Pyrolysed cellulose nanofibrils and dandelion pappus in supercapacitor application

Dandelion pappus and wood based nanocellulose fibrils were combined to form films that were subsequently pyrolyzed under low-pressure conditions in a carbon monoxide (CO) rich atmosphere to make supercapacitor electrode material. The electrodes were prepared from these materials and pyrolyzed under low-pressure conditions in a carbon monoxide-rich atmosphere. The electrode materials and assembled supercapacitors were electrically and structurally characterized. The assembled six supercapacitors showed specific capacitances per electrode ranging from 1 to 6 F/g and surface resistance of pyrolyzed electrodes ranging from 30 to 170 Ω. Finally, equivalent series resistance and leakage current measurements were conducted for three samples, resulting values from 125 to 500 Ω and from 0.5 to 5.5 µA, respectively.

General information
State: E-pub ahead of print
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Faculty of Biomedical Sciences and Engineering, Research area: Microsystems, Electronics and Communications Engineering, Materials Science, Research group: Plastics and Elastomer Technology, Research group: Plastics and Elastomer Technology, Research area: Measurement Technology and Process Control, Research group: Sensor Technology and Biomeasurements (STB), BioMediTech, BioMediTech Institute and Faculty of Biomedical Sciences and Engineering
Authors: Virtanen, J., Pammo, A., Keskinen, J., Sarlin, E., Tuukkanen, S.
Number of pages: 11
Publication date: 24 May 2017
Peer-reviewed: Yes

Publication Information
Journal: Cellulose
ISSN (Print): 0969-0239
Ratings:
Scopus rating (2016): CiteScore 3.68 SJR 1.126 SNIP 1.144
Scopus rating (2015): SJR 1.153 SNIP 1.24 CiteScore 3.55
Scopus rating (2014): SJR 1.071 SNIP 1.334 CiteScore 3.58
Scopus rating (2013): SJR 1.127 SNIP 1.48 CiteScore 3.83
Scopus rating (2012): SJR 1.179 SNIP 1.71 CiteScore 3.74
Scopus rating (2011): SJR 1.354 SNIP 1.795 CiteScore 3.99
Scopus rating (2010): SJR 0.873 SNIP 1.384
Scopus rating (2009): SJR 1.038 SNIP 1.219
Scopus rating (2008): SJR 0.926 SNIP 1.123
Scopus rating (2007): SJR 0.754 SNIP 1.034
Scopus rating (2006): SJR 0.699 SNIP 1.15
Scopus rating (2005): SJR 1.112 SNIP 1.318
Scopus rating (2004): SJR 0.855 SNIP 1.072
Scopus rating (2003): SJR 0.81 SNIP 1.02
Scopus rating (2002): SJR 0.649 SNIP 0.689
Scopus rating (2001): SJR 0.602 SNIP 0.785
Scopus rating (2000): SJR 0.583 SNIP 0.773
Scopus rating (1999): SJR 0.67 SNIP 1.14
Original language: English
Keywords: Supercapacitor, Nanocellulose, Dandelion, Pyrolysis
DOIs:
10.1007/s10570-017-1332-8
Links:
http://urn.fi/URN:NBN:fi: tty-201706051577. Embargo ends: 24/05/18

Bibliographical note
INT="Pammo, Arno"
Research output: Scientific - peer-review › Article

Modelling and Simulation of Radial Spruce Compression to Optimize Energy Efficiency in Mechanical Pulping

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Mechanical Engineering and Industrial Systems, Department of Automation Science and Engineering, Research area: Dynamic Systems, Research area: Measurement Technology and Process Control
High strain rate radial compression of Norway spruce earlywood and latewood
The mechanical properties of Norway spruce were studied and a compression model for mechanical pulping was developed. The split-Hopkinson pressure bar technique was combined with high-speed photography to analyse local radial compression. Data analysis focussed on the differences between mechanical properties of earlywood and latewood. Measurements were conducted at both room temperature and 135 °C. The effect of pre-fatigue treatment was also studied. A simple material model was defined linearly in parts and fitted to the measurement data to quantify the differences. New results were found on the differences in inelastic behaviour of earlywood and latewood at large deformations. In addition, other results were in line with previously published results.
Machine-coated starch-based dispersion coatings prevent mineral oil migration from paperboard

Mineral oil migration through paperboard presents a safety risk in modern food packaging. This study aimed to enhance the safety of fiber-based packaging by utilizing a bio-based composite barrier layer to protect against mineral oil. Starch-clay composite coatings on paperboard were created via dispersion coating. Thermal analysis of the coating components and field emission scanning electron microscopy imaging were performed to ascertain the physicochemical properties and morphology of the coatings. Coating functionality was evaluated using contact angles and transmission rate (water and oxygen) measurements. The packaging safety focus was implemented by measuring the gas phase migration of heptane and analyzing the migration of liquid mineral oil through the coated paperboards with FTIR. The functional properties of the coated paperboards were maintained or improved. The studied coatings were effective barriers against the migration of mineral oil and could hence improve the barrier properties and safety of fiber-based primary food packaging.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Materials Science, Research group: Paper Converting and Packaging
Authors: Koivula, H. M., Jalkanen, L., Saukkonen, E., Ovaska, S., Lahti, J., Christophliemk, H., Mikkonen, K. S.
Pages: 173-181
Publication date: 2016
Peer-reviewed: Yes

Publications information
Journal: Progress in Organic Coatings
Volume: 99
ISSN (Print): 0300-9440
Ratings:
Scopus rating (2016): SJR 0.852 SNIP 1.3 CiteScore 2.89
Planar fluidic channels on TiO2 nanoparticle coated paperboard

A new design for permanent, low-cost, and planar fluidic channels on TiO2 nanoparticle coated paperboard is demonstrated. Initially superhydrophobic TiO2 nanoparticle coatings can be converted to hydrophilic by ultraviolet (UVA) light, and fluidic channels can be generated. A simple water treatment after the UVA illumination converts the channels permanent when nanoparticles are removed from the illuminated and wetted areas as shown by water contact angle, FE-SEM, XPS, and ToF-SIMS analysis. This suggests new routes for inexpensive, easy to use point-of-care diagnostics based on planar fluidic channels.

General information

State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Physics, Research area: Aerosol Physics, Research group: Aerosol Synthesis, Department of Materials Science, Research group: Paper Converting and Packaging, SP Technical Research Institute of Sweden, Laboratory of Paper Coating and Converting, Center for Functional Materials, Abo Akademi University, Turku, AGH University of Science and Technology, Academic Centre for Materials and Nanotechnology
Authors: Valtakari, D., Stepień, M., Haapanen, J., Teisala, H., Tuominen, M., Kuusipalo, J., Mäkelä, J. M., Toivakka, M., Saarinen, J. J.
Number of pages: 7
Pages: 232-238
Publication date: 2016
Peer-reviewed: Yes

Publication information

Volume: 31
Issue number: 2
ISSN (Print): 0283-2631
Ratings:
Scopus rating (2016): CiteScore 1.2 SJR 0.385 SNIP 0.652
Scopus rating (2015): SJR 0.375 SNIP 0.787 CiteScore 0.91
Scopus rating (2014): SJR 0.444 SNIP 0.823 CiteScore 0.99
Scopus rating (2013): SJR 0.389 SNIP 0.684 CiteScore 0.71
Scopus rating (2012): SJR 0.628 SNIP 1.281 CiteScore 1.13
Scopus rating (2011): SJR 0.582 SNIP 0.902 CiteScore 0.78
Scopus rating (2010): SJR 0.658 SNIP 0.764
Scopus rating (2009): SJR 1.167 SNIP 0.984
Enhanced pre-treatment of cellulose pulp prior to dissolution into NaOH/ZnO

