



News Review

Issue Fifty-Nine

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Each month we review the latest news and select key announcements and commentary from across the biobased chemicals and materials sector.



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Foreword

A hearty welcome to the February edition of the NNFCC's Biobased Products news review.

2017 has made anything but a slow start for those in the biobased product sector, with policies, patents, and positive forecasts lurking in all corners. The early 2017 headlines were dominated by French capital city Paris, which has banned all non-compostable plastic bags. The ban follows similar legislation being introduced around the EU applying charges on plastic bags in order to discourage their use. France is not the first country to ban the bags, however, as they have been banned in Italy since 2011. The French ban goes further, however, with produce bags also being banned unless they are biodegradable and biosourced. Italian bioplastic manufacturers Novamont SpA have been commissioned to produce compliant plastic bags for use in Parisian markets now the ban is in place.

We may have just welcomed in the Chinese New Year of the Rooster, but in the bioplastics sector 2017 may well turn out to be the year of the shrimp. As Bubba Blue quips in Oscar winning film *Forrest Gump*: "Shrimp is the fruit of the sea," well it turns out shrimp may also be the plastic source of the sea. Chitosan, a polymer film produced from waste shrimp shells has already seen use in medical and pharmaceutical sectors as a biobased material for plastic bags with good antibacterial and antiviral properties, but researchers in the UK and Egypt are looking to produce plastic shopping bags from it also. This would go some way to recycling one of Egypt's biggest waste products: shrimp shells, while also reducing the country's dependence on petroleum-based plastics, since there is not enough available agricultural land to grow the required feedstocks for crop-based bioplastics. It is also posited by the same researchers that chitosan could be used to produce plastics that absorb oxygen, thus extending the shelf-life of any food packaged in a bag made from this plastic. This would have the added bonus of reducing food waste, making this a potentially revolutionary discovery, and rounding off a great start to 2017 where bioplastic bags are concerned. It should however be noted that in order to compete with traditional plastic bags, said revolution will need support in the form of policy mandates, which is what makes laws like that passed in Paris so important.

Read on for the latest biobased product news...

Policy

Analysis of Design for Recycling of bioplastics

When surveying the trends and criteria for the design for recycling (DfR) of bio-based polymers, priorities appear to lie in energy recovery at the end of the product life of durable products, such as bio-based thermosets. Non-durable products made of thermoplastic polymers exhibit good properties for material recycling. The latter commonly enjoy growing material recycling quotas in countries that enforce a landfill ban. Quantitative and qualitative indicators are needed for characterizing progress in the development towards more recycling friendly bio-based polymers. This would enable the deficits in recycling bio-based plastics to be tracked and improved. The aim of this paper is to analyse the trends in the DfR of bio-based polymers and the constraints posed by the recycling infrastructure on plastic polymers from a systems perspective. This analysis produces recommendations on how life cycle assessment indicators can be introduced into the dialogue between designers and recyclers in order to promote DfR principles to enhance the cascading use of bio-based polymers within the bioeconomy, and to meet circular economy goals.

Click [here](#) for more information.

Malaysia pledges funding for Biotech companies

A RM100 million fund for biotechnology companies to take their businesses global has been launched at Bank Negara Malaysia's (BNM) Karnival Kewangan.

The government fund, dubbed the Biotechnology Commercialisation Fund (BCF) 2.0, was launched by Science, Technology and Innovation Minister Datuk Seri Wilfred Madius Tangau.

He said the funds, which will be given as soft loans, are projected to assist 30 to 50 companies by the end of 2020.

The disbursement of the funds is in its second phase under the 11th Malaysia Plan, which intends to take home-grown bio-based companies to the world stage.

Madius said the fund's first phase was rolled out under the Ninth and 10th Malaysia Plan to provide seed capital for bio-based companies to establish their business and market the products.

He said 20 of the 278 bionexus status companies are also being groomed to take their businesses to international markets.

Companies will be selected by the Malaysian Bioeconomy Development Corporation and the funds will be disbursed by the Malaysian Industrial Development Finance.

Its chairman, Professor Tan Sri Zakri Abdul Hamid, said that BCF was offered through two schemes to accommodate the diverse needs of bio-based companies.

Click [here](#) for more information.

