

Nanocellulose in Japan: An industrial perspective

With the maturing of Japan's economy, domestic demand for paper and paperboard is more likely to level off in the long term. Japanese paper companies are accelerating overseas production, especially in the emerging Asian markets, while strengthening competitiveness of domestic mills and developing new products.

In Japan, we have always focused on emerging technologies and driving innovation in the pulp and paper industry. As a business definition, innovation does not equal innovative technology. Innovative technology can become innovation only when it is commercialized and used in industry.



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SHARED INTERNATIONAL INDUSTRY GOALS

The Alliance for Pulp and Paper Technology Innovation (APPTI, formerly Agenda 2020 Technology Alliance) encourages the development of advanced manufacturing technologies that promise transformational impact on the paper and forest-based industries. Like TAPPI, who is an APPTI association partner, JAPAN TAPPI shares the following APPTI priority areas for R&D:

- Next-generation chemical pulping
- Energy-efficient black liquor concentration
- Reuse of process water
- Drier web to paper machine dryers
- Cellulosic nanomaterials
- Value-added bioproducts made at pulp mills

RESEARCH TRENDS IN JAPAN

Research trends in Japan were investigated by comparing research areas of oral presentations at the JAPAN TAPPI Pulp and Paper Research Conference in Tokyo given in 2004 and 2019. In 2004, wet end chemistry was the largest session, followed by biotechnology and wood chemistry, coating and converting, pulp, functional materials, and recycling. In 2019, by contrast, 39% of oral presentations at the annual conference, to be held June 20-21 of this year, will be made on nanotechnology-related subjects and 32% on biorefinery and wood chemistry of cellulose and lignin.

Nanocellulose is a class of renewable nanoscale materials from natural origins that has increasingly been the subject of

R&D activities in many countries around the world. Current R&D in industry, academia, and government laboratories suggests that nanocellulose has a broad range of application potential in products and industries such as paper, building materials, polymer composites, medical, defense, electronics, automobiles, and aircraft.

ESTABLISHMENT OF JAPAN'S NANOCELLULOSE FORUM

For rapid commercialization and spreading the use of nanocellulose, it was important to establish a fully Japan-based consortium for sharing information, exchanging opinions,

and enhancing cooperation among R&D organizations and enterprising bodies in the field of materials, processing, and manufacturing equipment, and also between supply and demand sides. For this reason, the Nanocellulose Forum (NCF) was established to promote cooperation of these organizations and to promote commercialization of nanocellulose. The Forum already has 192 corporate members and 80 individual members. In addition, four Ministries of the central government and many local governments joined NCF. Corporate members include industries of pulp and paper, metal, forestry, construction, food, textile and fiber, chemicals and petroleum, rubber, machinery, precision machinery, and equipment for transportation, commerce, service, and more.

On another front, the Japan Revitalization Strategy was approved by Japan's cabinet in June 2014 and the liaison committees between four Ministries were established. The strategy states, "Concerning woody biomass, R&D shall be performed to promote international standardization of cellulose nanofibers and accelerate its commercialization to develop new materials." For that purpose, the technical specification was proposed and approved as a preliminary work item by the ISO technical committee. The objective is to characterize cellulose elementary fibril samples and develop applicable measurement methods.

PROGRAM OPERATIONS OF THE NANOCELLULOSE FORUM

To achieve its nanocellulose commercialization goals, the NCF focuses its activities in several key areas, as follows:



Nippon Paper Industries' three cellulose nanofibril (CNF) plants in Japan.

- **Surveys, sharing, information exchange, and dissemination of technology trends.** NCF organizes technical seminars for our members on themes such as manufacturing, application technology, application development, measurement technology, international standardization, and safety evaluation of nanocellulose.
- **Proposition for joint R&D and promotion of commercialization.** We promote joint R&D and commercialization by matchmaking between seeds and needs, and between manufacturing and application technologies. The Ministry of Economy, Trade and Industry (METI) and the National Institute of Advanced Industrial Science and Technology (AIST) will support any practical implementation when the possibility of new R&D and commercialization emerges through NCF activities. However, the NCF itself will not be involved in any proprietary or joint R&D efforts or commercialization projects of members.
- **Promotion of nanocellulose standardization.** There are no international standards governing nanocellulose, since evaluation and measurement technologies have not been unified. In addition, even the definitions of terminology remain unclear.

As nanocellulose has gathered interest in recent years, activities toward international standardization have emerged in Canada and Europe. NCF will collect and analyze information about international standardization,

while private enterprises, Japan TAPPI, METI, and AIST will cooperate and formulate standardization strategies, send representatives to international meetings, and participate in international standardization.

- **Provision for information on availability of R&D facilities.** Specialized facilities are required for manufacturing technology, application technology development, and sample evaluation of nanocellulose. NCF will support R&D and deployment by its members by providing notices about equipment owned by universities and public research institutions through its website. Usage of such facilities will require compliance with the rules set by each institution. Please note that there may be cases that require joint research agreements or incur fees for the use of facilities.
- **Human resource development.** In order to promote R&D and deployment of nanocellulose, it is necessary to develop human resources that are engaged in the effort. NCF will contribute to human resource development through the introduction of various programs at universities and public research institutions.
- **Sample information.** NCF will disclose information about nanocellulose and related samples provided by private enterprises, universities, and public research institutions through our websites. Requests for samples must be placed directly with sample providers.

BUSINESS APPLICATIONS OF NANOCELLULOSE IN JAPAN

In Japan, there are many activities surrounding business applications of nanocellulose. For instance, Dai-ichi Kogyo Seiyaku (DKS) installed a pilot plant for nanocellulose production, and a ball-point pen ink stabilizer was commercialized in North America by Mitsubishi Pencil Co.

The largest paper company in Japan, Oji Holdings Corporation, opened a cellulose nanofibril (CNF) pilot facility in 2016 with the capacity of 40 tons/year. The facility consists of patented chemical modification (phosphorylation) and mechanical fibrillation. Oji provides hydrophilic CNFs in three different forms of slurry, wet powder, and transparent roll sheets, as well as hydrophobic CNFs that are dispersible in solvent. Their applications include thickener (trademarked AUROVISCO for car chemicals, cosmetics applications with Nikko Chemicals), transparent sheets (trademarked AUROVEIL), and moldable transparent sheets (trademarked AUROVEIL, 3D). These products are used to produce nanofilters, flexible panels, and reinforcing plastic. Oji aims to break the annual sales barrier of US\$120 million by 2025.

Nippon Paper Industries is the second largest paper company in Japan. It constructed three demonstration plants in different areas of Japan to produce CNFs in 2017. In April, the first plant was implemented at the Ishinomaki mill, located 300 km north of Tokyo in Miyagi Prefecture, to produce

TEMPO mediated CNF for the use of functional sheets, additives, and composite materials. The production process is based on research at Tokyo University, and capacity is 500 tons/year, which may be the largest in the world. In June, 2017, the second plant began operation at the Fuji mill, located 100 km west of Tokyo in Shizuoka prefecture, to produce CNF for the development of resin composite materials by the Kyoto University Process. Its production rate is expected to be 10 tons/year. The third plant was inaugurated to manufacture carboxymethylated CNF (CMC) in order to find application in foods and cosmetics at the Gotsu mill, located 750 km west of Tokyo in Shimane prefecture, facing the Japan Sea. The annual production capacity is 30 tons.

In conclusion, Japan has abundant wood resources, as 68% of the land is covered with forests. The country's forest ratio is the third highest, after Finland and Sweden. I hope that R&D works on nanocellulose will transform the world's rich biomass into valuable products and rejuvenate the pulp and paper industry. **TJ**

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