As a result of the constantly growing demand for textile fibres interest in utilising cellulose pulps for manufacturing regenerated cellulose fibres is growing. One promising water-based process for the manufacture of regenerated cellulotic products is the Biocelsol process based on an NaOH/ZnO solvent system. The drawback of the Biocelsol process is the need for pre-treatment of the pulp, i.e. long mechanical pre-treatment (up to 5 h) followed by a 2–3-h enzymatic hydrolysis utilising a rather high amount of cellulolytic enzymes. In this work more efficient conditions to carry out the pre-treatment of cellulose pulp prior to dissolution into NaOH/ZnO are presented. Based on the results, cellulase treatment, when carried out in an extruder, can be used to effectively open up and fibrillate the fibres without completely destroying the fibre structure. The molar mass of the pulp treated enzymatically in an extruder was 14 % lower as compared to the state-of-the-art-treated cellulose. As a consequence, the alkaline solutions prepared from the pulp treated enzymatically in an extruder had clearly lower dope viscosities regarding the cellulose content than the solutions prepared from the state-of-the-art-treated pulp. This enabled increasing the cellulose content in the dope up to 7 % (w/w) without increasing the dope viscosity.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Materials Science, Research group: Fibre Materials, Department of Forest Products Technology, VTT Technical Research Centre of Finland, Aalto University
Authors: Grönqvist, S., Kamppuri, T., Maloney, T., Vehviläinen, M., Liliä, T., Suurnäkki, A.
Number of pages: 10
Pages: 3981-3990
Publication date: Dec 2015
Peer-reviewed: Yes

Publication information
Journal: Cellulose
Volume: 22
Issue number: 6
ISSN (Print): 0969-0239
Ratings:
Scopus rating (2016): CiteScore 3.68 SJR 1.126 SNIP 1.144
Scopus rating (2015): SJR 1.153 SNIP 1.24 CiteScore 3.55
Scopus rating (2014): SJR 1.071 SNIP 1.334 CiteScore 3.58
Scopus rating (2013): SJR 1.127 SNIP 1.48 CiteScore 3.83
Scopus rating (2012): SJR 1.179 SNIP 1.71 CiteScore 3.74
Scopus rating (2011): SJR 1.354 SNIP 1.795 CiteScore 3.99
Scopus rating (2010): SJR 0.873 SNIP 1.384
Scopus rating (2009): SJR 1.038 SNIP 1.219
Scopus rating (2008): SJR 0.926 SNIP 1.123
Scopus rating (2007): SJR 0.754 SNIP 1.034
Scopus rating (2006): SJR 0.699 SNIP 1.15
Scopus rating (2005): SJR 1.112 SNIP 1.318
Adhesive Behavior Study Between Cellulose and Borosilicate Glass Using Colloidal Probe Technique

Cellulose-glass fiber hybrid composites have been introduced to introduce weight and price benefits compared to glass composites. However, the interactions between glass and cellulose have not been extensively studied. Understanding the interactions between these two materials will help to improve the mechanical properties of the cellulose hybrid composites. In this paper, by employing the colloidal probe technique, we investigated the interaction forces between glass and cellulose material. A silicon probe with a borosilicate glass microsphere attached as the probe tip was implemented into an atomic force microscope (AFM) to complete the task. Cellulose membranes were used as experiment samples. By pressing and releasing the colloidal probe against the cellulose membrane, the adhesion force and the adhesion energy were directly obtained through the measurements. The interfacial energy was revealed by applying the Johnson-Kendall-Roberts (JKR) model, and a theoretical calculation of the material stiffness was conducted.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Automation Science and Engineering, Research area: Microsystems, Research area: Measurement Technology and Process Control
Authors: Lai, Y., Sugano, Y., Bobacka, J., Kallio, P.
Number of pages: 5
Pages: 85-89
Publication date: Oct 2015

Host publication information
Title of host publication: Proceedings of the Fifth International Conference on Manipulation, Manufacturing and Measurement on the Nanoscale (3M-NANO)
Publisher: IEEE
ISBN (Print): 978-1-4673-9625-7
DOIs:
10.1109/3M-NANO.2015.7425492
Research output: Scientific › peer-review › Conference contribution

Validity of traditional barrier-testing methods to predict the achievable benefits of the new generation water based barrier coatings for packaging materials
In the study, Next Gen WBBC materials were evaluated both in laboratory and pilot scale. Analyses were done for KIT, oxygen, water vapour, grease and oil barrier. The applicability of the testing methods was tested and compared to PE-coated ice cream boxes and fluorocarbon coated quick food packages, which both have different barrier demands. As a result, some of the test methods did not characterize well enough the barrier properties of WBBC materials. The Next Gen WBBC solutions had excellent grease and water vapour resistance even with low KIT values. For example the behaviour of WBBC materials in the oil resistance test was different compared to fluorocarbon coated packages, which also creates a need to further develop the test method and target setting.

The Next Gen WBBC materials can be used to replace PE-coatings, waxes and fluorocarbons in some of the common packaging applications. The future challenge is to commonly agree on and develop the accepted test methods for novelty WBBC products to evidence their performance and achievable benefits in barrier application areas.
**Wet-spinning of cellulosic fibres from water-based solution prepared from enzyme-treated pulp**

The demand for textile fibres is increasing constantly due to the growing population and improving standard of living. Currently, 64 % of the fibres produced globally are synthetic man-made fibres from oil-based raw materials, 29 % is cotton and the rest are man-made cellulosic fibres, wool and other natural fibres. The production of synthetic fibres and cotton cannot be increased in the future, thus creating a gap between the fibre demand and the production. One candidate to fill the gap is the viscose fibre which production covers currently 96 % of the man-made cellulosic fibres. However, the viscose process is challenging due to the occupational health and environmental issues relating to the use of carbon disulphide.

As a consequence, there is a need of such fibres that are made from the renewable resources (vs. oil), do not compete with the food production (as cotton) and do not need hazardous chemicals (as viscose).

This work introduces a new cellulosic fibre process which attempts to respond the need described. In the process, a dissolving grade wood pulp is treated with enzymes, dissolved in water-based solvent and regenerated to fibres using a wet spinning method. Thus the raw material is renewable, which growth does not use arable land, and the carbon disulphide needed in the viscose process is here replaced with enzymes.

Dissolution of the enzyme-treated pulp into aqueous sodium zincate and the regeneration of the solution into cellulosic fibres were demonstrated first. Thereafter, the preparation of the spin dope and the wet spinning of the fibres were studied in more detailed. The enzyme-treated cellulose was dissolved either by mixing-procedure or by freezing-thawing cycle. Both methods resulted in high quality solution for the spinning trials. However, the alkali ratio of the solution prepared by freezing-thawing cycle was lower (1.1 vs. 1.3) thus requiring less sulphuric acid during the coagulation. The spinneret draw ratio and the stretching ratio during the spinning exhibited negative correlation. This was due to the rapid coagulation of the solution. The coagulation rate decreased significantly when the sulphuric acid spin bath was replaced with an acetic acid bath. Equally, the stretching ratio of the fibres increased, but unexpectedly the tenacity of the fibres did not increase. It was found that the acetic acid spun fibres shrunk during the drying and thus the orientation gained during the stretching was lost.

Another route to modify the fibre properties was explored through the chemical modification of enzyme-treated cellulose with allyl glycidyl ether. The treatment resulted in the pulp with low amount of 3-allyloxy-2-hydroxypropyl groups (DSA 0.05) which had higher solubility in aqueous sodium zincate than the un-substituted enzyme-treated pulp. The 100 % solution from the modified pulp did not form fibres in acidic bath, thus the fibres were spun from the solutions containing 25 % and 10 % of the modified pulp. The 3-allyloxy-2-hydroxypropyl groups provide reactive C=C double bonds in the fibre structure, thus allowing the further functionalization to gain new properties for the fibres.

It was shown that the production of regenerated cellulosic fibres in an environmental manner is possible, thus providing one option to fill the gap between the fibre demand and the production in the following decades.
Automated Microrobotic Manipulation of Paper Fiber Bonds

This paper presents a novel method for automated manipulation of individual paper fiber bonds using a microrobotic platform, a computer vision algorithm and a robotic software framework. This is a challenging task due to the three-dimensional, heterogeneous and complex morphology of the fiber bonds. The goal is to automatically grasp the fiber bond, and break it by pulling apart the fibers it consists of. We present the components of the microrobotic platform, and the different rules utilized in detecting suitable grasp points from a 3D reconstruction of the bond generated from an image pair. We demonstrate the functionality of the approach with bond breaking experiments of seven fiber bonds. The time required for grasping and breaking of a bond is 10 – 15 seconds making the approach much faster than the current state-of-the-art testing, which is based on manual manipulation. The success rate of the tests is as high as 80%.