Non-Compostable Plastic Bags banned in Paris

The city of Paris has banned traditional plastic retail bags from its supermarkets in favour of compostable and bio-based bags.

In a Dec. 16 statement, the Paris mayor's office said the decision was a move to reinforce the provision of "energy transition law" on packaging and the city's bid to become a leader in the "fight against climate change and the campaign for a circular economy."

The move will only allow compostable biosourced bags as well as paper and cotton bags for primary packaging.

As part of the campaign, Italian bio-based plastic packaging company, Novamont SpA will offer more than 3 million bio-sourced and compostable bags to markets.

Public awareness workshops on the end of disposable plastic bags will also be held to educate the public on different types of existing degradable and biodegradable bags.

The move follows another already-in-place measure by Paris supermarkets to collect unsold food products and vegetable scraps as part of the city's environmental campaign.

Click [here](#) for more information.

EUBP praises EU Committee vote



European Bioplastics (EUBP), the association representing the bioplastics industry in Europe, has congratulated the European Parliament's Environment Committee and rapporteur Simona Bonafè on their strong efforts and the results of the Committee's vote on the waste legislation proposals concerning the EU Circular Economy Package.

The positive vote of the Members of Parliament resulted in amendments to the Waste Framework Directive that will help to ensure a separate collection of bio-waste across Europe facilitated by certified collection tools such as compostable bio-waste bags.

In line with its ambitious goal to increase resource efficiency, the European Parliament also voted to exclude mechanically or organically recyclable waste from landfills, supported a definition that confirms by-products not to be waste, and introduced a food waste definition and a food waste prevention hierarchy.

With regard to the Packaging and Packaging Waste Directive, the adoption of the amendment encouraging the use of bio-based resources for the production of packaging is a first important milestone that concretely links the concepts of circular economy and bioeconomy.

Bio-based mechanically and organically recyclable plastics support circular thinking by lowering carbon emissions, helping to reach recycling quotas and keep valuable secondary raw materials and renewable carbon in the loop.

Click [here](#) for more information.

Recirculation Concept aims to make bio-based product design more sustainability-conscious

Bio-based products are made from renewable materials, offering a promising basis for the production of sustainable chemicals, materials, and more complex articles. However, biomass is not a limitless resource or one without environmental and social impacts. Therefore, while it is important to use biomass and grow a bio-based economy, displacing the unsustainable petroleum basis of energy and chemical production, any resource must be used effectively to reduce waste. Standards have been developed

to support the bio-based product market in order to achieve this aim. However, the design of bio-based products has not received the same level of attention. Reported here are the first steps towards the development of a framework of understanding which connects product design to resource efficiency. Research and development scientists and engineers are encouraged to think beyond simple functionality and associate value to the potential of materials in their primary use and beyond.

Click [here](#) for more information.

Markets

Biobased lubricant market set to continue growth

Allied Market Research have published its forecasts for the global bio-based lubricant market.

Bio-based lubricants are used in industrial machinery and other automotive applications where environmental loss is more to prevent wear and tear and to increase the life of the machinery by reducing friction between metal parts. They offer several advantages over synthetic & mineral oil based lubricants due to their increased performance and environment friendly nature. Bio-based lubricants are renewable & biodegradable in nature and do not persist in the environment for a longer period of time.

The market for bio-based lubricants has grown considerably in the recent past, due to increase in adoption of bio-based materials owing to the stringent government regulation, especially in North America and Europe. For instance, Spill Prevention, Control and Counter (SPCC) measure rule was published by U.S. Environment Protection

Agency in 1973 under Clean Water Act for the prevention of water bodies from leakage of oils in the environment. This rule describes the prevention of, preparedness for, and response to the oil spills at non-transportation-related facilities.

In 2015, the hydraulic fluid segment occupied around one-fourth of the overall bio-based lubricants market in terms of volume, and is expected to maintain its lead throughout the analysis period. This is due to their extensive use in low and high pressure hydraulic systems in the construction, automotive, and agricultural sector.

Click [here](#) for more information.

Biodegradable Polymers market set to more than double by 2021

Technavio analysts forecast the global biodegradable polymers market to grow at a CAGR of over 21% during the forecast period, according to their latest report.

