**PAPERmaking!**

***FROM THE PUBLISHERS OF PAPER TECHNOLOGY***

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Paper Industry Technical Association

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# Technical Abstracts

*The general peer-reviewed 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, moulded pulp and wood panel manufacture. The edited abstracts contained in this report show the most recently published items likely to prove of interest to our readership, arranged as follows:*



**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 International* 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*.**

## 3-D PRINTING

**Composites of waterborne polyurethane and cellulose nanofibers for 3D printing and bioapplications, Ren-De Chen et al, *Carbohydrate Polymers*, Vol.212.** Waterborne polyurethane (PU) is a green, high performance elastomer but the viscosity of the dispersion is generally too low for direct three-dimensional (3D) printing. Composite brings additional properties while reinforcing the substrate. In the study, printable PU composites were successfully prepared by introducing cellulose nanofibrils (CNFs) and the viscosity was effectively regulated by the amount of neutralising agent during *in-situ* synthesis.

## COATING

**Study of chitosan with different degrees of acetylation as cardboard paper coating, Mariane Gatto et al, *Carbohydrate Polymers*, Vol.210.** The biodegradability of chitosan is significant for packaging systems. Another relevant property of chitosan is its degree of acetylation (DA), which affects other properties, such as crystallinity and hydrophobicity. The DA can be modulated by chitin deacetylation or even chitosan reacetylation. The novelty of this paper is the application of reacetylated chitosan as a coating for cardboard paper surfaces to improve the barrier and mechanical properties of the paper. Chitosan with 2% DA was reacetylated to yield chitosan with 48% DA. Both samples were applied as cardboard paper coating, and the coated materials were characterised. The paper-film system of chitosan with 2% DA had better water barrier and mechanical resistance.

## ENERGY / ENVIRONMENT

**Life cycle energy consumption analysis and green manufacture evolution for the papermaking industry in China, Yi Man et al, *Green Chemistry*, Issue 5.** Papermaking is a highly energy-consuming industry. The growth in paper demand will further intensify the need for energy and the stress of GHG emissions. Papermaking involves complex processing routes, and energy is required for collecting raw materials, producing chemicals, and pulp and papermaking. Previous investigations of energy consumption in the papermaking industry have focused primarily on the analysis of one single product or one single pathway, lacking a comprehensive and systematic comparison of various products and pathways. Herein, the results of a life cycle energy consumption analysis of major paper products in China using an extensive system boundary are presented. When 1 tonne of paper was produced in China in 2015, the maximum energy consumption was 38.17 GJ for tissue paper, with a minimum energy consumption of 15.90 GJ for corrugated medium. This study also predicts energy-related GHG emissions and a mitigation target in the papermaking industry in China by 2050.

**Short term electric load forecasting model and its verification for process industrial enterprises based on hybrid GA-PSO-BPNN algorithm—A case study of papermaking process, Y Hu et al, *Energy*, Vol.170.** Process industry consumes tremendous amounts of electricity for production. Electric load forecasting could be conducive to managing the electricity consumption, determining the optimal production scheduling, and planning the maintenance schedule, which could improve the energy efficiency and reduce the production cost. This paper proposed a short term electric load forecasting model based on the hybrid GA-PSO-BPNN algorithm. Besides the proposed GA-PSO-BPNN model, the GA-BPNN and PSO-BPNN based electric load forecasting models are also studied as the contrasting cases. The verification results reveal that the GA-PSO-BPNN model is superior to the other two hybrid forecasting models for future application in the papermaking process since its MAPE is only 0.77%.

**Resource value flow analysis of paper-making enterprises: A Chinese case study, Z Li et al, *Journal of Cleaner Production*, Vol.213.** Papermaking enterprises are currently under both environmental pressure and economic pressure for sustainable development in China. Thus, the efficiency, effectiveness, and benefits of resource utilisation need to be improved. High-consumption and high-pollution companies should manufacture paper using sustainable methods. This study highlights a resource value flow analysis from the circular economy perspective, developing an extension of material flow cost accounting and modifying it by accounting for environmental damage as well as economic benefits. In general, applying a resource value flow analysis can both reduce resource consumption and minimise environmental damage, enhancing the sustainable development of a process industry with limited resources.

## LOGISTICS

**A Description of Supply Chain Planning Problems in the Paper Industry with Literature Review, Florian Jaehn & Raisa Juopperi, *Asia-Pacific Journal of Operational Research*, Vol.36 (1).** The paper industry supply chain is highly complex and consists of many processes and planning tasks. It starts with the collection of raw wood and ends up in different paper products from paperboard to high class art papers. Managing the supply chain is difficult and the permanently changing business environment constantly brings new challenges. This paper starts with outlining the challenges in the supply chain management of today's paper industry. After that we evaluate the state of research to determine planning problems covered by the literature. The purpose is to catch up time-wise on the previous overview from 2009 and also to update the planning problems. This overview paper summarises comprehensively the paper industry as of today. It provides a reference work for researchers and other interested parties, and uncovers areas for future research.

