International Paper Physics and 8th International Paper and Coating Chemistry Coating Conference

Stockholm Sweden, June 10-14 2012.

Personal observations and highlights by Roman Popil, attendee.

Overview

The Paper Physics community holds a updating progress seminar and a formal peer reviewed conference on alternate years. Every four years, a Fundamental Research Symposium is held in either Oxford or Cambridge University in the UK which results in its plenary presentations and peer reviewed manuscripts published in hardcover textbook format. Attendance and participation is dominated by university academics and their graduate students followed by personnel from industrial research institutes and private companies. Topics covered were by session title: papermaking, paper structure and fibre networks, surface engineering of cellulosic materials, nanotechnology in paper applications, paper properties, new materials in paper and board products, coating technologies and colloid chemical interactions, computational modeling of paper and paperboards converting and end use, fluid flow and moisture transport, appearance properties, surface engineering of cellulosic materials, wet-end chemistry – material and process efficiency, coating technologies, paper and board barriers and films, applications of fibrillated cellulose. This year's combined conference was organized and hosted by Innventia, had 400 listed participants 20% of whom were from industry. Oral presentations ran from 8:00 am to 5:30 pm in four parallel sessions, each talk consisting of ½ hour. One afternoon was allocated for a poster session. Conference sponsors had booths set-up and staffed advertising their products services. Conference proceedings are contained in 3 bound (paper!) volumes of peer reviewed manuscripts or abstracts.

General impressions:

Traditional topics are still receiving about 50% of the attention, this regards fundamentals considering the load tensile behavior of paper, effects if repeated straining and modeling, testing methods and techniques, effect of wet draw on paper runnability and properties. Much focus directed to exploratory applications of Nano cellulose, active printed electronic layers, biopolymer films of chitosan, specialty starch, wheat gluten etc., all of which are interesting and promising but are generally far from commercialization. Barrier coatings for grease, moisture or water are another area attracting attention however no unusual break-throughs are apparent. All of the projects appear to have industrial or government initiative program sponsorship, particularly in Scandinavia. Overall, discussion and interaction with peers is instructive to clear up misconceptions, acquire tips on techniques, methods, interpretation, new research directions etc.

Notable known attendees included:

Anna Johanson Tetra-Pak, Artem Kulachenko KTH, Bandaru Ramarao SUNY ESF, Bo Norman Innventia, Bo Westerlind SCA R&D, Christer Fellers Innventia, Steve Keller Miami University, Derek Gray McGill University, Douglas Bousfield University of Maine, Douglas Coffin Miami University, Elias Retulainen VTT Finland, Fuushern Wuu Sappi Paper, Gil Garnier Australian PPI, Ho Fan Jang FP Innovations, James DeWitt Sappi Paper, James Olson UBC, Jean Francis Bloch LGP2/Grenoble, Joel Panek MWV, John Husband Imerys, Lennart Salmen Innventia, Marco Lucisano Innventia, Myat Htun Mid-Sweden University, Ning Yan University of Toronto, Ramin Farnood U Toronto, Rob Lowe Nalco Company, Sandeep Kulkarni Pepsico, Sven Arenander MWV, Tetsu Uesaka MidSweden University, Thomas Furst Lorentzen and Wettre, Tom Lindstron Innventia, Warren Batchelor Monash University, Oyvind Gregerson NTNU,Trondheim Norway.

Some take-away items from personal discussions:

Thermal conductivity of paper can be measured using first principles (Fourier's law) but only in steady state conditions and a typical set-up takes a few hours to stabilize to establish unchanging thermal gradients for a known flux of power. Surface contact resistance is eliminated in the measurement by measuring several layers at a time then extrapolating the data for a single layer. (Bandar Ramiro).

The elastic modulus of paper is principally governed by the fiber strength and much less by the level of fiber bonding. The tensile strength is affected by the level of fiber bonding which can be increase by the dry strength agents or decreased by deboning agents shown by Page and Seth in 1981 FRS proceedings. Ultrasonic measurements relate to the modulus and the correlation of ultrasonic measurements to strength properties should be regarded as a coincidence rather than causal (Soren Ostlund, Doug Coffin, Svetlana Borodulina).