Consumers have shown a clear preference towards sustainable options for plastic bags and food packaging. The preference for sustainability in these product categories is pushing vendors to adopt greener technologies and strategies for branding and gaining a larger consumer base. Therefore, the increasing acceptance of sustainable packaging and green products among consumers is directly driving the biodegradable polymers market.

Management of plastic waste is a top priority for most governments as mass consumption of products with short lifespans is increasing, leading to accumulation of an enormous amount of non-degradable waste. This waste takes up valuable real estate space and often ends up in landfills or dumping grounds that have grave environmental. To curb this, governments across the globe are aiding in and pushing for the adoption of

biodegradable polymers through various initiatives and reforms, thus bringing in a steady demand for these products.

In Europe, biopolymers that undergo 90% degradation when subjected to the industrial composting process can be marked with a compostable symbol under European Standard EN 13432 (2000). In the US, government agencies have enforced the Federal Farm Bill Energy Title, which requires procurements to comprise of only of bio-based items.

Another important factor pushing for adoption of biodegradable polymers is the present consumption pattern of fossil fuel sources, which are likely to get depleted in the next few decades. Well-developed, self-sufficient, and state-of-the-art integrated bio-refineries are the only way forward for a sustainable future. Thus, the focus of polymer manufacturers is shifting toward bio-based raw materials, which is very good for the global outlook of bio-based raw materials industries.

Click [here](#) for more information.

Bioplastic Market to approach \$6bn by 2022 – Market Research Future

Globally, the market for Bioplastic market is increasing due to various industries such as packaging, consumer goods, automotive industry and others. The growing segment is packaging due to Government's drive towards achieving a 'zero waste' economy, through reducing waste and increasing recycling, has fostered an increased consciousness of resource efficiency. This awareness has indirectly promoted the use of bioplastic products.

Click [here](#) for more information.

Natural oil polyol market growth set to continue

According to Global Market Insights, the Natural Oil Polyols (NOP) Market size was over 18 million tons in 2015 and is forecast to grow at more than 7% CAGR up to 2023.

Industry shift towards development of bio-based products in order to reduce dependency on petrochemicals may drive NOP market size. They are comparable in terms of longevity and sustainability when used as a substitute for petrochemical polyols. Polyurethane is expected to be sustainable and may positively impact performance and durability.

Increasing application scope in automotive, construction and furniture industry to reduce conventional plastic usage are considered to favour NOP market size growth. Favourable government initiatives in order to reduce greenhouse gases (GHG) emissions may positively influence the demand. EPA and REACH compliances to promote environment friendly products pertaining to health and ecosystem safety are key promising factor to stimulate natural oil polyol demand.

Furthermore, the European Emission Standards (EES) is increasingly implying stringent regulations on vehicular emissions from tail pipe. The trend of continuous efforts to reduce vehicular emissions is anticipated to continue over the next few years. These emissions are highly influenced by the overall vehicle weight, which may be lowered by using bio-based materials to build the chassis of the vehicle.

Click [here](#) for more information.

Biodegradable Mulch Market forecast to almost double by 2024

Grand View Research's market report posits that the global biodegradable mulch films market was worth USD 33.5 million in 2015. Increasing demand in green house application coupled with rising environmental concerns towards synthetic counter parts is anticipated to drive the market growth over the next eight years. Growing population coupled with a shrinking agricultural land owing to urbanization and industrialization have forced farmers to increase productivity in the same land holding. Various advantages offered by these films such as lower environmental impact, enhancing crop yield by inhibiting weed growth, maintaining soil moisture levels and the temperature is expected to drive the market growth over the forecast period.

Favourable government regulations regarding eco-friendly products, especially in Europe and North America is anticipated to impact market growth positively over the foreseeable future. Rising concern regarding plastic mulch residues in soil is expected to increase product penetration over the next eight years. Biodegradable films can provide benefits of plastic mulch, and eliminate the need for removal & disposal, and alleviate the negative environmental impact.

Mulch films that are currently available in the market are not entirely biobased and contain over 10% synthetic ingredients. In addition, concerns regarding biodegradable mulches not achieving 90% biodegradation within two years of tillage into the soil is anticipated to affect the market growth negatively in near future. Owing to the aforementioned factor, currently available biodegradable mulch films are not allowed in certified organic systems in the U.S.