**Warehouse Design and Operation using Augmented Reality technology: A Papermaking Industry Case Study, D Mourtzis et al, *Procedia CIRP*, Vol.79.** In modern, high competitive markets, efficient warehousing is critical as it accounts for a great part of logistics costs. Companies try to adopt highly adaptive and flexible warehouse design that may support the integration of novel technologies such as Augmented Reality (AR). This paper proposes a framework for warehouse design which minimises inventory cost while keeping a high degree of service by supporting the integration of an AR warehousing system. The AR system will support the effective management of operations, by providing meaningful information. The proposed methodology is tested and validated in a real-life case study of a papermaking industry.

## MOULDED PULP

**Research on the Preparation and Properties of Water Resistant and Oil Resistant Paper Tableware Made by Bagasse Brown Pulp, Li Liu et al, *Applied Sciences in Graphic Communication and Packaging*, pp.609-615. Part of the Lecture Notes in Electrical Engineering book series (LNEE, Vol.477).** Water-resistant and oil-resistant paper tableware has broad application prospects. The mechanism of water resistance and oil resistance properties of paper and the determination of oil resistance properties were introduced. The water/oil resisted paper was made of bagasse brown pulp by beating and adding oil-resistant agent, water-resistant agent and retention aid. The effects of water repellent, oil repellent and other factors on the oil and water repellency of paper tableware were studied.

***Molded Pulp Products Manufacturing: Process Development, Characterization and Modeling*, Mattia Didone, PhD Thesis, Manufacturing Engineering, Department of Mechanical Engineering, Technical University of Denmark, Produktionstorvet, 2800, Kgs. Lyngby, Denmark.** The matter of this thesis is the development, characterisation and ultimately modelling of the manufacturing process of moulded pulp products. In particular, focus was placed on studying and optimising the drying step, as the cost of energy required may be from eight to twenty times that needed for pre-forming.

## NANO-SCIENCE

**A bio-mechanical process for cellulose nanofiber production – Towards a greener and energy conservation solution, Xiuyu Liu et al, *Carbohydrate Polymers*, Vol.208.** Enzyme pretreatment prior to mechanical grinding in cellulose nanofiberes production was fully explored in order to save mechanical energy and to find an alternative to chemical treatment, thus reducing the environmental impact of the process. Grinding energy was determined in terms of total energy, effective energy, and was related to nanofibre yield. Fibre morphology, crystalline and chemical structures were analysed to reveal the mechanisms behind enzyme actions. The results showed that with enzyme pretreatment, the effective energy was reduced by 60%, and yield of nanofibres was increased by 76%.

**Comparative study of aramid nanofiber (ANF) and cellulose nanofiber (CNF), Bin Yang et al, *Carbohydrate Polymers*, Vol.208.** Cellulose nanofibre (CNF) has faced challenges toward advanced applications due to the poor water resistance, wet strength, and poor thermal stability. The fabrication methods, morphologies and dispersibility between CNF and aramid nanofibre (ANF) were compared. Then the mechanical strength, especially the retention of wet strength (RWS), optical property, UV shielding, wettability and thermal stability of CNF and ANF nanopapers were further investigated. The results show that ANF and ANF nanopaper have significant advantages in dispersibility, water resistance, wet strength, thermal stability and UV-blocking ability over the CNF and CNF nanopaper. This work demonstrates that the ANF could be an ideal alternative to CNF for advanced nanocomposites.

**A novel method for preparing microcrystalline cellulose from bleached chemical pulp using transition metal ions enhanced high temperature liquid water process, Xiaopeng Yue et al, *Carbohydrate Polymers*, Vol.208.** A novel method for preparing microcrystalline cellulose (MCC) from bleached chemical pulp based on the transition metal ion-enhanced high temperature liquid water (HTLW) process was established in this study. Transition metal ions (Fe3+, Cu2+ or Cr3+) were used to enhance the depolymerization effect of HTLW treatment on fibres. The transition metal ion-enhanced HTLW treatment provides an acid free method for preparing MCC.

**Preparation and characterization of cellulose nanofibrils from coconut coir fibers and their reinforcements in biodegradable composite films, Jun Wu et al, *Carbohydrate Polymers*, Vol.211.** Coconut waste husks were effectively utilised in this study as a promising cellulose source for production of purified coir cellulose (PCC) after multiple treatments, e.g., ultrasonic-assisted solvent immersion, alkaline treatment, bleaching, etc. The cellulose nanofibrils were comprehensively characterised in terms of their functional groups, crystallinity, morphology, and thermal stability. The potential reinforcement of CCNFs as a filler for biodegradable PVA based films was investigated.

