freeze-drying).

The feasibility of incorporating cellulose micro/nanofibers in papermaking processes: the relevance of enzymatic hydrolysis, Q. Tarrés *et al*, *Cellulose*, 23 (2). Cellulose nanofibre (CNF) is becoming a topic of great interest among the industrial and academic communities, mainly due to their potential applications in very well-differentiated industrial sectors. Among this wide range of applications, papermaking is one of the most accepted and studied. The present work attempts to assay the enzymatic hydrolysis of cellulose fibres to obtain CNFs, and offers a cost-efficient solution for the application of CNF in the production of paper from bleached pulp as well as a promising alternative to those conventional processes from a technical point of view.

Processing of wood-based microfibrillated cellulose and nanofibrillated cellulose, and applications relating to papermaking: a review, Sinke H. Osong *et al*, *Cellulose*, 23 (1). This review examines the past and current situation of wood-based MFC and NFC in relation to its processing and applications relating to papermaking.

Engineering cellulose nanofibre suspensions to control filtration resistance and sheet permeability, Qing Li *et al*, *Cellulose*, 23 (1). This study examines and quantifies the effect of adding polyelectrolytes to cellulose nanofibre suspensions on their gel point, which is the lowest solids concentration at which the suspension forms a continuous network. The lower the gel point, the faster the drainage time to produce a sheet and the higher the porosity of the final sheet formed.

Characterization of cellulose nanofiber sheets from different refining processes, Kohji Nobuta *et al*, *Cellulose*, 23 (1). Four types of kenaf bast fibres were prepared via a combination of treatments for delignification and alkaline treatments, for the removal of hemicellulose. Each type of kenaf bast fibre with different refining processes were nano-fibrillated by grinding.

NONWOVENS

3D-oriented fiber networks made by foam forming, Majid Alimadadi & Tetsu Uesaka, *Cellulose*, 23 (1). In industrial applications, such as paper and nonwovens, cellulose fibres are used in the form of a network where the fibres are oriented more or less in the sheet-plane direction. However, in many biological systems, fibres are instead oriented in three-dimensional (3D) space, creating a wide variety of functionalities. In this study researchers created a 3D-oriented fibre network on the laboratory scale and have identified some unique features of its structure and mechanical properties.

Hybrid adsorbent nonwoven structures: a review of current technologies, Hooman Amid *et al*, *Journal of Materials Science*, 51 (9). Adsorptive nonwoven substrates are composite media that contain adsorbent materials within their fibrous structure; the methods to incorporate adsorbents in nonwoven webs determine their adsorption capacity. The key objective for hybridisation is to immobilise the adsorbent while controlling the packing density and pressure drop of the composite media. The primary focus of this review is on hybridisation techniques that incorporate activated carbons and/or metal-organic frameworks in nonwoven structures, used in gas filtration.

NOVEL PAPER PRODUCTS

Large scale preparation of graphene oxide/cellulose paper with improved mechanical performance and gas barrier properties by conventional papermaking method, Quanbo Huanga *et al*, *Industrial Crops and Products*, 85. Graphene oxide (GO)/cellulose paper was prepared by adding aqueous dispersion of GO into cellulose fibre pulp in a traditional papermaking procedure. Cationic polyacrylamide (CPAM) was added as a mordant to induce the self-assembly of GO layers on the fibre surfaces. The surface morphology, mechanical properties and gas permeability of GO/cellulose paper with varying GO contents were investigated. The large scale preparation of GO/cellulose paper with high doping amount of GO, which exhibited dense and compact geometry and low gas permeability, is ideal for potential packaging applications.

Study on the Printing Quality Comprehensive Evaluation of Color Inkjet Paper, Xiaoxiu Hao *et al*, in *Proceedings of the 2015 International Conference on Advanced Material Engineering*, Chapter 2: Materials Process Engineering. The coating of inkjet paper can not only prevent the ink to the bottom, but also control the spread and thickness of the ink particles, which influence the printing definition. So the coating formulation of inkjet paper directly affects the quality of printed matter. Six kinds of inkjet papers from different companies were selected for experiment, and then their various printing quality parameters were compared. Experimental results showed that the parameters such as dot gain, printing colour density, relative contrast and ink absorbency could synthetically evaluate the printing quality of inkjet paper. The data could provide the theoretical basis for quality control of inkjet paper. Furthermore they have a strong guiding effect on the actual production of inkjet paper.

