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Development of highly functionalized transparent sheet from phosphorylated cellulose nanofiber

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Cellulose nanofiber (CNF) is highly crystallized microfibril in which molecular chains of cellulose regularly arranged. It has excellent properties such as high strength and Young's modulus, low thermal expansion, high surface area. From these features, it has been proposed to process CNF into sheet form and use it for various applications such as flexible electronic devices. However, there have been no examples of establishing CNF sheet production to the scale larger than laboratory equipment so far, and thus there are many problems in manufacturing. We applied CNF manufacturing technology by phosphorylation and CNF sheet manufacturing technology, and introduced the facility of CNF sheet production in the second half of fiscal 2017. AUROVEIL™, CNF sheet which is continuously produced in this facility has features, namely, high strength and modulus, flexibility and low thermal expansion, in addition to the transparency comparable to the optical film. We can also produce AUROVEIL 3D™, the sheet having a feature that it can be freely formed without cracking during molding process, and AUROVEIL WP™ overcoming the shortage of water resistance. We will further accelerate the application development of these CNF sheets.

Efforts for the practical use of cellulose nanofibers（CNF）
- Application development of various CNF -

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As a "comprehensive biomass company", we are striving not only to expand existing business such as paper products and chemical products utilizing wood biomass but also to develop new business area. Amid efforts of new businesses, we are focusing on developing manufacture and use of cellulose nanofiber (CNF) as a new cellulosic material. Since the participation in the project of New Energy and Industrial Technology Development Organization (NEDO) in 2007, we have been engaged in the development of CNF and have been developing practical use of various types of CNF. In 2017, we have prepared various CNF production systems by installing production

facilities at the Ishinomaki mill(TEMPO oxidized CNF) and Gotsu mill (Carboxymethylated CNF) as a commercial mass production facility and demonstration plant of CNF reinforced resin at the Fuji mill. In this report, characteristics of CNF produced at each production facilities installed last year and the situation of application development are reported.

Commercialization and application development of nanoforest

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Chuetsu Pulp & Paper Co., Ltd. is producing cellulose nano fiber(CNF) named as "nanoforest", which is produced with Aqueous Counter Collision(ACC) method. The product name "nanoforest" is mixture of the word "nano", means very small size, and "forest", means natural forest. CNF is becoming popular as nano-material derives from nature and has several special features such as light weight, high strength, high elasticity, and low linear thermal expansion. A lot of companies related with CNF from material manufacturers to application users are now participating industrial CNF organization "Nano cellulose forum" and are collaborating for future application development.

Chuetsu Pulp & Paper Co., Ltd. have started commercial production of nanoforest at our 1st commercial plant located in Sendai mill, Kagoshima Pref. on June 2017 to answer market request.

This paper will report about production technique of nanoforest, it's features, and application development situation.

Development of Chemically Modified CNF Reinforced Plastics

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Cellulose nanofiber(CNF) is a renewable material obtained from inedible biomass, such as wood and herbaceous plants, and has superior features such as light weight, high strength, high elasticity, low thermal expansion, high specific surface area, and so on. Therefore, extensive studies on CNF have been in progress in Japan and the other countries. While CNF holds superior potentials mentioned above, it is difficult to obtain homogeneous composites of CNF and hydrophobic resins due to CNF's hydrophilic and water absorbing characters. Chemical modifications on the surface is indispensable for CNF to be widely used in many industrial applications. We have been developing some chemically modified CNFs based on our paper-making chemical technologies. Once treated with amphiphilic reagents having both cellulose-reactive group and hydrophobic group, the hydrophobicized CNF surface shows improved dispersibility in polyolefin matrix. The obtained composites reveal various improvements in tensile strength, flexural strength, elastic modulus, and linear thermal expansion, to name a few.

In this article, we describe the main features of our chemically-modified CNF reinforced plastics, "STARCEL□", and its applications to thermoplastic composites, foamed resins, and rubber moldings.