**Mango Kernel Starch Films as Affected by Starch Nanocrystals and Cellulose Nanocrystals, Ana Priscila M. Silva et al, *Carbohydrate Polymers*, Vol.211.** Mango seeds have been used to obtain components for nanocomposite films, namely, starch and starch nanocrystals (SNC) from seed kernels, and cellulose nanocrystals (CNC) from seed shells. Starch-based films were prepared with different contents and combinations of SNC and CNC. The optimised conditions (1.5 wt% CNC and 8.5 wt% SNC on a starch basis) resulted in a film with enhanced strength, modulus, and barrier to water vapour when compared to the unfilled film, although the elongation has been impaired.

**Preparation of cellulose nanomaterials via cellulose oxalates, Jonatan Henschen et al, *Carbohydrate Polymers*, Vol.213.** The current work describes the use of a bulk reaction between pulp and oxalic acid dihydrate to prepare cellulose oxalate followed by homogenisation to produce nanocellulose. The presented results illustrate that cellulose oxalates may be a low-cost method to prepare nanocellulose with properties reminiscent of those of both cellulose nanofibrils and cellulose nanocrystals, which may open up new application areas for cellulose nanomaterials.

**Nanocellulose production from recycled paper mill sludge using ozonation pretreatment followed by recyclable maleic acid hydrolysis, Roi Peretz et al, *Carbohydrate Polymers*, online.** Nanocellulose (NC) has garnered much interest worldwide due to its physical and chemical properties. Nanocellulose is produced from biomass materials by bleaching pretreatment, followed by acid hydrolysis. This work demonstrated the production of NC from recycled paper sludge (RPS), a crystalline cellulose rich waste, by ozonation pretreatment, followed by maleic acid hydrolysis. These results demonstrate that ozonation can be used as an effective pretreatment for NC production.

## NOVEL PRODUCTS

**Development of microporous cellulose-based smart xerogel reversible sensor via freeze drying for naked-eye detection of ammonia gas, Tawfik A. Khattab et al, *Carbohydrate Polymers*, Vol.210.** Microporous cellulose xerogel can be defined as low density biomaterial that can be employed for a variety of promising applications of different fields. The characteristics of xerogel are a consequence of their microstructure. An easy-to-use and reversible solid-state colorimetric sensor for ammonia gas was developed by embedding a bromocresol purple (BCP) pH-sensory chromophore into the environmental friendly carboxymethyl cellulose as bio-based polymer (CMC) matrix. The vapochromic xerogel provided an instant colour alteration signal from yellow to purple when exposed to ammonia gas or an ammonium hydroxide aqueous environment as monitored by the absorption maxima, colour coordinates and colour strength.

**Stimuli-responsive cellulose paper materials, Zhijian Li et al, *Carbohydrate Polymers*, Vol.210.** Cellulose paper can be functionalised, such as modified with stimuli-responsive polymers, small molecules or inorganic particles, papers may be sensitive to external stimuli from environments and consequently find applications in wide ranges including protein separation, controlled drug release, switchable surfaces, sensoring devices and smart substrates with various colours, etc. However, there are no reviews summarising the progress of such exciting research field. Here in this mini review, we discuss the advantages of cellulose paper as stimuli-responsive substrate and summarise the fabrication techniques, properties and applications of various stimuli-responsive papers reported to date which are triggered by temperature, pH, humidity, ions, light, magnetic field, solvent gas and biomolecules.

**Using cellulose fibers to fabricate transparent paper by microfibrillation, Zhenzhen Li et al, *Carbohydrate Polymers*, Vol.214.** Fabricating transparent paper from cellulose nanofibres (CNFs) normally involves high energy or the use of expensive chemicals for the extraction of CNFs from cellulose fibres and time-consuming paper formation processes because of the slow filtration rate of CNFs. In this study, we reported a strategy for the fabrication of transparent paper using microfibrillated cellulose fibres (MFCFs), which were prepared by extracting nanosized fibrils from the cellulose fibre surfaces by a two-step refining process. The transparent paper made from MFCFs shows higher thermal stability, higher tensile strength, higher resistance to deformation, and more flexibility than the nanopaper made from commercial CNFs. This work provides a promising method for the manufacture of transparent paper from cellulose fibres.