General information

State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Hirvonen, J., Essen von, M., Kallio, P.
Number of pages: 6
Pages: 784-789
Publication date: Sep 2015

Host publication information

Publisher: IEEE
ISBN (Print): 978-1-4799-9994-1
Electronic versions:
IROS_post_print
DOIs:
10.1109/IROS.2015.7353461
Links:
http://urn.fi/URN:NBN:fi:tty-201603243756
Research output: Scientific - peer-review › Conference contribution

Microrobotic platform with integrated force sensing microgrippers for characterization of fibrous materials: Case study on individual paper fibers

Mechanical characterization of micro-scale fibrous materials determines the key parameters which affect the quality of products such as composites, textile and paper. The current laboratory tests are mainly based on bulk measurements. This thesis introduces a microrobotic platform to handle and to characterize micro-scale fibers (MF), with the dimensions of few micrometers to hundreds of micrometers, at individual fiber level. The platform facilitates handling and specimen preparation of micro-scale fibrous material. A major challenge in mechanical characterization of MF is lack of proper force sensing microgrippers in the market. MF do not need a lot of force to manipulate, but their ultimate tensile strength is high and relatively large forces are required to perform a micro-tensile test. In this thesis, three force sensing microgrippers are developed and they are integrated into the mentioned microrobotic platform. Two of them are developed to measure the bonding forces between individual pulp fibers, normal to the bonded area (Z-direction) and parallel to the bonded area
Their force sensing solution is based on bending polyvinylidene fluoride (PVDF) films and their force range is up to 10mN. The third one, with the force range of 20mN, is developed to perform micro-tensile tests on MF. It uses a microspring and a magnetic encoder to measure the force. The force range of this force sensing microgripper can easily be increased by changing its microspring to a stiffer one. This feature makes the proposed force sensing approach adaptable to a wide range of MF. Even though pulp and paper fibers are used as a case study in this thesis, the applications of microrobotic solutions presented here are not limited to pulp and paper fibers for the following reason: pulp and paper fibers are natural fibers with random morphology, therefore if a microrobotic solution is capable of handling these morphologically challenging fibers, it is easily adaptable to synthetic fibers which have uniform morphology. The prototypes of all three force sensing microgrippers are calibrated and their performance are validated.

General information
State: Published
Ministry of Education publication type: G4 Doctoral dissertation (monograph)
Authors: Saketi, P.
Number of pages: 116
Publication date: 21 Jul 2015

Publication information
Place of publication: Tampere
Publisher: Tampere University of Technology
Original language: English

Publication series
Name: Tampere University of Technology. Publication
Publisher: Tampere University of Technology
Volume: 1309
ISSN (Print): 1459-2045
Electronic versions:
saketi_1309
Links:

Bibliographical note
Awarding institution: Tampere University of Technology
Versio ok 16.12.2015
Research output: Monograph › Doctoral Thesis

Formability of paper and its improvement
Paper and paperboard are the most utilized packaging materials in the world. This position has been achieved due to several advantageous features of paper such as: renewability, biodegradability, recyclability, and unmatched printability. Paper can be produced anywhere in the world, using local resources and at relatively low cost, which also makes it the most sustainable packaging material. Despite these beneficial features, paper packaging is in tough competition with plastic materials. The competitiveness of paper is mitigated by barrier properties, sensitivity to moisture, and limited ability to be converted into advanced 3D shapes with added functionality. The ability of paper and paperboard to be formed into 3D shapes is described as formability, or sometimes, mouldability.

Formability can be defined as the ability of paper to be formed into 3D shapes without defects in appearance and functionality. Formability as a mechanical property represents a group of parameters which vary according to the type of forming process used. The primary objective of this thesis is to improve the formability of paper by increasing its extensibility. An additional objective is the characterization of formability as a mechanical property of paper and the development of a testing platform for the evaluation of formability.

It was found that the formability of paper in fixed blank forming processes is governed by the extensibility and tensile strength of paper. On the other hand, in sliding blank forming processes, it is dependent on the compressive properties of paper, elastic recovery, and the paper-to-metal coefficient of friction. The criteria of good formability are also different in these two cases, as fixed blank process formability is evaluated via the maximum depth of the shape, i.e. the deeper the shape, the better the formability. In the sliding blank process, formability is evaluated via the visual appearance of the shapes, i.e. the shapes with less profound compressive wrinkles and defects reflect good formability of paper. These results were established by comprehensive investigation of different forming processes and comparison of the outcome with the mechanical properties of paper.

Taking into account the hypothesis that the formability of paper is governed by the extensibility of paper, a set of methods
for its improvement was suggested. These methods included combined high- and low-consistency treatment of fibres, spraying of agar and gelatine, in-plane compaction of paper and unrestrained drying. High-consistency treatment of fibres under elevated temperature induces permanent deformations to fibres such as microcompressions and dislocations, which in turn may decrease the axial stiffness of fibres, promoting shrinkage of paper and fibres. The low-consistency treatment straightens the fibres and induces the fibrillation of fibres to promote bonding, while microcompressions in fibres still exist. The spraying of agar and gelatine is likely to modify the character of the fibre joints by making them more deformable, and the drying shrinkage is also increased due to polymer addition. Finally, the fibre network was subjected to in-plane compaction and drying shrinkage which lead to buckling and fibre and network compression.

As a result of these treatments, the extensibility of unrestrained dried paper was increased from 4% points (untreated fibres) to 15–18% points (mechanical treatment and addition of polymers). The extensibility can be increased further by up to 30% points in one direction by compaction. This corresponds to tray-like shapes with a depth of 2–3 cm, depending on the curvature. Such values of formability are the highest reported so far in the scientific literature. The approach for the production of formable paper developed in this thesis work allows the production of a paper-based material with unmatched formability, which can replace certain types of plastic packaging. Replacement of plastics with paper improves the sustainability of packaging in general, and reduces the harmful environmental impact of non-degradable and non-renewable packaging.

**General information**

State: Published
Ministry of Education publication type: G5 Doctoral dissertation (article)
Organisations: Department of Materials Science
Authors: Vishtal, A.
Number of pages: 108
Publication date: 4 Jun 2015

**Publication information**

Publisher: VTT
ISBN (Print): 978-951-38-8304-1
Original language: English

**Publication series**

Name: VTT Science
Publisher: VTT
Volume: 94
ISSN (Print): 2242-119X
ISSN (Electronic): 2242-1203
Electronic versions:
vishtal_s94
Links:
http://urn.fi/URN:NBN:fi:tty-201609134501

**Bibliographical note**

Awarding institution: Tampere University of Technology
Versio ok 16.12.2015
Research output: Collection of articles › Doctoral Thesis

**Dissolution of enzyme-treated cellulose using freezing thawing method and the properties of fibres regenerated from the solution**

The rapid coagulation of NaOH-based cellulose solution during the wet spinning process leads to a low stretching ratio and, consequently, the low mechanical properties of the fibres. The aim of this work was to slow down the coagulation by replacing the sulphuric acid spin bath with an acetic acid bath. The spin dope was prepared by dissolving the enzyme-treated dissolving pulp in aqueous sodium zincate using a freezing thawing method. The optimal zinc oxide and sodium hydroxide concentrations were studied first. The most thermally stable cellulose solution contained 6.5 wt% NaOH and 1.3 wt% ZnO with 6 wt% enzyme-treated dissolving pulp. The spin dope was prepared accordingly. Coagulation of the cellulose solution slowed down in the acetic acid bath, resulting in a significantly higher stretching ratio for the fibres than with the sulphuric acid bath. However, the acetic acid spun fibres shrunk strongly during drying, and the possibly aligned order of the molecular chains due to the high stretch was partly lost. As a consequence, the high stretch was not transferred to high tenacity of the fibres in this study. However, the result suggests attractive potential to develop processing conditions to increase fibre tenacity.