Fracture toughness of paper can be relatively assessed by measuring the tensile strength of notched or nicked strip specimens. TEA of notched specimens is also potentially informative if the elastic part of the deformation can be removed from the analysis. The new proposed method specific to paper using a precisely defined specimen with a center cut and the accompanying formulas is intended to provide a value for a critical failure strength value for paper of any arbitrary size. (Doug Coffin, Christer Fellers).

Titles and authors of attended talks, impressions and remarks.

"Challenges in the liquid packaging boards value chain" Jannicke Jennsjo Korsnas, Bo Lundgren Tetra Pak, - a history of the development of Tetra-pak packaging from its inception in 1952 was given. Korsnas talked about the paper requirements for food packaging including obtaining FSC certification. Tetra-pak now includes 30 different packaging products but is most famous for its aseptic beverage

packaging. Their aim is to replace prevalent PET bottles with paper based packaging and to make the point they supplied the conference throughout with an abundant quantity of water in paper "bottles". However, Tetra-pak aseptic containers being multi-layer polyethylene-aluminum-impregnated paper are not repulpable or recyclable in most facilities other than one reported in the Ukraine.

"Adhesion between natural and synthetic materials from molecular to macroscopic" Kevin Kendall Birmingham University - the basics of binding of fibers was discussed referring to the mechanisms of bacteria and virus clusters, causes for the formation of pigment clusters. The author feels the explanation lies in electromagnetics, van der Waals force attraction that occur on the scale below 1 nm. The basics of latex coalescence were discussed in terms of JKR theory where geometry and elastic properties of the pigment articles become important to minimize void volume for optimal film formation. The author's opinion is that van der Waals forces are sufficient for bonding in paper, hydrogen bonds are not required.

"Fiber-fiber bond: What the paper physicist sees" Tetsu Uesaka, Mid Sweden University Sundsvall Sweden. - The nature of the Page equation for tensile strength was discussed and reviewed. The nature of the bond strength is alluded to friction interlocking mechanisms, capillary forces, hydrogen bonds, van der Waals forces. Reference was made of the 1979 IPC PhD thesis of A. Button and the work of Kulchenko in FEA modeling to calculate fiber bond. Most recent work by the author investigated the meso-scale effect of mini water bridges between fibers.

"The effects of various chemical treatments on fiber-fiber joint strength in paper" Tom Lindstrom et al., Innventia. - If only one pulp is investigated, the Page equation for tensile strength turns out to be a surprisingly good predictor irrespective of treatments and additives. Although Hazelton originally correlated relative bonded area (RBA) in the Page equation, Lindstrom (2008) has shown since that this not the case. A series of experiments on one selected pulp consisted of grafting carboxymethycellulose to add strength to fibers, starch addition, addition of microfibrillated cellulose, beating of fibers and all treatments correlated well with the Page prediction, however it overestimates strength somewhat at very high values of tensile strength.

"Influence of the history of loading during beating in the evolution of drainage resistance", J.F. Bloch et al., Grenoble - this was a requested study for a client to optimize the refining operation of two refiners in series. The aim is to minimize fiber shortening and maximize eternal fibrillation of the fibers. The 2 main variables were the normal force and duration time in a Valley beater. Master curves were developed for the pulp of interest for the conditions required to attain an SR of 45. The main result is that what ultimately matters most is the total energy or work done on the pulp expressed as the normal force times the beating duration time.

"Incorporation of nanoparticles in paper sheets" Derek Gray et al., McGill University - two applications of nanoparticles embedded in paper are presented. Soaking filter paper in silver nitrate solution, the reducing the nitrate with an agent, produces a matrix of embedded silver nanoparticles of 7 nm size. This produces a bacteria killing water filter that can be used in the field in emergency applications. It takes 10 minutes for 100 mls of water to go through a filter like this. Another

application was to embed quantum dots from Evident Technologies for the purpose of counterfeit prevention. These quantum dots are intensely fluorescent, are cast into cellulose triacetate films which are bonded internally in layers to paper.

"Improvement of nanoparticles in paper sheets from biodegradable natural polymers" Laura Vikele et al., Latvian Institute of Wood Chemistry - To replace organic and inorganic additives that challenge the recycling process strengthening agents from biodegradable sources, cellulose, chitosan and woodworking residues are being considered here**.** Nanochitosan was prepared from commercial sources using high shear and applied to paper. Tensile strength improvement is observed to be 20%, wet strength improvement is 500%. NC gel applied as coating decreases air permeability up to 40% and contact angle by 15%.