**Poly (lactic acid) composites reinforced with kraft pulp fibres: Production by a papermaking process and characterisation, S Sousa et al, *Composites Part A: Applied Science and Manufacturing*, Vol.121.** Four different pulp fibres, representing short and long cellulose fibres and chemically modified fibres, were tested as reinforcements for poly(lactic acid) composites. A simple papermaking method was used to form the composite sheets, which were further compression moulded. The effects of morphological, chemical, and mechanical characteristics of kraft pulp fibres and their contents on the PLA composite characteristics were investigated.

## PACKAGING TECHNOLOGY

**Fabrication and characterization of starch-based nanocomposites reinforced with montmorillonite and cellulose nanofibers, Jiali Li et al, *Carbohydrate Polymers*, Vol.210.** In this study, one-dimensional (1D) cellulose nanofibres (CNFs) were used to stabilise the dispersion of two-dimensional (2D) montmorillonite (MMT) plates in aqueous system. Then the prepared MMT/CNF solution was simultaneously merged into water soluble corn starch (CS) to obtain CS/MMT/CNF composite freestanding films through a casting method. The reinforcing effect from building blocks of MMT and CNF, interfacial interactions of hydrogen and covalent bonding together led to enhanced tensile strength and Young's modulus, reduced moisture susceptibility and increased transparency of the ternary CS nanocomposites. These extraordinary properties of the ternary nanocomposites clearly point towards a new strategy for designing and fabricating high-performance starch-based nanocomposites by using binary fillers with different geometric shapes and aspect ratio. This kind of ternary nanocomposite can be widely used in food packing and preservation as a biodegradable and green film.

**Effect of electrolyte on regenerated cellulose film as gold nanoparticle carrier, Lijuan Liu et al, *Carbohydrate Polymers*, Vol.210.** The catalytic performances of gold nanoparticles immobilised on regenerated cellulose films were influenced by cellulose structure. Cellulose was regenerated in aqueous coagulants containing different electrolytes, to fabricate regenerated films with different coagulated network structure and property. Hofmeister sequence can be used to describe regeneration, namely more kosmotropic ions in the coagulants led to cellulose films with more homogeneous coagulated network structure, possibly due to the dehydration of cellulose caused by the ions. Gold nanoparticles were then immobilised on the films to prepare portable catalysts. This work provided not only the fundamental information about the intermolecular interactions between ions and macromolecules, but also an effective approach to construct powerful catalysts.

**Fabrication of food-safe superhydrophobic cellulose paper with improved moisture and air barrier properties, Hui Li et al, *Carbohydrate Polymers*, Vol.211.** We presented a facile method for preparing a food-safe superhydrophobic packaging paper with improved moisture and air barrier properties in this study, which is combining construction of polymer-nanoclay hybrid multilayers with subsequent carnauba wax treatment. The obtained paper was used for strawberry packaging at ambient temperature, and it was very effective at reducing the weight loss and maintaining titratable acidity compared with the unpackaged strawberries, which might has a great potential as food packaging materials.

**Highly transparent and thermally stable cellulose nanofibril films functionalized with colored metal ions for ultraviolet blocking activities, Weisheng Yang et al, *Carbohydrate Polymers*, Vol.213.** Although many preparation methods have been reported so far, it is still a great challenge for Ultraviolet (UV) protection films that simultaneously have extremely high transparency and excellent UV shielding properties. Herein, we reported a simple, eco-friendly process for preparing high transparency TOCN-COOM (M: metal ions) films with diverse UV-shielding performances via adsorption of coloured metal ions (Fe3+, Co2+, Ni2+, Cu2+). The introduction of Fe3+ led to an excellent UV blocking, especially almost 89% absorption of Ultraviolet A (UVA) and full absorption of Ultraviolet B (UVB). The formation of metal-carboxylate complexes is also advantageous for improving thermal stability. Hence, the obtained TOCN-COOM films have wide application prospect in the field of UV shielding.

**Role of the Relaxation State of Polymer Components in Wood When Making Composite Packaging Materials (Corrugated Cardboard), E. L. Akim et al, *Fibre Chemistry*, Vol.50 (4).** We consider targeted variation of the relaxation state for polymer components of wood in stages of the life cycle of corrugated cardboard. From the standpoint of the structural physicochemistry of wood, we present a mechanism for the processes occurring in traditional corrugated cardboard production technology. Our thesis is that cellulose and hemicellulose can go from the glassy state to the rubbery (highly elastic) state at 220°C, but under real conditions this transition occurs at room temperature and even at negative temperatures in the case of plasticization by a sufficient amount of water. Transition of lignin from the glassy state to the rubbery state occurs at a temperature above 130°C, and at 70°C-120°C under conditions of sufficient hydration. Formation of strong interfibre bonds is possible only when the polymers forming the contact are in the rubbery or viscous-flow state.