**General information**
Impact of mechanical and enzymatic pretreatments on softwood pulp fiber wall structure studied with NMR spectroscopy and X-ray scattering

Dissolution of wood pulp can be enhanced by applying certain pretreatments before exposing the fibers to solvents. We have analyzed the effect of mechanical and enzymatic pretreatments on softwood fiber wall structure using nuclear magnetic resonance (NMR) spectroscopic methods, small and wide angle X-ray scattering (SAXS, WAXS). NMR diffusometry was used to estimate the effect of pretreatments on average pore sizes at micrometer size scale and for the connectivity of the porous network. A proton NMR experiment was used to quantify the nonfreezing water content inside the fiber wall, and solid state NMR C-13 cross polarization (CP) magic angle spinning (MAS) spectroscopy was used to observe the effect of pretreatments on crystallinity and lateral fibril dimensions of cellulose fibrils, and in combination with fiber saturation point measurement to calculate the average pore size at nanometer size scale. Both WAXS and CP MAS NMR experiments confirmed that there were no changes in crystallinity nor in fibril lateral dimensions due to pretreatments. The pretreatments caused an increase in the amount of nonfreezing water, suggesting an opening of the pore system. According to diffusion experiments there are only minor changes in micrometer scale pore network due to pretreatments. SAXS results indicated that enzymatic treatment increased the microfibrillar distance, and there was also an increase in cross relaxation rate of magnetization from water to cellulose protons as observed by NMR. These were interpreted to be due to opening of microfibrillar bundles, leading to an increased accessibility of water.
Microrobotic system for multi-rate measurement of bio-based fibres Z-directional bond strength

The core content of this study is micro-testing of microscale objects - an emerging application area for microrobotics - where microrobotics has been used in paper industry for measuring properties at the single fibre level. Pulp and paper scientists are interested to have experimental data of single fibre-fibre bond strength distribution of paper/board products in different loading modes and rates. Meeting this demand is quite challenging since the system should be able to measure the bond strength i) in the individual fibre level, ii) in different loading modes, and iii) in different loading rates. The current methods of measurement do not satisfy all these three requirements. Among the four different loading modes, the Z-directional behaviour of paper/board products is a matter of high significance for papermaking and paper converting companies. The Z-directional properties influence compressive properties, and accordingly the performance of structural paper/board products. According to the literature, there is not any reported method to facilitate the measurement of Z-directional strength at the single fibre level in different loading rates. This paper reports an in-depth study of a measurement method for experimental evaluation of Z-directional individual fibre-fibre bond strength in multiple loading
rates using microrobotics and a Polyvinylidene fluoride (PVDF) film microforce sensor. The results from the measurement system are promising. In summary, the first concept for multi-rate measurement of Z-directional bond strength at the individual fibre level is developed during this work which has a high practical impact on the fibre characterization research field.

**General information**
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Automation Science and Engineering, Research area: Microsystems, Research area: Measurement Technology and Process Control
Authors: Latifi, S. K., Saketi, P., Kallio, P.
Number of pages: 14
Pages: 13-26
Publication date: 24 May 2015
Peer-reviewed: Yes

**Publication information**
Journal: Journal of Micro-Bio Robotics
Volume: 10
Issue number: 1
Article number: 1
ISSN (Print): 2194-6418
Ratings:
Scopus rating (2016): SJR 0.352 SNIP 0.646 CiteScore 1.7
Scopus rating (2015): SJR 0.336 SNIP 1.025 CiteScore 1
Scopus rating (2014): SJR 0.105 SNIP 0.02
Original language: English
Keywords: Microrobotics, Micro-testing, Multi-rate microforce sensing, Polyvinylidene fluoride (PVDF), Z-directional strength
ASJC Scopus subject areas: Engineering(all)
DOIs: 10.1007/s12213-015-0080-9
Research output: Scientific - peer-review › Article

**Compression model for radial compression of Norway spruce earlywood and latewood**

**General information**
State: Published
Ministry of Education publication type: D3 Professional conference proceedings
Authors: Moilanen, C., Björkqvist, T., Saarenrinne, P.
Publication date: 19 May 2015

**Host publication information**
Title of host publication: 9th International Mechanical Pulping Research Seminar
Place of publication: Trondheim, Norway

**Bibliographical note**
ORG=mei,0.7
ORG=ase,0.3
Research output: Professional › Conference contribution

**Regeneration of fibres from alkaline solution containing enzyme-treated 3-allyloxy-2-hydroxypropyl substituted cellulose**
The aim of this study was to regenerate fibres from the alkaline cellulose solution containing 3-allyloxy-2-hydroxypropyl substituents. Enzyme-treated cellulose was modified in alkaline aqueous tert-butanol (tBuOH) using allyl glycidyl ether (AGE) as the modification reagent. 3-allyloxy-2-hydroxypropyl substituted (AHP) enzyme-treated cellulose with DS<sup>A</sup> 0.05 was obtained. Enzyme-treated cellulose without (reference) and with substituents were dissolved in sodium zincate using the freezing-thawing cycle. The reference solution alone and the mixture solutions containing 10 or 25 % of the AHP cellulose were regenerated into cellulosic fibres using the wet spinning technique. The solutions containing 100 or 50 % of the AHP cellulose did not form fibres in acidic bath. The 10 % share of AHP cellulose did not affect the mechanical properties of the fibres (1.5 cN dtex<sup>&gt;</sup>1), while the 25 % share decreased the tenacity slightly (1.3 cN dtex<sup>&gt;</sup>1). Elongation of the fibres ranged from 18 to 22 %. The 10 and 25 % shares of AHP cellulose increased the water holding ability of fibres by 12 and 33 %, respectively. According to FESEM the fibre...
structures are composed of nanosized fibrils.

Effect of rheological properties of dissolved cellulose/microfibrillated cellulose blend suspensions on film forming
Enzymatically treated cellulose was dissolved in a NaOH/ZnO solvent system and mixed together with microfibrillated cellulose (MFC) in order to find the threshold in which MFC fibers form a percolation network within the dissolved cellulose solution and in order to improve the properties of regenerated cellulose films. In the aqueous state, correlations between the rheological properties of dissolved cellulose/MFC blend suspensions and MFC fiber concentrations were investigated and rationalized. In addition, rheological properties of diluted MFC suspensions were characterized and a correlation with NaOH concentration was found, thus partly explaining the flow properties of dissolved cellulose/MFC blend suspensions. Finally, based on results from Dynamic Mechanical Analysis (DMA), MFC addition had strengthening/plasticizing effect on regenerated cellulose films if low concentrations of MFC, below the percolation threshold (5.5-6 wt%, corresponding to 0.16-0.18 wt% of MFC in the blend suspensions), were used.
A Method and an Apparatus for Producing Nanocellulose

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Authors: Björkqvist, T., Koskinen, T., Nuopponen, M., Vehniäinen, A., Gustafsson, H.
Publication date: 18 Feb 2015

Publication information
IPC: D21H 11/ 18 A l
Patent number: EP2659061
Priority date: 31/12/10
Priority number: FI 20106402
Original language: English
Source: espacenet
Hydrofluoric-nitric-sulphuric-acid surface treatment of tungsten for carbon fibre-reinforced composite hybrids in space applications

Hybrid material systems, such as combinations of tungsten foils and carbon fibre-reinforced plastic (CFRP), are replacing metal alloy concepts in spacecraft enclosures. However, a good adhesion between the tungsten oxide scale and the epoxy resin used is required. Here, the effects of a hydrofluoric-nitric-sulphuric-acid (HFNS) treatment on tungsten oxides and subsequent adhesion to CFRP are analysed using atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS) and fracture testing. The work shows that HFNS treatment results in decreased oxygen content, over 50% thinner tungsten trioxide (WO3) layer and increased nano-roughness on thin tungsten foils. Fracture testing established a 39% increase in the average critical strain for tungsten-CFRP specimens after HFNS treatment was carried out on tungsten. The effect of the oxide scale modification regarding the critical strain energy release rate was $\Delta G_c \approx 8.4 \text{ J/m}^2$. (C) 2014 Elsevier By. All rights reserved.