"Wetting spreading and sorption measured by Raman confocal Raman microscopy " Birgit Brandner et al., YKI Sweden - a WITEC confocal microscope with red and green excitation lasers was used to in attempt to investigate the wetting and spreading of a water drop on hydrophobic and superhydrophobic surfaces. The separation distance between water and the surfaces was determined by looking at the depth profile of the Raman water peak 2000 nm. Dynamics of the technique are limited to 50 ms or greater. Swelling of the surface due to water absorption requires manual compensation of it occurs.

"Topographical modification of fibers by grafting of carboxymethylcellulose in pilot scale" Mikael Ankerfors et al., Innventia - This was work originally completed in 2006, since commercialized in 2 installations but is reported now. The aim here is to increase the pressability of fibers in the wet end by increasing the surface charge. Lindstron (2000) showed that by using $CaCl_2$ in solution (0.05 M) with fiber with 120 deg C temperature and pH 8 will attach CMC (Hercules Aquasorb A-500) in 2 hours onto the fiber surface. The result is increased tensile strength without densification as a result of increased molecular content. Trials were conducted on the FEX pilot paper machine at Innventia, 10 kg/tonne pulp loading of CMC, attachment of CMC was 97% and the surface/total charge ratio was 26%, higher than refined pulp. The resulting tensile index for CMC grafted pulp is equivalent to 100 kw-hr/tonne refining. The economic benefit of grafting to replace refining is that a higher dry solids content is obtained when the pulp mat is wet pressed thus requiring less drying energy. Funding was provided by Innventia's Paper Chemistry Cluster: Stora Enso, M-Real, Stora Cell, Eka Chemicals, Billerud, Kemira, Korsnas, Mondi Packaging, Holmen, Voith Paper, Norske Skogsindustrier.

"The number of contacts in random fibre networks" Anton Hagman et al., KTH - this was a talk about developing a method to determine the number of fiber contacts in a computerized network model. Assumptions used in the algorithm were discussed in detail, mention was made of a Chamfer digital filtering segmentation of digitized cross section fiber network images and preliminary results presented.

"Stress strain curve of paper revisited" Svetlana Borodulina et al., KTH - this work consists of modeling a fiber network subjected to tensile strain and predicting the effect of the degree of bonding on the stress strain curve. Modeling results replicate the experimental work previously shown by Page and Seth (1981) where the modulus remains constant but the tensile strength varies depending on the level of

bonding. The modeling results are supplemented with strain maps of tensile experiments using speckle digital analysis. Financial support by Woodwisdom-Net and BiMac Innovation partners

"Impact of morphology of SGW fibres and fines of sheet properties" Daniel Sodeburg et al., Innventia - using a series of hydrocyclone fractionators, a series of sheets were prepared from the slimmest to the coarsest fiber from the accept and reject fractions. Fines were screened out from the fiber fractions. The coarse reject fraction made sheets containing the least fines had the least opacity, highest surface roughness and the least ZD strength. Fines added to this fraction produced sheets with lower roughness. Sheets made from the slimmest fiber of accept fraction showed the highest ZD strength as desired for offset printing. The work is sponsored by the EU 7th Framework Program.

"Fiber deformations induced by different mechanical treatments and their effect of fiber strength" Elias Retulainen et al., VTT Finland - this work explores the concept that strongly deformed fibers tend to decrease the elastic modulus and tensile strength but may improve elongation and tear strength. Experimental design used 3 widely different mechanical treatments: a) a defibrator at high consistency, b) a Valley beater at low consistency, c) an E-compactor shearing compressor. Effects of treatment were evaluated using the zero span test. Best results were obtained from the Valley beater at low consistency where a good correlation was obtained between fiber length and zero span strength. The work is sponsored by the Future Biorefinery program.

"A new burnout test for wood containing papers" Matthias Trimmel et al., Technical University Graz Australia - the burnout test for white coated paper is used to blacken the substrate fibers such that the coating non-uniformity can be readily observed. The original technique using ammonium chloride solution published by O'Neil and Jordan does not work for lignin containing papers. This technique was devised using fire retarding chemicals to protect the fibers such that only the outer surface becomes charred and thereby visible under the pigmented coating.