## PAPERMAKING

**Study on the wet-web strength and pressability of paper sheet during the press process with the addition of nano-fibrillated cellulose (NFC), Zonghong Lu et al, *Carbohydrate Polymers*, Vol.210.** The properties of wet-web strength and pressability of base paper affect the frequency of sheet breaks and machine runnability during the paper-making process. In this paper, the effect of nano-fibrillated cellulose (NFC) on the wet-web strength and pressability of paper sheet during the press process of paper-making was explored. It was found that the tensile energy absorption (TEA) of the sample was increased from 6.32 to 10.93 $J/m^2$ at 50% wet web solid content when 5% NFC was added. The web solid content was decreased from 50.51% to 42.85% when 0%-5% NFC was added under the same drainage and press conditions, indicating that the addition of NFC during the paper-making process can retard the pressability of paper sheet. The study put forwards a new view to discuss/study the effect of added NFC on the wet-web strength and pressability of paper sheet.

**Carboxymethylated cellulose nanofibrils in papermaking: influence on filler retention and paper properties, AF Lourenço et al, *Cellulose*, Vol.26 (5).** The present paper deals with the production of cellulose nanofibrils (CNF) from bleached Eucalyptus kraft pulp by carboxymethylation and TEMPO-mediated oxidation, followed by high pressure homogenisation. The main purpose of the work was to increase the filler retention and mechanical strength of printing and writing paper grades. Mineral fillers are of utmost importance in papermaking and therefore a thorough study of the CNF influence in filler-containing handsheets is mandatory. In this sense, flocculation studies revealed the extraordinary ability of CNF to flocculate calcium carbonate, which was translated into high filler retentions in the paper matrix. Moreover, the interactions between bleached pulp, CNF, mineral fillers and common paper additives, such as cationic starch, alkenyl succinic anhydride and cationic polyacrylamide, were investigated. The results show that, depending on the materials applied, CNF are able to promote an adequate bonding between fibres and filler aggregates, reducing the requirements for the additives. The addition of carboxymethylated or TEMPO-oxidised CNF to the fibrous matrix led to handsheets with better structural, mechanical and optical properties than those of reference handsheets (without CNF and with additives).

**Mechanisms of strength and stiffness improvement of paper after PFI refining with a focus on the effect of fines, Hamid Reza Motamedian et al, *Cellulose*, Vol.26 (6).** Refining (i.e., mechanical beating of pulp) is a common procedure that is used in paper-making to improve the mechanical properties of the final product. The improvements caused by refining are mainly attributed to increased density and to a better bonding between fibres. In this work, we study how various mechanisms that can be triggered by refining affect the tensile behaviour of the sheets.

**A paper sizing agent based on leather collagen hydrolysates modified by glycol diglycidyl ether and its compound performance, X Wang et al, *International Journal of Biological Macromolecules*, Vol.124.** In this research, collagen hydrolysates with different average molecular weights from leather collagen were chosen as raw materials. Five environmental-friendly sizing agents (SA) were prepared by cross-linking collagen hydrolysates with glycol diglycidyl ether (GDE) and further grafting them with butyl acrylate (BA) and styrene (St). Then the compound sizing agents (SGDESA-x, x = 1, 2, 3 and 4) were obtained by simple physical mixing of GDESA and starch. The surface sizing performance of GDESA and compound sizing agents were studied. The coated corrugated paper exhibited strong water resistance, good physical and mechanical properties even after refolded for 20 times.

## PULP / PULPING

**Determining the repair and maintenance cost of wood chippers, Raffaele Spinelli et al, *Biomass and Bioenergy*, Vol. 122.** Chipping weighs heavily on the total delivered cost of wood fuel, which calls for accurate chipping cost estimates. Chipper repair and maintenance cost is perhaps the most obscure among the figures required for a reliable estimate of chipping cost. To clarify this issue, the authors examined the long-term repair and maintenance records for 51 wood chippers operated by 48 chipping service contractors. The study also provides reference figures for the contribution of labour cost to total maintenance cost. Farm tractors incur more repairs than preventive maintenance, contrary to the other dedicated components of the chipping operation, where preventive maintenance represents most of maintenance cost. Forestry users should make allowance for the lower structural strength of tractors and select large models.

**Deep eutectic solvents (DESs) for cellulose dissolution: a mini-review, Yang-Lei Chen et al, *Cellulose*, Vol.26 (1).** Deep eutectic solvents (DESs), which are a novel class of sustainable designer solvents, have attracted considerable attention in the field of cellulose chemistry. Due to their low cost and analogous physico-chemical properties to ionic liquids, DESs are expected to be alternative solvents for dissolving cellulose. However, at present, the solubility of cellulose in DESs is much lower than in most ionic liquids. In this mini-review, we briefly summarise the current state of knowledge about cellulose dissolution in DESs.

