# Green era on the horizon

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Japan's leading chemical companies are investing heavily in biobased materials, driven by the need to find alternative feedstocks and produce greener products

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Japanese companies are key players and continue to drive the development of interesting biobased materials through investment in many different biotechnology companies around the world. "As a major importer of fossil resources, Japan has been a front-runner in initiating the development of biobased chemicals as alternatives to fossil feedstocks," says Doris de Guzman, senior consultant for biomaterials with Tecnon OrbiChem.

Japanese industrial sectors, particularly the automotive, electronics and packaging industries, have strong interests in the development and use of bioplastics, while the well-established fermentation industry in Japan is looking to expand its portfolio in industrial applications to complement activities in food ingredients, fine chemicals and other niche specialty chemicals. "Japan's strong interests in sustainability and climate change have also pushed major domestic companies to implement their own corporate initiatives for solving these issues," de Guzman adds.

This often requires investment in overseas start-up firms, according to Meraldo Antonio, an analyst with US-based Lux Research, which sees global capacity for biobased chemicals and materials reaching over 7m tonnes/year within the next three years.

"Most Japanese chemical firms are mature, established companies with long track records in more traditional areas of chemistry [bulk chemicals and common polymers], but little experience with biobased chemicals and often little access to biobased feedstocks," he explains.

The greatest interest is in performance materials, according to Antonio, largely due to the sprawling automotive and consumer product industries in Japan. Parallel to this driver is the demand from Japanese consumers for more environmentally friendly products. "The combination of these two factors has resulted, in particular, in the flourishing of the biobased polymers industry in Japan," he observes.

However, like in the US, Japanese consumers are reluctant to pay any premium for biobased materials and products despite the country's higher concern about the environment and climate change, according to de Guzman.

"A big challenge for Japanese companies is to find competitive and stable biobased resources, which has also been driving their investments in renewable chemical technologies to bring costs down, improve performances and increase scale," she asserts.

## MCC'S *DURABIO* PLASTICS

Mitsubishi Chemical Corporation (MCC) has been very successful with its *Durabio* line of biobased engineering plastics made from plant-derived isosorbide. In 2013, *Durabio* was used in the interior colour panels of the Suzuki Hustler. In 2015, the two companies announced the co-development of a newer grade of *Durabio* for use in the interior resin colour panels of Suzuki's new Alto Lapin.

MCC has also worked with Mazda Motor Corporation to jointly develop *Durabio* grades for use in interior and exterior automotive components, the latest grade for use in the interior parts of the 2015 Mazda MX-5. MCC is also targeting the consumer electronics market, introducing a *Durabio* grade for use in the touch panels of automobiles in 2014. *Durabio* is also used for the front panels of Sharp Corporation's »

2015 *Aquos Crystal* 2 smartphone.

MCC also announced in 2015 that it has developed a biobased polycarbonate diol for the production of polyurethane (PU), acrylic and polyester polymers for use in automotive interior materials (seat covers, instrument panels) and exterior coatings, and as resins for electronic products and water-borne PU coatings.

Production capacity is claimed to be 1,000 tonnes/year, but MCC expects to expand that as demand increases. MCC's joint venture with Thai producer PTT (PTTMCC) laid the cornerstone of a 20,000 tonne/year biobased polybutylene succinate (PBS) plant at the Asia Industrial Estate in the province of Rayong, Thailand in September 2014. The plant is scheduled to start up some time in 2015.

Also in 2014, MCC agreed to an exclusive supply agreement with BioAmber and Mitsui & Co for biobased succinic acid for the PBS plant. The BioAmber Sarnia plant built with Mitsui & Co opened in August 2015 with a 30,000 tonne/year capacity for biobased succinic acid from glucose sourced from Canadian agricultural suppliers.

In April 2015, Mitsui & Co initiated construction of a 2,000 tonne/year plant within its Omuta Works for the manufacture new isocyanates, including the biobased polyisocyanate *Stabio*, which is prepared from bio-1,5-pentamethylene diisocyanate (PDI).