"Evaluation of the Scott bond test method" Soren Ostlund et al., KTH, - this was an investigation in the mechanisms of the Scott bond test using high speed photography which showed that much of the energy measured in the test is not related to the actual delamination of the paper sample. A UTM was instrumented to measure the fracture energy is the Scott bond test which is considered to be a better measurement of the quality of the internal bond of a sheet. Differences between the conventional and the UTM measurement f fracture energy indicate that the tape should be replaced by epoxy but this is tedious to do. The Paper Mechanics Cluster within the Innventia Research Program funded the work from 2009-11.

"Wet stretch of paper and its relation to CD shrinkage and tensile properties" Torbjorn Wahlstrom Stora Enso - this is a study of the effects of wet tensile draw and shrinkage at the edges of a paper web. CD shrinkage increases exponentially with MD strain and increase with moisture content. Laboratory and pilot scale experiments were made to form a general picture. The aim is to predict the shrinkage profile on a paper machine given the tension and operating parameters in open wet draw. Findings are that the mechanisms for shrinkage at paper web edges are the same in the static or dynamic cases.

VINNOVA, the Kempke Foundations, Swedish agency for economic and regional growth funded this work.

"Engineering fracture mechanics analysis of paper materials" Petri Makela Tetra Pak - the aim here is to provide a formulism and testing method to predict the failure stress for a web or arbitrary dimensions placed under tensile load using fracture mechanics. With this method it is possible to use an ordinary tensile test combined with a tensile test of a sample containing a cut to determine the fracture toughness using an analytical formula specific to the cut sample geometry. The new method will be implemented in the Lorentzen and Wettre fracture toughness instruments. Comparisons of critical failure load were made with results with webs in tension on pilot paper machines.

"Numerical investigation of paperboard forming" Hui Huang et al., KTH, - replacement of plastic bottles by molded pulp products is the motivation in this modeling exercise of the press forming of a pear shaped pulp sheet which was also supplemented by experimental work to verify the model predictions regarding fracture points on the blank sheet. 13 elastic constants of the pulp sheet were measured and used in the forming numerical simulation. Results show that low stiffness material is better for forming without fracture or delamination of the sheet blank. Funding provided by BiMac Innovation and its industrial partners.

"Computational modeling of the mechanisms of failure of paper packaging under dynamic and impact loading" Bandaru Ramarao et al SUNY ESF - a medical equipment supplier (Becton Dickinson Medical) required the analysis of the failure of their sterile packages in order to design the package to avoid failure. Microscopic examination of he failed packages showed that the impact causes a cut to form followed by a tear. A commercial software system LS Dyna 971 was used to model the damage caused by impacts. The work led to the proprietary redesign of the packaging to be able to survive the impacts without sustaining damage.

"Utilizing atomic force microscopy to characterize various single fiber-fiber bonds" Franz Schmied et al., University of Dublin - microfibrils in paper fibers can be visualized by AFM. A large amount of effort was expended in finding the right AFM cantilever to use to flex fibers and determine the force required to break 2 fibers apart, the energy to do so was determined by experiments to be about 10^{-12} to 10^{-13} kJ. Supported by Mondi and the Federal Ministry of Economy Austria.

Anisotropic light propagation in paper" Tomas Linder et al., Lulea University Sweden - Monte Carlo simulation methods were used to trace the propagation of light through a fiber network. Variables in the model were the scattering and absorption coefficients and the scattering angle. The result was a prediction of the elliptical transmitted light beam intensity patterns on the other side of the sheet. Comparisons were made with actual light intensity patterns obtained from an optical fiber illuminating the underside of a sheet imaged by a CCD camera. The work is reminiscent of the development of optical fiber orientation measuring instruments by Lippke, Honeywell an ABB in the 1980's. Financially supported by EU Structural Fund.

"Fluorescence model for multi-layer paper using conventional spectrophotometers" Ludovic Coppel et al., Innventia - the motivation here was to devise a method to obtain more information that is normally

available from a conventional brightness measuring instrument. Using the fluorescence model of Kohanovsky the scattering coefficients can be determined down to 400 nm. The technique was applied to laboratory prepared papers having 0, 15 and 30% PCC filler and dosings of 0 , 9 and 18 kg/tonne FWA (fluorescence whitening agent). The Swedish Government Agency for Innovation Systems (VINNOVA), the Kempe Foundation and the Knowledge Foundation provided finding.

