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Use of Wood in Space - The Impact of Outer Space on Wood

Koji Murata
Graduate School of Agriculture, Kyoto-University

Space wood project research has been conducted at Kyoto University by Professor Takao Doi since 2017. This research is part of manned space studies aimed at forming a permanent society in space. To address the problem of material procurement in space, the focus is on utilizing wood resources. Wood offers significant environmental and psychological benefits, and if a plantation forest in space is possible, it could contribute to the realization of a permanent society. The research investigates tree growth in low air-pressure and microgravity environments, as well as changes in the physical properties of wood in a vacuum environment. In 2022, a space exposure experiment involving wood was conducted on the International Space Station. Furthermore, in collaboration with Sumitomo Forestry, the development of a wooden satellite called "LignoSat" is underway, with a launch scheduled for October 2024

LignoSat is a satellite that uses wood instead of aluminum or titanium, leveraging the strength-to-weight advantages of wood material. Wood is suitable as a satellite material because it does not suffer from biological degradation or flammability issues in a vacuum environment. In low Earth orbit, when a satellite re-enters the atmosphere after completing its mission, the wooden structure burns up into gas. This burnable property may reduce aerosols in the stratosphere, which an aluminum structure generates.

Pre-Emptive Life Cycle Thinking for Utilization of Lignocellulosic Resources

Yasunori Kikuchi
Institute for Future Initiatives, the University of Tokyo

Plant resources can be an essential alternative to fossil resources. Lignocellulosic resources can be obtained in diverse forms, such as herbaceous and woody species. By combining different plant resources in different regions, it is possible to obtain the raw materials needed to reduce fossil resources. As various conversion technologies for lignocellulosic resources with such potential are being developed from the research and demonstration stage to practical application, it is essential to evaluate them based on appropriate life cycle thinking. This study discusses the requirements for life cycle thinking regarding the utilization of lignocellulosic resources. Scenarios must be planned while preemptively analyzing future resource and energy structures, and the life cycle and material flow of lignocellulosic resources must be understood. In particular, paper mills have process systems that have utilized lignocellulosic resources as material, chemical, and energy, and are expected to increase in value in the future as hubs for aggregating renewable resources in the region.

Development of a high performance paper to be capable of erasing written ballpoint ink for a certain period of time

Hiromi Uchimura, Bunta Imura, Tomoki Yabutani
Paper Industry Innovation Center of Ehime University
Graduate School of Agriculture, Ehime University

With the recent rapid digitization, records and communication processes are shifting from paper media to electronic devices. However, even today, paper media are still widely used for official documents such as contracts and resumes. Ballpoint pens are generally utilized for preparation of important and official documents. Characters written with a ballpoint pen can not be erased with a normal eraser when corrections are needed. There are several erasing methods for ballpoint pens, but all of them are not applicable to erasing written for official documents because they can erase the characters at any time. Thus, in this research, we attempted to develop a high performance paper having a unique function to be capable of erasing the ink for a certain of time and keeping it from erasing after a certain period of time.

The utilization of CNF sheets for reinforcing polycarbonate

Taiga Koga and Hayato Fushimi
Oji Holdings Corporation

We have been actively exploring the incorporation of cellulose nanofibers (CNF) into rubbers or thermoplastics for their application. However, difficulty arises when attempting to diperse CNF with polycarbonate (PC), as it leads to a loss of PC's excellent transparency. To address this issue, we have developed a technique that involves phosphorylated CNF sheets with PC, thereby improving the mechanical properties. We refer to these composite materials as CNF-PC composites.

The phosphorylated CNF is fully nanofibrillated, with a width of approximately 3 nm. Consequently, CNF sheets derived from phosphorylated CNF as a raw material exhibit outstanding mechanical strength, dimensional stability, and high transparency. Therefore, through laminating CNF sheets with PC, it is possible to improve the mechanical properties without compromising the transparency of PC.

In this presentation, we demonstrated several types of CNF-PC composites by varying the thickness of CNF sheets and PC films. The mechanical properties were improved without significant loss of transparency compared to polycarbonate sheets of similar thickness. Therefore, it may be possible to achieve weight reduction of PC components by reducing the amount of PC used. We also investigated the molding of CNF-PC composites and confirmed that their capability to be bent at a wide range of curvature radii. CNF-PC composites may be applicable to components with curved shapes.

Development of Micro Fibrillated cellulose

Kei Funatsu, Yusuke Sugimura, Takeshi Nakatani and Haruo Konno
NIPPON PAPER INDUSTRIES Co.,Ltd.

Cellulose nanofiber (CNF) is gaining attention as next-generation carbon-neutral material. CNF is expected to be used for a wide range of applications, including food additives, cosmetics, and industrial products. Production of CNF requires specialized equipment due to its high energy requirements. Therefore, we focused on micro-sized cellulose fibers, "Micro Fibrillated Cellulose (MFC)", that can be manufactured with lower energy consumption. We have conducted the studies on the manufacturing and utilization methods of MFC. In this paper, we introduce the production of MFC using conventional pressure washer, and the evaluation of MFC for some applications.