**Non-Wood Plant Fibers: Applications in Pulp and Papermaking, JE Atchison - *Encyclopedia of Plant and Crop Science* (Print), 2019.** Originally paper was being made from non-wood materials such as papyrus, hemp and textile rags. With the development of technologies for isolating pulp from wood, it resulted in abandoning paper making from many non-wood materials. In this paper we have reviewed the trend in pulp and paper production from different non-wood materials since the perception of the paper making technology up to date through literature review and consultations with experts in the area of pulp and paper production.

**Cleaner approach for improving the papermaking from agro and hardwood blended pulps using biopolymers, S Bhardwaj et al, *Journal of Cleaner Production*, Vol.213.** Due to rapid deforestation, the paper industry is facing problems like shortage of forest based raw materials, cost increment and negative effects on the environment including increasing air, water and soil pollution. In India, agro residues utilised in stubble burning could be used as a sustainable fibre resource for papermaking, but the paper made from these possesses poor strength properties. Considering the multiple advantages of using agro residues and weak strength properties of the paper made from these, this study was conducted. The effect of blending hardwood pulp and agro pulp with cationic starch or chitosan at wet-end of papermaking with and without subsequent surface sizing using oxidized starch was explored.

**Approaches for converting sugarcane trash, a promising agro residue, into pulp and paper using soda pulping and elemental chlorine-free bleaching, NK Bhardwaj et al, *Journal of Cleaner Production*, Vol.217.** Industrialisation and urbanisation are the key drivers to threaten the environmental quality and natural resources. Traditionally, pulp and paper industry has been highly reliant on forest based resources for its escalation. Shortage of forest based raw materials, strict environmental regulations and policies have compelled the industry to seek for alternate raw materials for its production. Mills are now focusing on exploring the potential of different agro wastes such as cereal straws and bagasse etc. In present research, sugarcane trash, one of the most abundant agro residues in India, was investigated for its capability in pulping and bleaching.

## RECYCLING

**Optimal scheduling ratio of recycling waste paper with NSGAII based on deinked-pulp properties prediction, Wenhao Shen et al, *Computers & Industrial Engineering*, Vol.132.** The recycling of waste paper has been an effective way to achieve the environmental-friendly growth of papermaking industry. Focusing on the mixed-pulping process which has been generally employed, to ensure the required properties of the deinking pulp (DIP) and minimise the purchase cost of waste paper, an intelligent model scheduling the mixing ratio of waste paper was developed in the study.

## STARCH

**Modification of retrogradation property of rice starch by improved extrusion cooking technology, Yunfei Liu et al, *Carbohydrate Polymers*, Vol.213.** Modifications of molecular structure, and of short- and long-term retrogradation properties, in rice starch by an "improved extrusion cooking technology" (IECT) were studied. These results show that, under appropriate conditions, IECT is a type of extrusion which can be used to change retrogradation properties of rice starch that have not been previously available.

**Effect of Octenylsuccinylation of Oxidized Cassava Starch on Grease Resistance and Waterproofing of Food Wrapping Paper, Li Zhong et al, *Starch - Stärke*, No.1-2, 2019.** The surface of food wrapping paper is coated with octenylsuccinic anhydride (OSA)-modified cassava starch to develop food packaging with high waterproofing and low grease permeability. Oxidised cassava starch is modified using various concentrations of OSA. The effects of OSA concentration, starch content, incubation time, and coating rate on oil resistance and hydrophobicity, grease and water barrier properties are quantified. The influence of octenylsuccinylation of oxidised cassava starch on the optical and physical properties of paper is also investigated.

## TESTING

**Maximum Vibration Transmissibility of Paper Honeycomb Sandwich Structures, Rui Yang et al, *International Journal of Structural Stability and Dynamics*, Online.** The maximum vibration transmissibility of paper honeycomb sandwich structures with different sizes of honeycomb core under various static stresses was investigated using the sine frequency sweep test. The effects of the cell length of the honeycomb, the thickness of the sandwich structure, and the static stress on the maximum vibration transmissibility were evaluated.

**Test method for enhanced mechanical shock fragility statistics accuracy, Shogo Horiguchi & Katsuhiko Saito, *Packaging Technology and Science*, Vol.30 (4).** An optimum cushioning package, which is neither excessive nor inadequate, must be designed to ensure cushioning performance that maintains an acceptable failure rate during transportation while also minimising packaging costs. For this purpose, statistics pertaining to transport hazards and product shock strength must be engaged. The proposed study presents a test method to enhance the statistical accuracy of mechanical shock fragility of products. An example of the application of experimental results to stress-strength models has also been described.