"Significance of surface and bulk light scattering in microgloss and microgloss non-uniformity" Ramin Farnood et al., University of Toronto - several different types of coatings with different pigment size were applied to paper then lab super-calendered and analyzed using specularly reflected polarized light for analysis of textured gloss images and the variation the gloss. At a Tappi gloss of 30 points, the surface gloss dominates the gloss attributable to the bulk of the coated sheet. Gloss levels were lower of GCC pigments and in general, microgloss variation is largest for the smaller pigment size. The coefficient of variation of gloss was found to be constant for the sample set. RMS roughness measured optically by the WYCO noncontacting method showed not to be a good predictor of gloss, instead a mathematical surface texture parameter was developed based on the surface topology correlation length. Thus a better predictor for gloss level was obtained. Surface Science Research Consortium at UT Pulp and Paper Center and Natural Sciences and Engineering Research Council of Canada supported this work.

"Role of chitosan of folding boxboard strength and printability" Mousa Nazhad et al., Asia Institute of Technology - the idea here is to replace starch with chitosan as a surface strengthening agent. Chitosan solubilized in acetic acid and mixed with starch was sprayed onto sheet surfaces and in between plies of multi-ply board. Many strength properties improved with the application, notably ZD strength. Reduced print mottle was also observed form the application of this surface sizing.

"Effects of coating formulation on coating thermal properties and coated print quality in xerography" Ning Yan et al., University of Toronto - this is a study of the effects of various different coatings in the thermodynamics in xerography. The aim is to have thermal transfer to be effective heat sink for fusing the toner onto the surface. A non-contact method was used to measure the thermal diffusivity of various free standing coatings prepares of various aspect ratios of GCC and kaolin. This was a xenon flash Nanoflash thermal diffusivity instrument at Xerox Research. Heat capacity was measured by differential calorimetry and the apparent density of the coatings by mercury intrusion porosimetry. The largest contrast in result was between platy kaolin and spherical GCC coatings. Platy kaolin coating had the highest specific heat capacity and the least thermal conductivity. Surface Science Research Consortium at UT Pulp and Paper Center and Natural Sciences and Engineering Research Council of Canada, FP Innovations, Xerox Research Center Canada supported this work.

"Strong nanofibrillated cellulose films with high barrier properties" Monika Osterberg et al., Aalto University Finland - NFC films were made by casting and evaporation, admittedly a tedious time consuming lab method, these were tested for oxygen barrier properties which were shown to be good below 80% RH, the films were later compressed to have an increased modulus in the range of 8.1 to 11.2 GPa. Addition of nanoclay decreases the modulus but improves the oxygen barrier properties to be better than cellophane. The WVTR of NFC is 600 gsm therefore the application is where oxygen

penetration is required to be limited by the passage of water vapor unrestricted, perhaps the packaging of fresh fruit to limit spoilage in transport.

"Hygromechanical behavior of natural fibre networks and analysis combining macroscopic tests and x –ray microtomography" Cyril Marulier et al., LGP2 Grenoble - the synchrotron e-beam at CERN is used to generate intense monochromatic x-rays used in microtomography of sheets pressed to various densities. The sample is incrementally rotated about an axis and 1500 x-ray images are taken and computer analyzed to produce a 3D map of the structure with 0.7 cubic micron resolution. Fiber cross section morphology is obtained such as the collapse of the lumens at high pressing pressure. Results include measuring the bonded are to be about 250 square microns and the RBA (relative bonded area) to range 0.05 at 400 kg/m^3 to 0.2 at 600 kg/m^3

"Analysis of the local compressibility and density in spatial partitions of paper towel" Steven Keller et al., Miami University - this is a continuing study localizing density variations in the structure of embossed commercial towels. The differences in density structure between a CWP (conventional wet pressed) towel and TAD (through air dried) towel are aptly measured and illustrated by using a scanning contact probe compression tester. Point by point density maps are made, stress ranges for 300 to 20 kPa and the thickness correspondingly ranges from 20 to 200 microns. At 20 kPa the caliper is pretty close to the original caliper for the towel samples studied. This is consistent with the tissue softness measuring technique developed at IPST.