PACKAGING TECHNOLOGY

Silver-nanoparticle-impregnated cellulose nanofiber coating for packaging paper, Elahe Amini *et al*, *Cellulose*, 23 (1). In this study, antimicrobial packaging was prepared by mixing colloidal silver nanoparticles with cellulose nanofibre (CNF) and depositing this hybrid coating (CNF/Ag) as a layer on different paper substrates. Although the coating coverage was influenced by paper surface characteristics and coat weights, almost all properties (except water absorption of greaseproof paper) including the water vapour transmission rate, oil resistance, and tensile strength of the CNF/Ag-coated papers, were improved in comparison with uncoated papers.

Effect of Pallet Deckboard Stiffness on Corrugated Box Compression Strength, Matthew Baker *et al*, *Packaging Technology and Science*, 29 (3). The packaging industry has long considered pallets to be rigid structures. However, in a unit load, the weight of the product produces compressive forces that are distributed across the pallet causing the top deckboards to deflect. Corrugated paperboard boxes are highly susceptible to changing support conditions; therefore, the deckboard deflection directly impacts the vertical compression strength of the box. Therefore, the objective of this study is to evaluate the effect of pallet deckboard stiffness on the vertical compression strength and deflection of corrugated paperboard boxes.

Strategies to improve the mechanical strength and water resistance of agar films for food packaging applications, Ana M.M. Sousa & Maria P. Gonçalves, *Carbohydrate Polymers*, 132. Agar films possess several properties adequate for food packaging applications. In this work, native and alkali-modified agars obtained from sustainably grown seaweeds were mixed with locust bean gum (LBG) to make 'knife-coated' films with fixed final concentration (1wt%) and variable agar/LBG ratios. The findings can help reduce the cost-production of agar packaging films; moreover, the controlled cultivation of seaweeds can provide continuous and reliable feedstock for transformation industries.

Preparation of the CNC/Ag/beeswax composites for enhancing antibacterial and water resistance properties of paper, Kai Liu *et al*, *Carbohydrate Polymers*, 142. An effective method of preparing composites containing inorganic (Ag) and organic (beeswax) particles was established in this study. When applied onto paper surface by coating, the CNC/Ag/beeswax composites can impact paper with antibacterial property and improved water resistance.

Microcrystalline-cellulose and polypropylene based composite: A simple, selective and effective material for microwavable packaging, S. Ummartyotin & C. Pechyen, *Carbohydrate Polymers*, 142. Cellulose based composite was successfully designed as active packaging with additional feature of microwavable properties. Small amount of cellulose with 10μm in diameter was integrated into polypropylene matrix. The use of maleic anhydride was employed as coupling agent. Morphological properties of cellulose based composite presented the good distribution and excellent uniformity.

PAPER CHEMISTRY

Novel paper sizing agents based on renewables. Part 8: on the binding behavior of reactive sizing agents—the question of covalent versus adsorptive binding, Elisabeth Lackinger *et al*, *Cellulose*, 23 (1). The binding mechanisms of two reactive sizing agents, alkenyl succinic anhydride (ASA) and maleated sunflower oil high-oleic (MSOHO), with cellulose were studied. While ASA is produced from olefins out of fossil resources, MSOHO is a green sizing agent based on renewable plant materials.

Properties and paper sizing application of waterborne polyurethanemicroemulsions: Effects of extender, cross-linker, and polyol, Ke Zhu *et al*, *Journal of Applied Polymer Science*, online. A series of waterborne polyurethane (WPU) microemulsions were synthesised through self-emulsification methodology. The resultant WPU microemulsions were utilised as surface-sizing agents for cellulose fibre paper. The influences of chemical composition on the physicochemical properties of the resultant emulsions and sized paper have been investigated in detail.

Green coconut shell extract and boric acid: new formulation for making thermally stable cellulosic paper, Santanu Basak *et al*, *Journal of Chemical Technology and Biotechnology*, 91 (5). For the first time, green coconut shell extract (GCSE) has been employed along with boric acid (BA) as a novel fire retardant agent to be applied to cellulosic paper. Green coconut shell extract can be considered a condensed phase based flame retardant agent as it contains silicate, other metals like potassium, zinc, copper and magnesium in the form of metallic salts, oxides etc. When GCSE was applied on paper, combine synergistic action of all these metal salts and oxides catalyze dehydration of the treated paper and also increased char formation.