Development of Efficient Production Systems for Forest Tree seedlings

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Nippon paper Industries Co., Ltd. announce the commencement of an initiative to develop a large scion plantation in a bid to facilitate the quick propagation and full-scale production of cutting seedlings taken from specified mother trees of Japanese cedar to assist reforestation of the Company-owned forest in Kyushu. The Kyushu region is known for its abundant forest resources and Japanese cedars are widely chosen. The Company has taken 824 cutting seedlings from specified mother trees of Japanese cedar, which were propagated using an exclusive technology, and planted them on land in Hitoyoshi City, kumamoto Prefecture, which is owned by the Company's Yatsushiro Mill (Yatsushiro City, Kumamoto Prefecture). The scion plantation will be extended gradually, aiming to develop a space for 14,000 cutting seedlings by 2019. Test Plantation is due to start from next year with a view to producing and shipping approximately 280,000 cutting seedlings per annum from 2023 and onwards.

The Development of Wind Power Business in the Location Adjacent to the Akita Mill

Takashi Sasama

Nippon Paper Industries Co., Ltd.

Amid the high expectation for renewable energy as measures against global warming, its introduction has been rapidly advanced from a global perspective, including a power-generating facility newly built in 2015 of which ratio of renewable energy facilities exceeds 50%. Along with introduction of Feed-in Tariff (FIT) system, ratio of renewable energy accounting for composition of power sources has increased from 10%(2011) to 15%(2016) in Japan. When viewing its breakdown, introduction of renewable energy has been led by wind power overseas, whereas it has been advanced mainly led by solar power domestically as shown by the fact that approximately 90% of renewable energy introduced after start of the FIT system was solar power. In addition, electricity generation cost by wind power and solar power has decreased below 10 yen overseas, whereas in Japan purchase price for electricity generated by wind power and solar power based on FIT system is at a level less than 20 yen. Between Japan and overseas, there are some differences we could find.

The wind power generation facility has commenced business operations as of this January in the location adjacent to the Company's Akita Mill. It is a first wind power generation facility for Nippon Paper Industries Co., Ltd.

We introduce the latest wind turbines and facilities manufactured by General Electric at one of the most suitable locations for wind power generation in Japan and the power generation output is 7,485 kW (three units in total).

CFD technology for slot coating

-Consideration the penetration of liquid into porous paper-

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Coating is a significant basic technology in the field of chemical engineering and in Japan, VOF(Volume Of Fluid) method has been frequently applied to the coating industry to analyze free surface of the coating bead. This analysis method can reproduce various coating defects such as air entrainment, ribbing, rivulet, chatter, non-uniformity of layer thickness near the coating edge, and so on. Furthermore, the operability window of coating, quantitative correlation

between coating conditions and state of coating defects, shows well similar phenomena to the actual coating. Thus the coating analysis method can provide the investigation of the cause of coating defects and the estimation of coating defects under coating conditions without experience, and recently is available to design the optimum coating condition mainly in the electronic materials industry.

On the other hand, in the field of paper making industry, the fluid structure interaction analysis method is applied to the analysis of blade coating, while the penetration of coating material to base paper does not be taken into account. However, on the analysis for printing process, penetration model has already reproduced the behavior when liquid penetrates to porous paper, and the next target is application of this model to the blade coating.

In this study, we advanced the consideration on the penetration of liquid into porous paper material in slot coating process.

The History of Paperboard

Part 1: Paper Recycling Before 1800

Kiyoaki Iida

The paper industry developed the method of producing paperboard from waste paper in the late 1800s and doubled the market size of paper. Its history is followed in this series.

Before the Industrial Revolution, paper was manufactured with huge amount of labor and was very expensive. After used as document, waste paper was further used in different ways in different regions of the world.

Japan had a record in 886 saying that letters were recycled to sheets of paper on which sutra was written. It was very common since Heian period that reclaimed (waste) paper was recycled to sheets of paper which were used again for writing. Kyoto and Edo were famous with that recycling business. Recycled papers were called Usuzumi-gami (gray-colored sheet), Shikisi (colored sheet), and Syukus (old sheet). Asakusa-gami (toilet paper) was also manufactured in Edo, Asakusa being one of its district.

Europe, on the other hand, did not manufacture recycled paper. Waste paper was converted to paste board which was used mainly as book front covers. Its demand might be balanced with the supply of waste paper. In China, it is reported that recycled paper was used in the 1600s, though it seemed not to be so common. Waste paper might be used for making many kinds of paper products.

Then, the Industrial Revolution changed social systems, and the USA, a newcomer in paper manufacturing, developed paperboard market and changed the way of using waste paper.