"A barrier coating approach to counter oil migration" John Husband et al., Imerys UK - Platy kaolin clay is applied in coating formulations to demonstrate the efficacy in limiting oil migration. Super platy clay of aspect ratio 60 -100 is selected and touted to have an advantage in performance compared to finer clays. Although performance is not as good as petroleum based polymer coatings, the carbon footprint for polymer coatings is 3500 – 4400 kg CO_2 compared to 5 -30 for kaolin. Recent concerns of printing ink oil migration in food board and recycled content in food grade board has renewed interest in cost effective oil barrier applications. Results are presented from a commercial application where the oil barrier was achieved using a platy kaolin coating. Volatile transmission is measured sing n-heptane sealed in a contained with the coated paper as a seal.

"Surface modification of renewable wheat gluten and starch-based films for improved water resistance" Agne Swerin et al., YKI Sweden - starch films were applied to paper and starch solutions were then applied on top through the electrospinning process to provide a superhydrophobic surface. Siloxane was also later applied using a plasma treatment. Similar coatings and film structures were made of wheat gluten. In general, the findings are that these structures cannot withstand any stress, although the water drop contact angle is high the WVTR is not reduced, hence superhydrophbicity does not waterproof a surface as have the experiments at IPST shown some years ago. Funding is provided by Vinnova.

"Evaluation of the stress-strain properties in the thickness direction, for thin and strong papers" Christer Fellers et al., Innventia - this is an examination of the ZD tensile test to determine whether it can be improved. Photo mounting tape has been shown to be better for stronger papers than using the

conventional double sided tape. Test specimens were prepared by running them through a heat laminator first then constructing the plastic to a dummy paper impregnated with adhesive then attached to a loading platen. A strain gauge is mounted to the platens to obtain a ZD tensile load curve from the ZD modulus and energy to failure are obtained. The investigations showed that Z fracture energy increases with paper grammage but the Z strength and elastic modulus do not as fracture typically occurs along a fiber plane. Supported by Aracruz, Billerud, Eka Chemicals, Holmen, Korsnas, Metsa-Botnia, Mondi Packaging Paper, M-Real, Peterson, Stora Enso, Sodra, Tetra Pak and Voith.

"Investigation of size effects in tensile testing of paperboard" Anton Hagman et al., KTH - The effect of differing sample sizes in the tensile test were examined. The strain to break and tensile strength were studied as a function of the sample geometry. Hardening behavior and yield points are different for different sample geometries. Insight into the mechanism for the effect on sample geometry was studied using digital speckle photography a commercial system called Aramis was used. Strain zones appear which are 5 mm wide perpendicular to the direction of straining. Smaller samples are more covered by these strain zones which when combine lead to fracture failure. A reduction in variation occurs with larger samples. The strain zones correspond with the floc structure of the paper. The opportunity exists to optimize the geometry for the tensile test to minimize the variation for improved quality control.

"The effect of previous straining on the tensile behavior of paper" Douglas Coffin Miami University - this is a re-examination of the hardening behavior of paper placed in cyclic tensile stress. Paper exhibits a different behavior when placed under repeated stress and the consideration here is how to model this phenomenon. An efficiency factor is derived much along the lines of the 1981 work of Page and Seth who showed how bonding affects modulus and strength. The modulus drops with repeated straining and plastic strain is the most sensitive to bonding damage. Different data sets are presented for different types of papers.

"An in-situ microbotic approach for assessing the stiffness properties of microfibrillated cellulose" Manuel Mikczinski et al., University of Oldenburg Germany - A sophisticated SEM/TEM stage is constructed consisting of controllable micromanipulators , AFM cantilevers, micropositioners. This is placed in an ion beam FEI Quanta 600 system achieving 4% RH 20 degrees C 0.5 mbar environment in which microfibrils of cellulose can be mechanically flexed and properties measured. Young's modulus is determined to 8 – 10 GPa consistent with the literature using other inferred techniques.

" Vulcanized fiber as a strength construction material for highly loaded construction units" Dominik Dumke et al., Technical University Dortmund - this is revisiting a technique patented in 1853 and has been used in the manufacture of military combat helmets among other objects. Cotton fabric is pulverized and soaked in zinc chloride acid, then pressed washed and dried, material modulus is in the range of 4 – 8 GPa. Properties are improved by impregnation by resin melamine or phenol. Aerogel filler is used to increase the elongation to break to 20% for automobile fender and side panel applications. The aim is to substitute this material for many plastics applications.