Flocculation and viscoelastic behavior of industrial papermaking suspensions, Mustafa S. Nasser *et al*, *Korean Journal of Chemical Engineering*, 33 (2). The effects of the surface charge type and density C496, C492 and A130LMW polyacrylamides (PAMs) on the rheological behaviour of real industrial papermaking suspensions were quantitatively related to the degree of flocculation for the same industrial papermaking suspensions. Results revealed that increasing the cationic PAM surface charge decreases the floc size but increases the adsorption rate, elasticity and effective floc density proposing differences in the floc structures, which are not revealed clearly in the Bingham yield stress measurements.

Improving strength properties of recycled and virgin pulp mixtures with dry strength agents, S.G. Gulsoy & S Erenturk, *Starch*, online. In the paper industry, the increasing use of recycled fibres as a substitute for virgin fibres has resulted in decreased strength properties. In this study, old corrugated container fibres were added in different ratios to virgin kraft fibres, and the effects on paper properties were investigated. Furthermore, 0.75% cationic starch and 0.75% Luredur® (a cationic polymer-based vinyl amine and N-vinylformamide) with respect to oven-dry fibres were added separately to old corrugated container fibre-containing/fibre-free suspensions, and the effects on handsheet strength properties were determined.

STARCH

Quality controlling of brown rice by ultrasound treatment and its effect on isolated starch, Dong-June Park & Jung-Ah Han, *Carbohydrate Polymers*, 137. Ultrasonic treatment (UT) was applied to brown rice at two different conditions: mild (25°C, 30min) and harsh (50°C, 60min) after soaking for several times (2, 3, 5, and 8h). After UT, starch was isolated from the brown rice grains, and the physicochemical properties of the starch, as well as the textural and nutritional properties of the grains, were compared.

Processing surface sizing starch using oxidation, enzymatic hydrolysis and ultrasonic treatment methods—Preparation and application, Tobias Brenner *et al*, *Carbohydrate Polymers*, 138. The surface application of starch is a well-established method for increasing paper strength. In surface sizing, a solution of degraded starch is

applied to the paper. Two procedures have proved valuable for starch degradation in the paper mill: enzymatic and thermo-oxidative degradation. The objective of this study was to determine achievable efficiencies of cavitation in preparing degraded starch for surface application on paper.

Biodegradable and non-retrogradable eco-films based on starch–glycerol with citric acid as crosslinking agent, Paula González Seligra *et al*, *Carbohydrate Polymers*, 138. Biodegradable and non-retrogradable starch–glycerol based films were obtained using citric acid (CA) as crosslinking agent at 75°C. This material allowed decreasing water vapour permeability (WVP) more than 35%, remained amorphous for at least 45 days as a result of the network formed by the CA that avoided starch retrogradation and maintained the degradability in compost, occurring only six days after the films without citric acid.

Infrared spectroscopy as a tool to characterise starch ordered structure—a joint FTIR–ATR, NMR, XRD and DSC study, Frederick J. Warren *et al*, *Carbohydrate Polymers*, 139. Starch has a heterogeneous, semi-crystalline granular structure and the degree of ordered structure can affect its behaviour in foods and bioplastics. Here, the authors subject 61 starch samples to structural analysis, and systematically correlate FTIR spectra with other measures of starch structure. They demonstrate that FTIR is a tool that can quantitatively probe short range interactions in starch structure.

Small differences in amylopectin fine structure may explain large functional differences of starch, Eric Bertoft *et al*, *Carbohydrate Polymers*, 140. Four amylose-free waxy rice starches were found to give rise to gels with clearly different morphology after storage for seven days at 4°C. The thermal and rheological properties of these gels were also different. This was remarkable in light of the subtle differences in the molecular structure of the amylopectin in the samples. Addition of iodine to the amylopectin samples suggested that not only external chains, but also the internal chains of amylopectin, could form helical inclusion complexes. It is suggested that these internal helical segments participate in the retrogradation of amylopectin, thereby stabilising the gels through double helical structures with external chains of adjacent molecules. Albeit few in number, such interactions appear to have important influences on starch functional properties.

Insights into the hierarchical structure and digestion rate of alkali-modulated starches with different amylose contents, Dongling Qiao *et al*, *Carbohydrate Polymers*, 144. Combined analytical techniques were used to explore the effects of alkali treatment on the multi-scale structure and digestion behaviour of starches with different amylose/amylopectin ratios.