General information
State: Published

Publication information
Journal: Applied Surface Science
Volume: 328
ISSN (Print): 0169-4332
Ratings:
Scopus rating (2016): CiteScore 3.37 SJR 0.951 SNIP 1.225
Scopus rating (2015): SJR 0.914 SNIP 1.3 CiteScore 3.13
Scopus rating (2014): SJR 0.958 SNIP 1.477 CiteScore 2.96
Scopus rating (2013): SJR 0.965 SNIP 1.488 CiteScore 2.78
Scopus rating (2012): SJR 0.918 SNIP 1.373 CiteScore 2.26
Scopus rating (2011): SJR 0.908 SNIP 1.402 CiteScore 2.27
Scopus rating (2010): SJR 0.924 SNIP 1.141
Scopus rating (2009): SJR 0.842 SNIP 1.023
Scopus rating (2008): SJR 0.899 SNIP 1.087
Scopus rating (2007): SJR 0.795 SNIP 0.945
Scopus rating (2006): SJR 0.852 SNIP 1.052
Scopus rating (2005): SJR 0.679 SNIP 0.946
Scopus rating (2004): SJR 0.964 SNIP 1.126
Scopus rating (2003): SJR 0.988 SNIP 1.027
Scopus rating (2002): SJR 0.921 SNIP 0.954
Scopus rating (2001): SJR 0.841 SNIP 0.796
Scopus rating (2000): SJR 0.866 SNIP 0.772
Scopus rating (1999): SJR 1.064 SNIP 0.907

Original language: English
Keywords: surface treatments, XPS, Tungsten trioxide, Interface, Composites
DOI: 10.1016/j.apsusc.2014.12.036

Bibliographical note
ORG=mol,0.5
ORG=elt,0.5
Source: WOS
Source-ID: 000349615800054
**Method and an Apparatus for Producing Nanocellulose**

Described herein is nanocellulose produced by introducing a mixture of cellulose based fiber raw material and water through a refining gap, having a width smaller than 0.1 mm. In the refining gap, the fiber raw material is subjected to processing forces varying in the direction of introducing said mixture, by means of refining zones provided in the gap one after each other in the feeding direction, whereby the refining surfaces differ in surface patterning and/or surface roughness. The mixture of fiber raw material and water is guided past the refining surfaces in the feeding direction to different locations in the refining zone by by-pass channels provided in the stator. The width of the refining gap is maintained by the combined effect of the feeding pressure of the mixture of fiber raw material and water fed into the refining gap and the axial force of the rotor.

**General information**

**State:** Published

**Ministry of Education publication type:** H1 Granted patent

**Organisations:** Department of Automation Science and Engineering, Research area: Dynamic Systems, Research area: Measurement Technology and Process Control, UPM-KYMMENE CORPORATION

**Authors:** Björkqvist, T., Gustafsson, H., Koskinen, T., Nuoopponen, M., Vehniäinen, A., Gustafsson, S.

**Publication date:** 3 Feb 2015

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**Binary TiO2/SiO2 nanoparticle coating for controlling the wetting properties of paperboard**

We introduce a flame based aerosol method to fabricate thin films consisting of binary TiO2/SiO2 nanoparticles deposited directly from the flame onto the paperboard. Nanocoatings were prepared with Liquid Flame Spray (LFS) in a roll-to-roll process with the line speed of 50 m/min. Surface wetting behavior of nanocoated paperboard was studied for different Ti/Si ratios in the precursor, affecting TiO2/ SiO2 ratio in the coating. Wettability could be adjusted to practically any water contact angle between 10 and 160° by setting the Ti/Si ratio in the liquid precursor. Structure of the two component nanocoating was analysed with FE-SEM, TEM, EDS, XPS and XRD. The porous thin film coating was concluded to consist of ca. 10 nm sized mixed oxide nanoparticles with segregated TiO2 and SiO2 phases. Accumulation of carbonaceous compounds on the surface was seen to be almost linearly dependent on the Ti/Si ratio, indicating of each species being exposed in corresponding amount. However, wetting of the surface was observed to follow merely an S-shaped curve, caused by the roughness of the nanocoated surface. Reasons for the observed superhydrophobicity and superhydrophilicity of these binary nanocoatings on paperboard are discussed. (C) 2014 Elsevier B.V. All rights reserved.

**General information**

**State:** Published

**Ministry of Education publication type:** A1 Journal article-refereed

**Organisations:** Department of Physics, Research area: Aerosol Physics, Research group: Aerosol Synthesis, Department of Materials Science, Research group: Paper Converting and Packaging, Engineering materials science and solutions (EMASS), Abo Akad Univ, Abo Akademi University, Lab Paper Coating & Converting, Univ Helsinki, University of Helsinki, Dept Chem, Inorgan Chem Lab

**Authors:** Haapanen, J., Aromaa, M., Teisala, H., Tuominen, M., Stepien, M., Saarinen, J. J., Heikkila, M., Toivakka, M., Kuusipalo, J., Mäkelä, J.

**Number of pages:** 8

**Pages:** 230-237

**Publication date:** 15 Jan 2015

**Peer-reviewed:** Yes

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Characterisation of novel regenerated cellulosic, viscose, and cotton fibres and the dyeing properties of fabrics

There is a global demand for constant increase in the production of textile fibres. Currently, the market for cellulosic fibres is dominated by cotton and viscose fibres. However, new alternative cellulosic fibres are being sought to meet the growing demand. The dyeing properties of novel fibres aiming at the marketplace are among the properties that determine their applicability to textiles. Recently, a novel process for producing cellulosic fibres, the Biocelsol process, has been scaled up so that the spinning of yarn from Biocelsol fibres is now possible. In this study, the reactive dye Levafix CA Blue was applied to cellulosic fabrics made from viscose, cotton, and Biocelsol yarns. The crystalline structure and morphology of the fibres were studied by Fourier transform infrared spectroscopy and field-emission scanning electron microscopy. The crystalline structure and morphology of the Biocelsol fibres resembled those of viscose fibres, but, owing to higher water absorption, the Biocelsol fabric had a higher dye exhaustion. The colour yield of the Biocelsol fabric was 62% and 41% higher than that of cotton and viscose fabrics respectively, suggesting that less dye is needed to gain a shade in Biocelsol fabric than in viscose and cotton fabrics.

General information

State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Materials Science, Research group: Fibre Materials, Research group: Materials Characterization, Engineering materials science and solutions (EMASS)
Authors: Kamppuri, T., Vehviläinen, M., Puolakka, A., Honkanen, M., Vippola, M., Rissanen, M.
Number of pages: 7
Pages: 396-402
Publication date: 2015
Peer-reviewed: Yes

Publication information

Journal: Coloration Technology
Volume: 131
Issue number: 5
ISSN (Print): 1472-3581
Ratings: Scopus rating (2016): SJR 0.432 SNIP 0.761 CiteScore 1.35
Effect of alkali and silane surface treatments on regenerated cellulose fibre type (Lyocell) intended for composites

Cellulose fibres have significant importance and potential for polymer reinforcement. It is essential to modify the surface of the fibre to obtain good fibre-matrix interface. Surface treatments can increase surface roughness of the fibre, change its chemical composition and introduce new moieties that can effectively interlock with the matrix, resulting in good mechanical properties in the composites. This is mainly due to improved fibre-matrix adhesion. The treatments may also reduce the water absorption rate by converting part of the hydroxyl groups on the fibre surface into other functional groups. Chemical modification of the surface of a regenerated cellulose fibre of the Lyocell type was carried out by alkali and silane treatments, which significantly changed the properties of the Lyocell fibres. Three parameters were considered when the fibre surface treatment was done: concentration (2–15 wt%), temperature (25 and 50 °C) and time (30 min–72 h). Fourier transform infrared spectroscopy and Raman spectroscopy were used for chemical analysis and qualitative analysis of the cellulose crystallinity due to the surface treatments; subsequently, mechanical strength of the fibres was tested by tensile testing. Weight loss, moisture regain and swelling measurements were taken before and after treatments, which showed the obvious changes in fibre properties on treatment. Heat capacity of the fibres was measured for untreated and treated fibres, and thermal degradation of fibres was examined to see the stability of fibres at elevated temperatures. Wettability and surface energies were measured using dynamic contact angle method in three wetting mediums. Scanning electron microscopy was used to study the morphological properties of the fibres.
Enhanced In-line detection, cleaning and repair of nano-scale defects in thin-films used for flexible photovoltaic and food packaging applications

General information
State: Published
Organisations: Department of Materials Science, Research group: Paper Converting and Packaging
Authors: Lahti, J. M. K.
Publication date: 2015
Peer-reviewed: Unknown

Bibliographical note
poster
Research output: Scientific → Paper, poster or abstract

Image-Based Stress and Strain Measurement of Wood in the Split-Hopkinson Pressure Bar
The properties of wood must be considered when designing mechanical pulping machinery. The composition of wood within the annual ring is important. This paper proposes a novel image-based method to measure stress and planar strain distribution in soft, heterogeneous materials. The main advantage of this method in comparison to traditional methods that are based on strain gauges is that it captures local strain gradients and not only average strains. Wood samples were subjected to compression at strain rates of 1000-2500 s⁻¹ in an encapsulated split-Hopkinson device. High-speed photography captured images at 50 000-100 000 Hz and different magnifications to achieve spatial resolutions of 2.9 to 9.7 μm pixels⁻¹. The image-based analysis utilized an image correlation technique with a method that was developed for particle image velocimetry. The image analysis gave local strain distribution and average stress as a function of time. Two stress approximations, using the material properties of the split-Hopkinson bars and the displacement of the transmitter bar/sample interface, are presented. Strain gauges on the bars of the split-Hopkinson device give the reference average stress and strain. The most accurate image-based stress approximation differed from the strain gauge result by 5%.