## WASTE TREATMENT

**Preparation of geopolymer inorganic membrane and purification of pulp-papermaking green liquor, M Xu et al, *Applied Clay Science*, Vol.168.** This paper describes a low-cost and highly efficient metakaolin-based geopolymer composite membrane (support + dense layer) at normal pressure and <70 °C. The support was fabricated using geopolymer foam materials and shows a large water flux and good mechanical properties. The dense layer was prepared using a dip-coating process with geopolymer paste on the porous geopolymer support surface. The preliminary ultra-filtration test (0.2 MPa operation pressure) demonstrates that the geopolymer-based composite membrane can effectively treat suspended particles in wastewater and is expected to be applied in the field of wastewater treatment. We then used the composite membrane in the pulp-papermaking green liquor at different temperatures, and it was found that the SS (suspended solids) of the filtrate can be decreased to far below the industrial requirements of green liquor recycling (SS < 20 mg·L−1).

**Statistical analysis of sustainable production of algal biomass from wastewater treatment process, Indu Ambat et al, *Biomass and Bioenergy*, Vol.120.** Algal biodiesel is one of the most promising renewable and eco-friendly source of energy for transportation, when algae is produced from wastewater. During the process, both goals of biodiesel production and wastewater treatment could be achieved simultaneously. However, the optimal condition for algae production remained unanswered. Algal biodiesel could be produced from various wastewater treatments. In this study the relationship between biomass production versus lipid productivity in various wastewater sources is statistically analysed.

**A green composite hydrogel based on cellulose and clay as efficient absorbent of colored organic effluent, Qiyang Wang et al, *Carbohydrate Polymers*, Vol.210.** This work has developed a convenient way of constructing wood cellulose and clay green composite hydrogel as efficient adsorbent of coloured organic effluent. The simple procedure and cost effective wood cellulose as raw material for the composite absorbent construction presented in this research are favourable for industrial applications.

**Phosphonium-Enhanced Chitosan for Cr(VI) Adsorption in Wastewater Treatment, Sebastian Sessarego et al, *Carbohydrate Polymers*, Vol.211.** Adsorption is a commonly used method for industrial wastewater treatment because of its low-cost, easy operation and high efficiency. In this work, chitosan was crosslinked and functionalised with a low-cost phosphonium salt, tetrakis(hydroxymethyl)phosphonium sulfate (THPS), to enhance its adsorption capacity for Cr(VI).

## WOOD PANEL

**Application of surface chemical functionalized cellulose nanocrystals to improve the performance of UF adhesives used in wood based composites - MDF type, Hossein Khanjanzadeh et al, *Carbohydrate Polymers*, Vol.206.** The aim of this research was to investigate the effect of functionalised cellulose nanocrystals (CNC) on the performance of urea-formaldehyde (UF) adhesive for the production of medium density fiberboard (MDF). Surface modification of CNC was performed using 3-Aminopropyltriethoxysilane (APTES). Some physical and thermal properties of reinforced and neat UF as well as formaldehyde emission and some mechanical (modulus of rupture (MOR), modulus of elasticity (MOE) and internal bond strength (IB)) and physical properties (thickness swelling (TS) and water absorption (WA)) of the resulting MDF panels were determined.

**Quasi-static and dynamic response of oriented strand boards based on balsa wood waste, G.Barbirato et al, *Composite Structures*, Vol.219.** This work presents an evaluation of the performance of Oriented Strand Boards (OSB) panels based on balsa wood (Ochroma Pyramidale) waste agglomerated with castor oil polyurethane resin. In this study, were evaluated OSB panels with different densities (300 kg/m$^3$, 400 kg/m$^3$ and 650 kg/m$^3$), with 10 mm thickness and castor oil polyurethane resin in different contents (11% and 15%). The OSB panels were preliminary characterised by physical and quasi-static mechanical tests to identify the class of application of this material according to the recommendations of standard EN 300: 2002. Subsequently, the OSB panels were characterised by low velocity impact tests.

**Solid Wood and Wood Based Composites: The Challenge of Sustainability Looking for a Short and Smart Supply Chain, M. Romagnoli et al, *Digital Wood Design*, Chapter, pp.783-807. (Part of the Lecture Notes in Civil Engineering book series (LNCE, volume 24).)** The paper takes into account the most important wood based products used in architecture, structural engineering and design. The amount of roundwood, sawnwood and wood panel production is analysed and forest certification is reported as possible tool to ensure a sustainable forest management, fighting illegal logging and deforestation. A smart review of the most used wood-based products is performed together with the chance to activate a modern short supply chain. The state of art of the wood species actually used is considered together with most important actual challenges addressed to obtain sustainable wood-based products referring to eco-friendly process of gluing and increasing durability.