STOCK PREPARATION

Energy and paper recycling: Modelling the time and energy requirements for low consistency batch repulping, F. Saville *et al*, *Canadian Journal of Chemical Engineering*, 94 (3). An analytical model for low-consistency repulping linking pulp material properties, consistency, temperature, and rotor and vat geometry is provided, which allows for accurate prediction of the time and energy required for repulping in both a 0.25m^3 laboratory-scale repulper and a 15m^3 industrial-scale repulper.

Improving the material efficiency of recycled furnish for papermaking through enzyme modifications, P.K. Verma *et al*, *Canadian Journal of Chemical Engineering*, 94 (3). Fibre fines and fibrils within recycled cellulosic pulp have high amorphous cellulose

content. These fines, having a high surface area, restrict the free drainage of water and retain bound water within the pressed sheet but contribute little to the hydrogen bonding potential of the fibre slurry. The advantage of higher freeness, achieved by selective hydrolysis of excess fines through enzymes, can be used for enhancement of the drainage rate, leading to increased paper production. In this study, monocomponent cellulase treatment of recycled pulp for drainage improvement as a result of selective and controlled hydrolysis is investigated. The effectiveness of specific types of enzyme activity, endoglucanase or cellobiohydrolase, is studied. The increased solubilisation of amorphous cellulose mediated by endoglucanase treatments improved pulp drainability by 11–25 %, along with providing better paper properties such as tensile index and smoothness.

Cellulase-assisted refining of bleached softwood kraft pulp for making water vapor barrier and grease-resistant paper, Peng Lu *et al*, *Cellulose*, 23 (1). The effect of cellulase pretreatment of bleached softwood kraft fibre before laboratory refining on the water vapour barrier and grease resistance properties of handsheets was investigated in this work. The role of cellulase pretreatment in reducing the WVTR and grease-stained areas was revealed on morphological observation by scanning electron microscopy, atomic force microscopy, X-ray photoelectron spectroscopy, as well as water contact angle testing.

TESTING

Detailed analysis of the UV-adjustment techniques used in paper and graphic industries, Li Yang, *Color Research & Application*, online. Many commercial materials (papers and boards) contain optical brightening agents also known as fluorescent whitening agents. Adequate adjustment of the UV content of a measurement device (e.g., spectrophotometer) is essential for accurate colour measurement. As specified in the ISO standards, the UV content is adjusted against an assigned value of an international reference transfer standard, for example, CIE whiteness (D65/10°) for the CIE illuminant D65 or ISO brightness for the C illuminant. Because of the simplicity, these approaches have gained great popularity in papermaking industry. Yet, there has been little evidence indicating how accurate the total spectral radiance factor corresponding to the single assigned value is reproduced. Hence, we present a method that quantitatively evaluates the accuracy of the UV-adjustment technique, through comparing the total spectral radiance factors obtained from UV adjustment with the assigned ones.

A novel cup with a pressure-adjusting mechanism for high-temperature water vapor transmission rate measurements, Shinya Iizuka *et al*, *Polymer Testing*, online. Water vapour transmission rate measurements with the conventional cup method do not yield accurate values at high temperatures because the film specimens deform and are damaged owing to air expansion in the cup. This article describes a new cup with a pressure-adjusting mechanism allows measurements at 85°C and prevents specimen deformation and damage.

WASTE TREATMENT

Saccharification of newspaper waste after ammonia fiber expansion or extractive ammonia, Salvatore Montella *et al*, *ABM Express*, online. The lignocellulosic fractions of municipal solid waste (MSW) can be used as renewable resources due to the widespread availability, predictable and low pricing and suitability for most conversion technologies. In particular, after the typical paper recycling loop, the newspaper waste (NW) could be further valorised as feedstock in biorefinering industry since it still contains up to 70% polysaccharides. In this study, two different physicochemical methods -

ammonia fibre expansion (AFEX) and extractive ammonia (EA) were tested for the pre-treatment of NW.

Hemicellulose isolation, characterization, and the production of xylo-oligosaccharides from the wastewater of a viscose fiber mill, Yuedong Zhang *et al*, *Carbohydrate Polymers*, 141. Viscose fibre mills generate a lot of wastewater enriched with hemicelluloses. The structure of the hemicellulose in the wastewater was characterised and the hemicellulose was isolated to produce xylo-oligosaccharides (XOS). Results demonstrated the potential economical and environmental benefits of the process to utilise the byproducts from viscose fibre mills.