In early 2013, Mitsui & Co entered into a multi-year agreement with Solazyme to jointly develop high-value tailored oils from microalgae as alternatives for palm and coconut oils used in lubricant and plastic additives. That same year, Mitsui Chemicals formed a joint venture with Japan's Itoh Oil Chemicals and India's Jayant Agro Organics to producing biopolyols in India based on castor oil.

Also in 2013, Mitsui and Dow Chemical announced the indefinite postponement of plans to build a sugarcane ethanol-based biopolymer (largely biopolyethylene) plant in Brazil, citing rising design and construction costs and land ownership laws in the country.

## TORAY'S FORAY INTO BIOMATERIALS

*LumiLid* biobased, dual-ovenable, solvent-free lidding films introduced in 2015 are manufactured with Toray's proprietary sustainable resin blends comprising greater than 50% renewable feedstocks. They are designed for frozen, wet and dry food and dairy applications and are FDA-compliant for oven temperatures of up to 400°F for 30 minutes.

In April 2013, Toray announced that it was progressing towards commercialisation of biobased polybutylene terephthalate (PBT) using bio-butanediol (BDO) from Genomatica. Toray successfully produced a partially biobased PBT and moulded prototypes at the bench scale and confirmed its physical properties. It was planning to make PBT samples available that year and market the PBT commercially once the bio-BD) is readily available from a Genomatica licensee.

Under an offtake agreement established in 2012, Toray began purchasing bio-paraxylene (bio-PX) produced in the US by Gevo from renewable isobutanol in May 2014 for the manufacture for biobased polyethylene terephthalate (PET). Toray also provided funding assistance for Gevo's PX demonstration plant at its biorefinery at South Hampton Resources.

Toray is also working with Ajinomoto to develop and commercialise nylon-56 from dicarboxylic acid and bio-1,5-pentanediamine (1,5-PD) produced from the amino acid lysine, which is made from plant materials by Ajinomoto using fermentation technology. In addition, Toray offers *Ecodear* polylactic acid (PLA) derived from plants.

Ajinomoto and T.HASEGAWA CO reached an agreement in August 2015 to combine T. HASEGAWA's flavour refining and formulation technologies with Ajinomoto's biotechnologies and fermentation technologies to accelerate the research, development and commercialisation of fermentation-derived natural flavours derived from natural raw materials.

In March 2014, Ajinomoto also announced that it established an industrial fermentation process for L-tyrosine using only plant-based raw materials that offers 100% traceability.

Sojitz furthered its relationship with Myriant in 2014, signing an agreement with the bio-succinic acid producer and Taiwanese chemical company UPC to promote bio-succinic acid based plasticisers.

Kuraray expanded into biobased barrier materials in April 2015 with the acquisition of Australian Plantic Technologies, which offers biobased food packaging and in 2014 extended its joint development agreement with Amyris

**JAPANESE COMPANIES INVOLVED IN RENEWABLE CHEMICALS AND THEIR PARTNERS**

| Company | Partner | Products |
|---|---|---|
| **Ajinomoto** | Bridgestone | Bio-isoprene |
| | Toray | Bio-nylon |
| **Allied Carbon Solutions** | - | Bio-surfactants |
| **Daicel** | PCL | Partially bio-based cellulose acetow |
| **Denso** | DuPont Tate & Lyle | Bio-PTT |
| **Kaneka** | - | PHA |
| **Kao Corporation** | - | Bio-surfactants |
| **Kuraray** | - | Bioplastic |
| | Amyris | Farnesene-based rubber |
| **Lion Corporation** | - | Bio-surfactants |
| **Mitsubishi Chemical** | - | PLA |
| | PTT Group | Bio-PBS |
| | Roquette | Isosorbide-based polymers |
| | Mazda | Bio-based engineering plastics |
| **Mitsui & Co.** | - | PDI, PLA, oleochemicals, biosurfactants |
| | Jayant Agro/Itoh Oil | Castor polyols |
| | Dow Chemical | Bio-ethanol |
| | BioAmber | Bio-succinic acid |
| | Solazyme | Algal-based fatty acids |
| **Nippon Shokubai** | - | Bio-acrylic acid |
| **NOK** | - | Bio-EPDM |
| **Riken Corporation** | Yokohama Rubber, Zeon | Bio-isoprene rubber |
| **Saraya** | - | Bio-surfactants |
| **Showa Denko** | - | Bio-PBS, PLA |
| **Sojitz** | Myriant | Bio-succinic acid |
| | Braskem | Bio-polyethylene |
| **Takasago** | Amyris | Farnesene-based fragrance ingredients |
| **Teijin** | - | Bio-PET |
| | Toyota | PLA |
| **Toray** | - | Bio-nylon 6,10 |
| | Gevo | Bio-PET |
| | Genomatica | Bio-PBT |
| | Braskem | Bio-based polyolefin foam |
| | NatureWorks | PLA-based polymers |
| | Ajinomoto | Bio-nylon |
| **Toyobo** | - | PLA |
| **Toyota** | - | Bio-PET, Biobased plastic alloy, PLA |
| **Toyota Tsusho** | CFFC (via Greencol) | Bio-PET, Bio-MEG |
| | Braskem | Bio-PE |
| **Unitika** | - | PLA, bio-nylon |