Intellectual Property Strategies in Companies

Masahiro Samejima
UCHIDA & SAMEJIMA LAW FIRM

In line with trends such as the Corporate Governance Code and economic security, we will explain how intellectual property strategies should be in companies.

Development of Dry Strengthening Agent with High Concentration Containing a Specific Functional Biomass Material

Ryusuke Kambara
Research & Development H.Q., Water-Based Polymer Development Dept., Arakawa Chemical Industries, Ltd.

Paper is a recyclable material, but its strength tends to decrease after repeated recycling. Therefore, dry strengthening agent is widely used to reinforce the strength reduction of paper. We manufacture and sell amphoteric polyacrylamide-based dry strengthening agent (Polystron series). Polystron is used for a wide range of applications ranging from acid-to-weak acid papers, neutral papers, paperboards (e.g. liner, corrugating medium and core paper), fine papers and coat papers. The role of Polystron is to improve not only paper strengths, but also the retention of pulp fibers and various chemicals (sizing agents, dyes, etc.), and water drainage on the wire by aggregating the pulp fiber. This reduce the consumption of electricity and steam used in the drying process, contributing to improved productivity of paper machines.

In recent years, the utilization of biomass materials and the reduction of CO_2 in the life cycle have been attracting attention toward the realization of a sustainable society. The product form of Polystron is mainly an aqueous solution with a concentration of 15% to 20%. If it is possible to reduce the frequency of transportation by increasing the concentration, it is expected that CO_2 derived from transportation fuel can be reduced. As a result of the examination, we have developed PS-4000 and PS-4100 that increases the concentration and maintains the performance by blending a specific functional biomass material.

Development of a Novel Polyacrylamide Copolymer for Improving the Papermaking Process

Kairi Yamato
Technology Management Department, Paper Chemical Business Division, SEIKO PMC Corporation

Recently, the quality of recycled pulp has deteriorated due to the decrease in strength and refined fibers when recycled paper is utilized at a high ratio. Furthermore, the fillers and starches in the repetitive recycled pulp accumulated in the papermaking system have caused many troubles for the papermaking processes. The spread of topics on Carbon Neutral and CO_2 Reduction also leads to challenges in Energy Reduction during papermaking processes.

Under these circumstances, we have developed Papermaking Improvers with the PM series, which can reduce the steam cost by improving the dewatering properties at the press section, improve the retention of internal chemicals, refined fibers, and fillers, as well as clean up the papermaking system.

Compared to the current dry strength resins, the PM series has higher amounts of cationic groups, is optimized in ionic balance to prevent over-aggregation, and is controlled in molecular weight. The utilization of the PM series can also decrease the dosage of aluminum compounds, improve the adsorption of sizing agents and other internal chemicals, as well as improve the retention of refined fibers and ash contents in the paper.

In the paper mill, the reduction of aluminum compounds and the papermaking chemicals, cleaning up the papermaking system, and improving operability have been achieved while maintaining the quality of paper.

Surface Free Energy Analysis of Cellulose Nanofibers through Contact Angle Measurements

Tomohito Yagita, Tsuguyuki Saito, and Shuji Fujisawa
Department of Biomaterial Sciences, Graduate School of Agricultural and Life Sciences,
The University of Tokyo

Accurate measurements of the surface free energy (SFE) are essential for determining the interfacial properties of materials, including the adsorption characteristics of solid particles at the water/oil interface in emulsions. The SFE of cellulose nanofibers (CNFs), which are nanomaterials derived from wood resources, has thus far been evaluated by inverse gas chromatography (IGC), and the emulsifying capacity of CNFs is effectively explained by the desorption energy calculated from the SFE. However, IGC suffers from a long measurement time and complicated analysis. Among the various methods proposed for measuring the SFE, contact angle measurements have the advantage of simplicity in both measurement and analysis. Here, the SFE of CNFs was evaluated by contact angle measurements. Two types of CNFs with different surface structures were prepared through ion exchange of surface-carboxylated CNFs: one with sodium and the other with tetrabutylammonium ions. The contact angle measurements were performed on the CNF films using a combination of three different probe liquids, and the SFE of the CNFs was determined based on the van Oss–Chaudhury–Good theory. However, a substantial decrease in the electron-donor component of SFE was observed through the ion exchange from sodium to tetrabutylammonium; this result was inconsistent with previous reports. Furthermore, the calculated desorption energies of the CNFs could not explain the emulsification behavior in the experimental system. These discrepancies were attributed to the swelling of the CNF films against the probe liquid. This study showed the limitations of contact angle measurements for accurate SFE determination of CNFs.