Regeneration of cello-oligomers via selective depolymerization of cellulose fibers derived from printed paper wastes, Lee Ken Voon *et al*, *Carbohydrate Polymers*, 142. Cellulose extracted from printed paper wastes were selectively depolymerised under controlled conditions into cello-oligomers of controllable chain lengths via dissolution in an ionic liquid and in the presence of an acid catalyst. The cellulose depolymerisation process could afford some degree of control on the degree of polymerisation or chain lengths of cello-oligomers formed.

Evaluation of pine kraft cellulosic pulps and fines from papermaking as potential feedstocks for biofuel production, Kamila Przybysz Buzała *et al*, *Cellulose*, 23 (1). Results of enzymatic hydrolysis of pine kraft cellulosic pulps (Kappa numbers ranging from 17.2 to 86.2) and waste fines from paper production line suggest that they are potential feedstocks for biofuel production. The complete lignin removal from pine wood was not necessary to obtain maximum yields of glucose and other reducing sugars.

Advanced treatment of biologically treated medium density fiberboard (MDF) wastewater with Fenton and Fenton enhanced hydrodynamic cavitation process, Cigdem Balcik-Canbolat *et al*, *Journal of Chemical Technology and Biotechnology*, 91 (5). Biological treatment processes are often ineffective for the treatment of medium density fibreboard wastewater due the presence of non-biodegradable and refractory compounds. Fenton and Fenton enhanced hydrodynamic cavitation (HC) processes may be cost effective solutions for the treatment of such wastewater. Removals of COD, formaldehyde and colour by Fenton and Fenton enhanced HC processes were investigated in this study.

WOOD PANELS

Effect of addition of microfibrillated cellulose to urea-formaldehyde on selected adhesive characteristics and distribution in particle board, Eike Mahrdt *et al*, *Cellulose*, 23 (1). Several studies demonstrate that the addition of microfibrillated cellulose (MFC) to urea-formaldehyde (UF) wood adhesive improves the mechanical bond strength of wood particle board. In order to elucidate potential underlying mechanisms, the distribution of unmodified UF as well as MFC-modified UF (UF-MFC) in particle board was studied by means of light microscopy. The viscosity and cure characteristic of the adhesive systems were also characterised.

Thermophysical properties of medium density fiberboards measured by quasi-stationary method: experimental and numerical evaluation, Eva Troppová *et al*, *Heat and Mass Transfer*, online. This paper presents an experimental measurement of thermal properties of medium density fibreboards with different thicknesses (12, 18 and 25 mm) and sample sizes (50 × 50 mm and 100 × 100 mm) by quasi-stationary method. The

quasi-stationary method is a transient method which allows measurement of three thermal parameters (thermal conductivity, thermal diffusivity and heat capacity).

Medium density fiberboard production by hot pressing without adhesive using *Triarrhena sacchariflora* residue bio-pretreated by white-rot fungus *Coriolus versicolor*, Wu J. *et al*, *Journal of Applied Microbiology*, online. White-rot fungus *Coriolus versicolor* was used to pretreat TSR and biochemical and physical analysis were investigated by Ultraviolet Spectrophotometry, Fourier Transform Infra-red Spectroscopy and Environmental Scanning Electron Microscopy method. TSR was suitable to produce fibreboard without adhesive by bio-pretreatment with *C. versicolor*. The property of fibreboard became stronger by optimisation of bio-pretreatment parameters, and the moduli of rupture and elasticity of fiberboard were increased to 18.12 MPa and 4.3 GPa respectively, which were close to national standard of medium density fiberboard with adhesive.

Preparation and properties of multifunctional thermochromic energy-storage wood materials, La Hu *et al*, *Journal of Materials Science*, 51 (5). To develop a smart multifunctional wood material, thermochromic energy-storage microcapsules were incorporated into coatings while painting medium density fiberboard (MDF). The morphologies, chemical structures, and thermal properties of the microcapsules were characterised. The coating performance, including the thickness, wearability, and adhesion were investigated. Overall it was found the microcapsule concentration could potentially be used to adjust the performance of the multifunctional MDF.

Properties of Composite Panels Made from Tetra-Pak and Polyethylene Waste Material, Pavlo Bekhta *et al*, *Journal of Polymers and the Environment*, online. The objective of this study was to evaluate some of the properties of experimental composite panels manufactured from waste packaging materials without using any additional binders. Particles from three types of materials, namely Tetra-Pak, food packaging films as recycled stretch wraps, and candy polyethylene wrappers were used at different ratios in the panels at a target density of 900kg/m^3. Based on the findings in this work it was determined that the ratio of different raw materials significantly influenced overall properties of the samples.