SOURCE: Tecnon OrbiChem

on biobased farnesene derivatives, such as liquid farnesene rubber and hydrogenated styrene thermoplastic elastomers and made a $4m strategic capital investment in the company.

Also in 2014, Kuraray completed construction of its facility for the manufacture of *Biocarbotron* (jointly developed by Kureha Corporation and Kuraray), a plant-based hard carbon anode material for lithium-ion batteries.

Showa Denko developed HCAP (2-palmitoyl hydroxycitric acid), a lipophilic derivative of HCA, an acid found in the skin of the *Garcinia cambogia* plant that has the ability to block fat synthesis. The company is offering HCAP in 2015 as a cosmetic raw material that deeply permeates the skin and cell membrane, contributing significantly to the effect of slimming and skin anti-aging.

*Bionolle Starcla* from Showa Denko is a biodegradable blend of *Bionolle* PBS and biobased starch and PLA that is positioned as an environmentally friendly alternative to non-biodegradable plastics used for bags. "We see increasing demand for biodegradable materials due to tightening environmental regulation in EU and the growing use of biodegradable plastics as agricultural mulches in China," says Tomoko Yazaki with Showa Denko.

**"Japan's strong interests in sustainability and climate change have also pushed major domestic companies to implement their own corporate initiatives"**

**DORIS DE GUZMAN**
Senior consultant biomaterials, Tecnon OrbiChem

Early in 2015, Teijin and Kansai University announced the development of piezoelectric fabrics comprising poly-L-lactic acid (PLLA) fibres and carbon fibre electrodes. The sensing function allows detection of complicated, and even three-dimensional, movements.

In 2013, Teijin reported that it had improved the heat and impact resistance of its transparent polycarbonate biobased plastic *Planext*, which uses isosorbide obtained from corn starch as a raw material. Teijin also produces *Biofront* stereocomplex PLA with a melting point 40°C higher than that of conventional PLA.

Teijin and Teijin Frontier's *Solotex* polytrimethylene terephthalate fibre is a partially bioderived material prepared from bio-1,3-propanediol (PDO), and Teijin's *Eco Circle Plantfiber* is PET made using biobased ethylene glycol.

"The acceptance of the Japanese Eco Mark certification is standardising expectations for biobased fibres, and the reduction of CO2 emissions is now a very important and serious global issue. As a result, we see demand for biobased fibres growing rapidly," says Miora Ono, assistant to the general manager of the advanced fibres and composites business group of Teijin.

ZEON Corporation, Yokohama Rubber Co. and RIKEN (the Japan National Research and Development Agency) have been engaged in joint research for the production of synthetic rubbers from biomass since 2013 and announced in September 2015 the successful synthesis of isoprene from biomass using an artificial metabolic pathway. ZEON intends to commercialise the technology by the early 2020s for the production of polyisoprene.

These examples underscore the high level of interest in biobased chemicals and materials at many Japanese firms. Notably, according to Antonio, much of the investment is going towards biobased materials and chemicals that offer added performance vis-à-vis their petrochemical counterparts, particularly advanced bioplastics. ■