General information
State: Published
Improving the extensibility of paper: Sequential spray addition of gelatine and agar

High extensibility of paper is of key importance for production of novel 3D-packaging materials. The application of agar onto a wet web has been shown to significantly improve the extensibility of dry paper as a result of shrinkage during drying while addition of gelatine strengthens inter-fibre bonding. In this work, these two bio-based materials were applied sequentially to yield paper with higher extensibility compared to that obtained by single component application. We studied the interactions between agar, gelatine and cellulose by using quartz crystal micro-gravimetry and atomic force microscopy. Agar adsorption was significantly improved after priming the cellulose surface with gelatine. This synergistic effect on extensibility only occurred if the protein was added first. It is hypothesized that the gelatine strengthens the interfibre bonds while the polysaccharide forms a film on the web surface, and reinforces it. The extensibility of webs treated with gelatine (4%) and agar (4%) was ca. 15% after unrestrained drying. Such remarkable level of extensibility allows production of tray-like shapes via conventional thermoforming machine to depths of up to 2 cm. Overall, a protocol based on the sequential application of two abundant biopolymers is proposed to enhance formability of paper.
In situ hybridization of pulp fibres using Mg-Al layered double hydroxides

Inorganic Mg2+ and Al3+ containing layered double hydroxide (LDH) particles were synthesised in situ from aqueous solution onto chemical pulp fibers of pine (Pinus sylvestris). High super saturated (hss) solution with sodium carbonate produced LDH particles with an average diameter of 100–200 nm. Nano-size (70 nm) LDH particles were found from fibers external surface and, to a lesser degree, from the S2 cell wall after synthesis via low super saturated (lss) route. The synthesis via slow urea hydrolysis (Uhyd) yielded micron and clay sized LDH (2–5 µm) and enabled efficient fiber densification via mineralization of S2 fiber wall layer as indicated by TEM and compliance analysis.

The Uhyd method decreased fiber compliance up to 50%. Reduction in the polymerization degree of cellulose was observed with capillary viscometry. Thermogravimetric analysis showed that the hybridization with LDH reduced the exothermic heat, indicating, that this material can be incorporated in flame retardant applications. Fiber charge was assessed by adsorption experiments with methylene blue (MB) and metanil yellow (MY). Synthesis via lss route retained most of the fibers original charge and provided the highest capacity (10 µmol/g) for anionic MY, indicating cationic character of hybrid fibers. Our results suggested that mineralized fibers can be potentially used in advanced applications such as biocomposites and adsorbent materials.
Roll-to-roll coating by liquid flame spray nanoparticle deposition

Nanostructured coatings have been prepared on a flexible, moving paperboard using deposition of ca. 10-50-nm-sized titanium dioxide and silicon dioxide nanoparticles generated by a liquid flame spray process, directly above the paperboard, to achieve improved functional properties for the material. With moderately high production rate (~ g/min), the method is applicable for thin aerosol coating of large area surfaces. LFS-made nanocoating can be synthesized e.g. on paper, board or polymer film in roll-to-roll process. The degree of particle agglomeration is governed by both physicochemical properties of the particle material and residence time in aerosol phase prior to deposition. By adjusting the speed of the substrate, even heat sensitive materials can be coated. In this study, nanoparticles were deposited directly on a moving paperboard with line speeds 50-300 m/min. Functional properties of the nanocoating can be varied by changing nanoparticle material; e.g. TiO2 and SiO2 are used for changing the surface wetting properties. If the liquid precursors are dissolved in one solution, synthesis of multi component nanoparticle coatings is possible in a one phase
Here, we present analysis of the properties of LFS-fabricated nanocoatings on paperboard. The thermophoretic flux of nanoparticles is estimated to be very high from the hot flame onto the cold substrate. A highly hydrophobic coating was obtained by a mass loading in the order of 50-100 mg/m² of titanium dioxide on the paperboard.

The effect of the outermost fibre layers on solubility of dissolving grade pulp
Dissolving pulps are used to manufacture various cellulose derived products through cellulose dissolution. Solubility of cellulose pulp has been claimed to be strongly dependent on the porosity development, the degree of polymerisation and the pulp viscosity. The removal of external cell walls has been proposed to have a key role in the pulp solubility. In this paper, the effect of the outermost surface layers on the solubility of a dissolving grade pulp was studied. Furthermore the effect of mechanical peeling and combined mechanical and enzymatic treatment on pulp solubility was compared. Based on the results combined mechanical and enzymatic treatment efficiently opens up the fibre structure and has a clear positive effect on the solubility of dissolving pulp. It seems that long fibre fraction is less accessible to solvent chemicals than the other pulp fractions. Mechanical peeling of outer fibre layers does not improve fibre dissolution to NaOH/ZnO. Thus, it seems that peeling alone is not a sufficient pre-treatment prior to dissolution. The results also revealed that the
peeling treatment does not enhance the effects of enzymes as the studied mechanical treatment does.

Wood compression model for radial compression of earlywood and latewood

General information
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Authors: Moilanen, C., Björkqvist, T., Saarenrinne, P.
Number of pages: 6
Pages: 261-266
Publication date: 2015
Switchable water absorption of paper via liquid flame spray nanoparticle coating

Surface wetting/anti-wetting and liquid absorption are relevant properties of many porous solids including paper and other cellulose-based materials. Here we demonstrate how surface wetting by water and water absorption of commercially available kraft paper can be altered by thin nanoparticle coatings fabricated by liquid flame spray in facile and continuous one-step process. Surface wettability and absorption properties of paper increased with silica and decreased with titania (TiO2) nanoparticle coatings. Moreover, the water-repellent (superhydrophobic) TiO2 nanoparticle coated paper could be switched to superhydrophilic and water absorbing by ultraviolet illumination. The experiments revealed that although surface wetting and liquid absorption of nanoparticle coated paper are strongly related to each other, they are two distinct phenomena which do not necessarily correlate. We propose wetting regimes on the nanoparticle coated paper samples on the basis of the experimental observations.
Process for producing microfibrillated cellulose
A process for treating cellulosic fibers comprises mechanically pre-treating the fibers followed by treating the fibers with an enzyme and thereafter mixing the fibers with a solution comprising an alkali metal hydroxide followed by mechanically treating the fibers to form microfibrillated cellulose. In this way it is possible to produce microfibrillated cellulose (MFC) in an improved and energy efficient way.

Adjustable wetting of Liquid Flame Spray (LFS) TiO2-nanoparticle coated board: Batch-type versus roll-to-roll Stimulation methods

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Materials Science, Department of Physics, Engineering materials science and solutions (EMASS)
Authors: Tuominen, M., Teisala, H., Haapanen, J., Aromaa, M., Mäkelä, J. M., Stepien, M., Saarinen, J. J., Toivakka, M., Kuusipalo, J.
Number of pages: 9
Pages: 271-279
Publication date: 2014
Peer-reviewed: Yes
Scopus rating (2008): SJR 0.928 SNIP 0.857
Scopus rating (2007): SJR 2.018 SNIP 1.035
Scopus rating (2006): SJR 1.002 SNIP 0.951
Scopus rating (2005): SJR 1.181 SNIP 0.997
Scopus rating (2004): SJR 2.08 SNIP 1.354
Scopus rating (2003): SJR 2.952 SNIP 1.129
Scopus rating (2002): SJR 1.836 SNIP 1.145
Scopus rating (2001): SJR 1.12 SNIP 1.147
Scopus rating (2000): SJR 1.086 SNIP 1.154
Scopus rating (1999): SJR 1.086 SNIP 1.001
Original language: English
DOIs:
10.3183/NPPRJ-2014-29-02-p271-279