On the Effectiveness of Profile Monitoring to Enhance Functional Performance of Particleboards, Bianca M. Colosimo *et al*, *Quality and Reliability Engineering International*, 31 (8). This paper explores connection between profile monitoring and functional performance of manufactured products. In particular, the empirical relationship between the vertical density profile of the particleboards and their functional performances (the internal bond and the surface soundness) is studied. Results based on a real case study showed that the profile shape clearly affects the final performance of the panel, and thus profile monitoring is really worth to keep the final quality of the product at its target level.

PITA Calendar of World Events

May 2016		
31 - 10 June	Drupa @ Messe Düsseldorf, Germany	www.drupa.com
June 2016		
1 - 3	Asian Paper @ Bangkok, Thailand	www.asianpapershow.com
21 - 23	RISI Asian Forest Business Summit @ Shanghai, China	www.risi.com
22 - 23	Technologie Kring @ Hoenderloo, The Netherlands	www.technologiekring.nl
23	Henkel Webinars “Mineral Oil / Food Packaging” @ 8AM or 2PM (London time)	www.henkel-premium-area.com/webinars
28 - 29	PITA Appreciation Course @ PITA HQ, Bury, UK	info@pita.co.uk
28 - 30	Zellcheming @ Frankfurt am Main, Germany	https://www.mesago.de
July 2016		
5	**Paper Matters!** event @ Shotton Mill, UK	info@pita.co.uk
5	PEFC Annual Stakeholder meeting @ SCI HQ, London, UK	www.pefc.co.uk
August 2016		
22 - 26	The Progress in Paper Physics Seminar @ Technical University Darmstadt, Germany	pmv@papier.tu-darmstadt.de
September 2016		
6 - 7	PTS Paper & Board Symposium 2016 @ Munich, Germany	www.ptspaper.de
12 - 16	Printing for Fabrication 2016 @ Manchester, UK	www.imaging.org
13 - 15	Resource Efficiency & Waste Management Solutions (RWM) @ NEC, Birmingham, UK	www.rwmexhibition.com
14 - 15	Packaging Innovations @ Olympia, London, UK	www.easyfairs.com
20	Safety Health & Environment Show North-West @ Blackpool, UK	www.thesheshow-northwest.com
20 - 22	PITA Introduction to Tissue Course @ PITA HQ, Bury, UK	info@pita.co.uk
21 - 23	Specialty Papers US @ Chicago, IL, USA	www.specialtypaperconference.com
23	PITA Meet North @ Pool Mill, Otley, UK	info@pita.co.uk
23 - 25	27th BAPH Annual Conference @ Harrogate, UK	www.baph.org.uk
26 - 29	PEERS 2016 & International Mechanical Pulping Conference @ Jacksonville, FL, USA	www.tappi.org
27 - 29	Tissue World Istanbul @ Istanbul, Turkey	www.tissueworld.com
October 2016		
12 - 14	MIAC @ Lucca, Italy	www.miactissue.com
18 - 19	PITA Energy Optimisation Course @ PITA HQ, Bury, UK	info@pita.co.uk
25 - 28	Pan Pacific Conference of the Tech. Assns of the P&P Industry @ Seoul, South Korea	ppc2016@ktappi.or.kr
25 - 28	PAP-FOR @ St Petersburg, Russia	http://v2-papfor.rxnova.com
November 2016		
2 - 3	2016 Paper Recycling Conference Europe @ Rotterdam, The Netherlands	http://papereurope.recyclingtodayevents.com
7 - 11	CIC 24 (international conference on colour and imaging) @ San Diego, CA, USA	www.imaging.org
8	Advances in printed sensors @ IOP, London, UK	www.iop.org
11 - 13	Paperex ‘The Road Ahead for Paper and Packaging’ @ Chennai, India	www.paperex.in
15	Safety Health & Environment Show North-East @ Newcastle, UK	www.thesheshow-northeast.com
16	PITA Pump Efficiency Course @ tba, UK	info@pita.co.uk
16 - 17	Technologie Kring @ tbc, The Netherlands	www.technologiekring.nl
19 - 21	Print World 2016 @ Toronto, Canada	www.printworldshow.com
23 - 24	DITP Conference @ Bled, Slovenia	ditp@icp-lj.si
December 2016		
7 - 9	Tissue World Shanghai @ Shanghai, China	www.tissueworld.com/en
October 2017		
31 - 3 Non	IPEX @ NEC, Birmingham, UK	www.ipex.org