"Practical experience with C*iCoat as coating binder" Andreas Becker et al., Cargill Company - This sounds very much like the "nanostarch" developed by EcoSynthetix and since usurped by Cargill. The

application described here is to replace 5 part latex in a coating formulation with this nanostarch which does not require cooing like conventional starch. The other advantage is that a high solids content can be run with this starch up to 70% as compared to 44% using a conventional starch coating color formulation. The main positive result that is being touted is that the nanostarch has a higher water retention value requiring less drying energy for the coating since less water penetrates into the base sheet. Printed gloss improved by 5%. The cost savings in replacing latex by this starch is 13% and the savings in energy demand is 43% by the increase of 3% in the ability to run higher solids.

"Dynamics of moisture interaction with polyelctrolyte multilayers containing nanofibrillated cellulose" Hjalmar Granberg et al, Innventia - Alternating thin layers of nanocellulosic films were prepared and placed on silicon wafer substrates so as to construct an in optical interference filter. When the moisture changes, the colors change so that the film structures can be used as a moisture sensor. The application may be to place such sensors once produced economically into packaging as moisture monitors. Funded by partners in the Paper Beacon project, VINNOVA.

"Mechanical properties of cellulose nanofibrils determined through atomistic molecular dynamics simulations" J. Ketoja et al., VTT Finland - the work is driven by the idea that the molecular level drives macroscopic behavior strength and stiffness emanating from the cellulose crystalline structure. Based on the work by A. Kulachenko (2012) the focus is to explain the modulus of nanofibrils modeled as lines of crystalline cellulose 150 nm length coupled by amorphous cellulose chains of 30 nm length. Crystalline cellulose has a modulus of 130 – 150 GPa but cellulosic nanopaper has a modulus of 10 – 15 GPa. The model explains the loss of modulus due to amorphous cellulose chains. Stora Enso, UPM, Metso, Kemira, Andritz and Myllykoski are supporters of this project.

"The effect of microfibrillated cellulose on the pressability of TMP and filler mixtures and on paper properties" Oyvind Gregerson et al., NTNU Trondheim Finland - The aim here is to see how replacement of filler with MFC will aid thermomechanical pulp papermaking. MFC was homogenized at 1000 bar using 3 passes so as not to severely deteriorate the cellulose. A dynamic press simulator was constructed and used to provide a dewatering pulse of 8 ms duration. Addition of MFC slows down drainage but increase the tensile strength strain at break air resistance and ZDT more effectively that the equivalent weight of TMP fines. The higher ZDT values are attractive to limit surface linting in offset printing. Funded by the Research Council of Norway, Norske Skog, PFI, Voith, News International, Omya and Sun Chemical.

"Application and interpretation of zero and short-span testing on nanofibre sheet materials" Warren Batchelor et al., Monash University Australia - The short span tensile test wet and dry as applied to prepared nanocellulose films. MFC from Daicel was purchased and filtered to remove long fibers, the mean fiber length of the filtrate was 7 microns. Zero span test with increasing gap length showed a flat curve for the dry films and much lower values for wetted films. The interpretation is that for such short nanofibers the zero span test is equivalent to a network Research tensile test much the same as a conventional paper tensile test. Funding was provided by Australian ouncil, Australian Paper, Nopco Australia, SA Hygeine Australia and Visy.

"Time dependent stochastic failure of paper and board" Tetsu Uesaka et al., Mid Sweden University, Sundsval - This is a rethinking about what causes failure of board structures and the requirement for large safety factors of 4 -7 for paper materials compared to others e.g. metals or plastics. Using an old formulism of accumulated damage evolution and subsequent failure probability originally proposed by Coleman in 1958, Uesaka analyzes old box failure data culled from the literature on log-log scales and analytical formulisms to characterize the failure probability in terms of a "sensitivity factor". The sensitivity factor is 3 – 7 for corrugated panel failure data but 13 – 27 for corrugated boxes. Experimental work has recently commenced to augment the theoretical analyses. The puzzle remains why some failure data show a coefficient of variation ranging from 6% for some boxes to 90% for others. The work is funded by SCA R&D, Billerud and the Bo Rydin Foundation.

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