Bibliographical note
Contribution: organisation=mol,FACT1=0.5<br/>Contribution: organisation=fys,FACT2=0.5<br/>Portfolio EDEND: 2014-08-04<br/>Publisher name: Svenska Pappers- och Cellulosaingeniorsfoereningen
Source: researchoutputwizard
Source-ID: 1655
Research output: Scientific › peer-review › Article

Biorefinery products. Initial process piloting and material prototype production in the case of barriers, 3D-mouldable packaging and filters

General information
State: Published
Ministry of Education publication type: D4 Published development or research report or study
Organisations: Department of Materials Science
Number of pages: 17
Publication date: 2014

Publication information
Publisher: Finnish Bioeconomy Cluster FIBIC
ISBN (Print): 978-952-67969-6-3
ISBN (Electronic): 978-952-67969-7-0
Original language: English

Bibliographical note
Contribution: organisation=mol,FACT1=1<br/>Portfolio EDEND: 2015-01-08
Source: researchoutputwizard
Source-ID: 40
Research output: Professional › Commissioned report

Design driven world of cellulose-from bulk to luxury?
Tekes-the Finnish Funding Agency for Innovation has granted funding 4.5 million funding for a project targeting on new approaches for use of wood-based cellulose. Project "Design Driven Value Chains in The World of Cellulose" (DWoC) launched by VTT Technical Research Centre of Finland, Aalto University and Tampere University of Technology integrates design and design processes into the strategic development of businesses operating in the field. The aim is to create a business ecosystem to serve both existing industry and a new, growing cellulose-based industry, and to brand Finland as a producer of refined, cellulose-based products. This manuscript summarises the future visions and background aspects and facts that have led to the initiation of the project. The presentation based on the manuscript also presents some of the first demonstrator processes and products developed during the first operational year of the project. These demonstrators include: Fibre yarn process that produces yarn from cellulose pulp fibres without traditional spinning process using novel wet extrusion technique (figure on right). Foam forming method for manufacturing well-formed foamed structures for new product applications 3D-printing technology enabling customisable on demand production of fibre structures and components using modified cellulosic raw materials.

General information
State: Published
Extruded polymer films for optimal enzyme-catalyzed oxygen scavenging

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Materials Science, Engineering materials science and solutions (EMASS)
Authors: Johansson, K., Kotkamo, S., Rotabakk, T. B., Johansson, C., Kuusipalo, J., Jönsson, L. J., Jörnström, L.
Number of pages: 9
Pages: 1-8
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Chemical Engineering Science
Volume: 108
ISSN (Print): 0009-2509
Ratings:
Scopus rating (2016): CiteScore 3.05 SJR 1.037 SNIP 1.442
Scopus rating (2015): SJR 1.038 SNIP 1.606 CiteScore 2.96
Scopus rating (2014): SJR 1.115 SNIP 1.642 CiteScore 2.81
Scopus rating (2013): SJR 1.157 SNIP 1.866 CiteScore 2.95
Scopus rating (2012): SJR 1.189 SNIP 1.847 CiteScore 2.77
Scopus rating (2011): SJR 1.205 SNIP 1.685 CiteScore 2.8
Scopus rating (2010): SJR 1.319 SNIP 1.708
Scopus rating (2009): SJR 1.293 SNIP 1.759
Scopus rating (2008): SJR 1.299 SNIP 1.6
Scopus rating (2007): SJR 1.347 SNIP 1.523
Scopus rating (2006): SJR 1.308 SNIP 1.553
Scopus rating (2005): SJR 1.445 SNIP 1.801
Scopus rating (2004): SJR 1.301 SNIP 1.858
Scopus rating (2003): SJR 1.7 SNIP 1.676
Scopus rating (2002): SJR 1.675 SNIP 1.279
Scopus rating (2001): SJR 1.706 SNIP 1.734
Scopus rating (2000): SJR 1.313 SNIP 1.307
Scopus rating (1999): SJR 1.214 SNIP 1.539
Original language: English
DOIs:
Improving the extensibility, wet web and dry strength of paper by addition of agar

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Materials Science
Authors: Vishtal, A., Retulainen, E.
Number of pages: 10
Pages: 434-443
Publication date: 2014
Peer-reviewed: Yes

Publication information
Volume: 29
Issue number: 3
ISSN (Print): 0283-2631
Ratings:
Scopus rating (2016): CiteScore 1.2 SJR 0.385 SNIP 0.652
Scopus rating (2015): SJR 0.375 SNIP 0.787 CiteScore 0.91
Scopus rating (2014): SJR 0.444 SNIP 0.823 CiteScore 0.99
Scopus rating (2013): SJR 0.389 SNIP 0.684 CiteScore 0.71
Scopus rating (2012): SJR 0.628 SNIP 1.281 CiteScore 1.13
Scopus rating (2011): SJR 0.582 SNIP 0.902 CiteScore 0.78
Scopus rating (2010): SJR 0.658 SNIP 0.764
Scopus rating (2009): SJR 1.167 SNIP 0.984
Scopus rating (2008): SJR 0.928 SNIP 0.857
Scopus rating (2007): SJR 2.018 SNIP 1.035
Scopus rating (2006): SJR 1.002 SNIP 0.951
Scopus rating (2005): SJR 1.181 SNIP 0.997
Scopus rating (2004): SJR 2.08 SNIP 1.354
Scopus rating (2003): SJR 2.952 SNIP 1.129
Scopus rating (2002): SJR 1.836 SNIP 1.145
Scopus rating (2001): SJR 1.12 SNIP 1.147
Scopus rating (2000): SJR 1.086 SNIP 1.154
Scopus rating (1999): SJR 1.086 SNIP 1.001
Original language: English

Influence of substrate contamination, web handling, and pretreatments on the barrier performance of aluminum oxide atomic layer-deposited BOPP film

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Materials Science, Engineering materials science and solutions (EMASS)
Authors: Lahtinen, K., Lahti, J., Johansson, P., Seppänen, T., Cameron, D. C.
Number of pages: 10
Pages: 1-10
Nanoparticle Depositon on Packaging Materials by Liquid Flame Spray: Generation of Superhydrophilic and Superhydrophobic Coatings

General information
State: Published
Ministry of Education publication type: A3 Part of a book or another research book
Organisations: Department of Materials Science, Department of Physics
Authors: Teisala, H., Tuominen, M., Aromaa, M., Stepien, M., Mäkelä, J. M., Saarinen, J. J., Toivakka, M., Kuusipalo, J.
Number of pages: 13
Pages: 331-343
Publication date: 2014

Host publication information
Title of host publication: Recent Advances in Adhesion Science and Technology
Place of publication: Boca Raton
Publisher: CRC Press
Editors: Gutowski, W. (., Dodiuk, H.
ISBN (Print): 978-90-04-20173-6

Bibliographical note
Contribution: organisation=mol,FACT1=0.5<br/>Contribution: organisation=fys,FACT2=0.5<br/>Portfolio EDEND: 2014-08-30
Source: researchoutputwizard
Source-ID: 1609
Research output: Scientific - peer-review › Chapter

Novel Regenerated Cellulose Fibers with High Water Absorption Properties

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Materials Science
Authors: Kamppuri, T., Vehviläinen, M., Grönqvist, S., Rissanen, M.
Number of pages: 5
Pages: 1-5
Publication date: 2014

Host publication information
Title of host publication: Ambience 14&10i3m, Tampere Hall, Tampere, Finland 7-9 September 2014
Place of publication: Tampere
Publisher: Tampere University of Technology
Editor: Varheenmaa, M.
Review on Liquid Flame Spray in paper converting: Multifunctional superhydrophobic nanoparticle coatings

Wettability of a solid surface by a liquid plays an important role in several phenomena and applications, for example in adhesion, printing, and coating. Especially, wetting of rough surfaces has attracted a considerable scientific interest in recent decades. Superhydrophobic surfaces, which possess extraordinary water repellency properties due to their low surface energy chemistry and specific nano- and microscale roughness, are of particular interest due to the great variety of potential applications ranging from self-cleaning surfaces to microfluidic devices. Here we examine functional superhydrophobic and superhydrophilic nanoparticle coatings fabricated by liquid flame spray (LFS) on cellulose-based substrate materials. The article is a review of earlier papers with some new results and conclusions added. LFS has proved itself straightforward and versatile one-step method to fabricate broad range of functional nanoparticle coatings on various substrate materials in an atmospheric roll-to-roll process. It has established itself among the most potential candidates for large-scale production of superhydrophobic coatings on affordable cellulose-based substrates.