**Preparation, characterization and properties of starch-based adhesive for wood-based panels, YongGu et al, *International Journal of Biological Macromolecules*, online.** A new biodegradable, renewable, and environmentally friendly starch-based adhesive for wood-based panels was synthesised. The synthesis was conducted by grafting polymerisation of vinyl acetate (VAC) monomer onto corn starch and crosslinking polymerisation with N-methylol acrylamide (NMA). Compared with the traditional starch-based wood adhesive, the water resistance of starch-based adhesive with NMA (SWA-N) was greatly improved to more than 1 MPa; this exceeds the Chinese standard by 40%. The complex network structure was found to inhibit excessive expansion of the adhesive during high temperature pressing and water absorption. As a result, the adhesive remained intact when subjected to hot pressing and placed in wet conditions.

**Latex and rosin films as alternative waterproofing coatings for 3-layer sugarcane-bamboo-based particleboards, Erika Yukari Nakanishi et al, *Polymer Testing*, Vol.75.** This paper studied two alternative polymeric films based on natural latex and rosin as a waterproofing coating for 3-layer sugarcane-bamboo-based particleboards (3LP). To study the roughness as well as evaluate the coating surfaces on the 3LP, scanning confocal electron microscopy (SCEM) was used. The wettability performance of the coatings was evaluated by the surface energy through the contact angle method. The 3LP coated thermal, physical and mechanical properties were evaluated following ASTM-E1530: 2011 and ABNT NBR 14810 standards, respectively. Latex successfully formed a smooth and continuous film which covered the surface pores of the 3LP, whereas rosin did not form a smooth and continuous, forming only a thin film on the 3LP.

**Dynamic accounting of greenhouse gas emissions from cascading utilisation of wood waste, Giorgia Faraca et al, *Science of The Total Environment*, Vol.651 (2).** Cascading utilisation of post-consumer wood waste has recently gained increasing attention in the European Union, aiming for a society in which the resource's properties are optimised through sequential uses. To date, material utilisation of wood waste has been limited to particleboard production, with additional niche alternatives being restricted by quality requirements for wood waste. In this consequential life cycle assessment focusing on post-consumer wood collected at Danish recycling centres, Global Warming Potential (GWP) impacts from quality-driven choices for cascading management of wood waste were compared with those from handling mixed wood waste qualities. The results demonstrated that valuing quality over quantity in wood waste management can ensure larger GWP savings, especially if recycling applications have a long lifetime and/or substitute energy-intensive products; such results were confirmed under all scenario analyses. More cascade steps of the wood waste resource ensured larger savings.

**Nanocellulose-Reinforced Adhesives for Wood-Based Panels, Elaine Cristina Lengowski et al, *Sustainable Polymer Composites and Nanocomposites*, pp.1001-1025.** Considering that the solid wood, being a heterogeneous and anisotropic product, presents several disadvantages such as unsatisfactory mechanical properties for certain uses and limitations of wood due to dimensions of wood pieces, reconstituted wood products have been developed by gluing of veneer, boards, lignocellulosic fibres, etc., which are joined using adhesives. It should be noted that changes in adhesion to wood are desirable in terms of performance improvement and adhesive economy. Within the constant search for better performance of adhesives, the use of nanocelluloses appears as a viable option. Further, identification of reinforcement of adhesives with nanocellulose is being considered as an opportunity among the several opportunities offered by nanotechnology for the forest products industry. Use of nanocelluloses as reinforcements in adhesives for the production of reconstituted wood panels has several benefits such as possibility of altering the properties of adhesives, gain in mechanical and physical properties of panels and reduction in formaldehyde emissions by panels using synthetic adhesives. Despite all the advantages mentioned above, the Chapter ends with the conclusion that there are still some problems to be looked into suggesting need for more research either in the application of nanocellulose and its modification in different types of resin, as well as application technologies appropriate to the new conditions of the adhesives.

**Resource quality of wood waste: The importance of physical and chemical impurities in wood waste for recycling, Giorgia Faraca et al, *Waste Management*, Vol.87.** Recycling of post-consumer wood waste into particleboard may be hindered by the presence of physical and chemical impurities in the waste stream, therefore calling for increased attention on the quality of wood waste. However, wood waste comprises several uses/types of wood, along with different levels of contamination. This study provides the detailed sampling and characterisation of wood waste according to its source, type and resource quality grade. The results showed that chemical contamination was significantly higher for low-quality wood waste, thus clearly indicating that improvements in separate collection, sorting and handling of wood waste may improve the resource quality of wood waste and potentially achieve cleaner recycling practices.