General information
State: Published
Ministry of Education publication type: A2 Review article in a scientific journal

Review on Liquid Flame Spray in paper converting: Multifunctional superhydrophobic nanoparticle coatings

Wettability of a solid surface by a liquid plays an important role in several phenomena and applications, for example in adhesion, printing, and coating. Especially, wetting of rough surfaces has attracted a considerable scientific interest in recent decades. Superhydrophobic surfaces, which possess extraordinary water repellency properties due to their low surface energy chemistry and specific nano- and microscale roughness, are of particular interest due to the great variety of potential applications ranging from self-cleaning surfaces to microfluidic devices. Here we examine functional superhydrophobic and superhydrophilic nanoparticle coatings fabricated by liquid flame spray (LFS) on cellulose-based substrate materials. The article is a review of earlier papers with some new results and conclusions added. LFS has proved itself straightforward and versatile one-step method to fabricate broad range of functional nanoparticle coatings on various substrate materials in an atmospheric roll-to-roll process. It has established itself among the most potential candidates for large-scale production of superhydrophobic coatings on affordable cellulose-based substrates.

General information
State: Published
Ministry of Education publication type: A2 Review article in a scientific journal
Organisations: Department of Materials Science, Department of Physics, Research area: Aerosol Physics, Research group: Aerosol Synthesis, Engineering materials science and solutions (EMASS)
Authors: Teisala, H., Tuominen, M., Haapanen, J., Aromaa, M., Stepień, M., Mäkelä, J. M., Saarinen, J. J., Toivakka, M., Kuusipalo, J.
Number of pages: 13
Pages: 747-759
Publication date: 2014
Peer-reviewed: Yes

Publication information
Volume: 29
Issue number: 4
ISSN (Print): 0283-2631
Ratings:
Scopus rating (2016): CiteScore 1.2 SJR 0.385 SNIP 0.652
Scopus rating (2015): SJR 0.375 SNIP 0.787 CiteScore 0.91
Scopus rating (2014): SJR 0.444 SNIP 0.823 CiteScore 0.99
Scopus rating (2013): SJR 0.389 SNIP 0.684 CiteScore 0.71
Scopus rating (2012): SJR 0.628 SNIP 1.281 CiteScore 1.13
Scopus rating (2011): SJR 0.582 SNIP 0.902 CiteScore 0.78
Scopus rating (2010): SJR 0.658 SNIP 0.764
Scopus rating (2009): SJR 1.167 SNIP 0.984
Scopus rating (2008): SJR 0.928 SNIP 0.857
Scopus rating (2007): SJR 2.018 SNIP 1.035
Scopus rating (2006): SJR 1.002 SNIP 0.951
Scopus rating (2005): SJR 1.181 SNIP 0.997
Scopus rating (2004): SJR 2.08 SNIP 1.354
Scopus rating (2003): SJR 2.952 SNIP 1.129
Scopus rating (2002): SJR 1.836 SNIP 1.145
Scopus rating (2001): SJR 1.12 SNIP 1.147
Scopus rating (2000): SJR 1.086 SNIP 1.154
Scopus rating (1999): SJR 1.086 SNIP 1.001
Original language: English
Keywords: Cellulose, Functional coating, Liquid flame spray, Nanoparticle coating, Review, Superhydrophobic
DOI:
10.3183/NPPRJ-2014-29-04-p747-759
Links:
http://www.scopus.com/inward/record.url?eid=2-s2.0-84914820253&partnerID=tZOtx3y1

Bibliographical note
Contribution: organisation=mol,FACT1=0.5<br/>Contribution: organisation=fys,FACT2=0.5<br/>Portfolio EDEND: 2014-12-30<br/>Publisher name: Svenska Pappers- och Cellulosaingeniorsfoereningen
Source: researchoutputwizard
Source-ID: 1611
Research output: Scientific - peer-review » Review Article

Vanerin pinnoittaminen muovilla

General information
State: Published
Ministry of Education publication type: D4 Published development or research report or study
Organisations: Department of Materials Science
Authors: Järvelä, P., Järvelä, P.
Number of pages: 10
Publication date: 2014

Publication information
Impresión digital de papel o cartón estucado con polímeros

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Department of Materials Science, Department of Energy and Process Engineering, Stora Enso Oyj, Imatran tehtaat, 12.05.2005
Authors: Räsänen, J., Lahti, J., Savolainen, A., Kuusipalo, J.
Publication date: 28 May 2010

Publication information
IPC: G03G 7/ 00 A I
Patent number: ES2340049T
Priority date: 17/06/04
Priority number: FI2004000840
Original language: English
Source: espacenet
Source-ID: ES2340049T
Research output: Scientific › Patent

Digital Printing of Polymer-coated Paper or Board

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Department of Materials Science
Authors: Räsänen, J., Lahti, J., Savolainen, A., Kuusipalo, J.
Publication date: 15 May 2010

Publication information
IPC: G03G 7/ 00 A I
Patent number: AT465436T
Priority date: 16/06/05
Priority number: WO2005FI00282
Original language: English
Source: espacenet
Source-ID: AT465436T
Research output: Scientific › Patent

Un procedimiento de impresion digital y uso de un papel o carton aplicable al mismo

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Department of Materials Science, Department of Energy and Process Engineering, Stora Enso Oyj, Imatran tehtaat, 12.05.2005
Authors: Lahti, J., Penttinen, T., Räsänen, J., Kuusipalo, J., Savolainen, A.
Publication date: 1 Feb 2009
Measurement of annual ring width of log ends in forest machinery

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Materials Science
Authors: Marjanen, K., Ojala, P., Ihalainen, H.
Number of pages: 11
Pages: 1-11
Publication date: 2008

Host publication information
Title of host publication: Proceedings of SPIE 6812, Image Processing Algorithms and Systems VI
Publisher: SPIE
Editors: Astola, J. T., Egiazarian, K. O., Dougherty, E. R.
Article number: 68120D
DOIs:
10.1117/12.766464

Bibliographical note
Contribution: organisation=mol,FACT1=1<br/>Portfolio EDEND: 2014-12-17
Source: researchoutputwizard
Source-ID: 12980
Research output: Scientific - peer-review › Conference contribution

Digital printing method and a paper or board applicable thereto

The invention relates to a digital printing method and a paper or board applicable thereto. In digital printing, the surface of a paper or board is charged electrically, toner particles are brought to the surface in an electric field in accordance with the printing, and the particles are melted fast to the surface with the help of heat for forming the printing. According to the invention, the paper or board (2) is provided with a coating layer (3) containing an electrically chargeable acrylate copolymer of ethylene, which receives the toner that is fused to the coating with the help of infra red radiation. Suitable coating polymers are especially methyl, ethyl and butyl acrylate copolymers of ethylene (EMA, EEA and EBA). Especially in packaging boards, besides the digitally printable layer, the polymer coatings can comprise a water vapour or oxygen barrier layer for protecting the packed product, and a heat-sealable layer on the opposite side of the board for sealing the package.

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Department of Materials Science, Department of Energy and Process Engineering, STORA ENSO OYI, Stora Enso Oyj, Imatran tehtaat, 12.05.2005
Authors: Lahti, J., Penttinen, T., Räsänen, J. P., Kuusipalo, J., Savolainen, A.
Publication date: 30 Aug 2007

Publication information
IPC: G03G 7/00 A I
Patent number: US2007202308
Priority date: 15/03/07
Priority number: US20070724538
Original language: English
Source: espacenet
Source-ID: US2007202308
Research output: Scientific › Patent
Digital printing method and a paper or board applicable thereto

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Department of Materials Science, Department of Energy and Process Engineering, Stora Enso Oyj, Imatran tehtaat, 12.05.2005
Authors: Lahti, J., Penttinen, T., Räsänen, J., Kuusipalo, J., Savolainen, A.
Publication date: 1 Sep 2004

Publication information
IPC: G03G 7/00 A I
Patent number: EP1451644
Priority date: 5/12/02
Priority number: WO2002FI00994
Original language: English
Source: espacenet
Source-ID: EP1451644
Research output: Scientific > Patent