Growing R&D to create new biobased formulas is anticipated to create immense opportunities for the market over the foreseeable future. Rising biodegradable mulch demand is projected to

lower product costs and become competitive with polyethylene counterparts over the forecast period.

Click [here](#) for more information.

Biodegradable Plastic Packaging market set to grow

Transparency Market Research have published their review into the global market for biodegradable plastic.

Bioplastic packaging refers to use of bioplastics in packaging materials. The global bioplastics packaging market is expected to witness a strong growth owing to the increasing consumer awareness about nature friendly products and changing inclination of consumers towards sustainable products. Other growth drivers for the bioplastic packaging market include increased focus on sustainable packaging by brand owners and retail companies, global rise in implementation of plastic bag bans, etc.

However, the complications associated with the production of bioplastic packaging materials through agro-based raw materials, coupled with the increasing production of crude oil and natural gas in the Middle East and Russia (leading to reduced oil prices), is anticipated to pose a threat to the overall growth of the bioplastic packaging market over the forecast period. Other factors which could hamper the market growth include high cost of biodegradable plastics as compared to petrol-based plastics, as well as performance, durability, and quality concerns.

Click [here](#) for more information.

Research & Development

Microbial adhesive binds chitosan to biological tissue

Natural biomaterials, such as chitosan and collagen, are useful for biomedical applications because they are biocompatible, mechanically robust, and biodegradable, but it is difficult to rapidly and tightly bond them to living tissues. In this study, we demonstrate that the microbial transglutaminase (mTG), can be used to rapidly (<5 min) bond chitosan and collagen biomaterials to the surfaces of hepatic, cardiac, and dermal tissues, as well as to functionalized polydimethylsiloxane (PDMS) materials that are used in medical products. The mTG-bonded chitosan patches effectively sealed intestinal perforations, and a newly developed two-component mTG-bonded chitosan spray effectively repaired ruptures in a breathing lung when tested ex vivo. The mechanical strength of mTG-catalysed chitosan adhesive bonds were comparable to those generated by commonly used surgical glues. These results suggest that mTG preparations may be broadly employed to bond various types of organic materials, including polysaccharides, proteins, and functionalized inorganic polymers to living tissues, which may open new avenues for biomedical engineering, medical device integration, and tissue repair.

Click [here](#) for more information.

Biobased alternatives to Bisphenol A as polyepoxide monomers

The synthesis of polymers from renewable resources is a burning issue that is actively

investigated. Polyepoxide networks constitute a major class of thermosetting polymers and are extensively used as coatings, electronic materials, adhesives. Owing to their outstanding mechanical and electrical properties, chemical resistance, adhesion, and minimal shrinkage after curing, they are used in structural applications as well. Most of these thermosets are industrially manufactured from bisphenol A (BPA), a substance that was initially synthesized as a chemical oestrogen. The awareness on BPA toxicity combined with the limited availability and volatile cost of fossil resources and the non-recyclability of thermosets implies necessary changes in the field of epoxy networks. Thus, substitution of BPA has witnessed an increasing number of studies both from the academic and industrial sides. This review proposes to give an overview of the reported aromatic multifunctional epoxide building blocks synthesized from biomass or from molecules that could be obtained from transformed biomass. After a reminder of the main glycidylation routes and mechanisms and the recent knowledge on BPA toxicity and legal issues, this review will provide a brief description of the main natural sources of aromatic molecules. The different epoxy prepolymers will then be organized from simple, mono-aromatic di-epoxy, to mono-aromatic poly-epoxy, to di-aromatic di-epoxy compounds, and finally to derivatives possessing numerous aromatic rings and epoxy groups.

Click [here](#) for more information.

UK Centre for Process Innovation receives funding for biorefinery equipment

UK-based Centre for Process Innovation (CPI) has secured funding of £896,000 for state of the art equipment to be installed within the industrial biotechnology and biorefinery facilities at Wilton, UK.

All equipment is scaled and modelled to reflect the existing pilot plant assets at CPI's National Industrial Biotechnology Facility to provide greater confidence and mitigate the risks associated with taking innovations from the laboratory to commercial operation.

The addition of multiple small scale reactors within CPI fermentation labs will allow CPI to perform characterisation studies of industrial microbes with a greater efficiency, accuracy and higher throughput.

Isolating products following industrial biotechnology processes can contribute up to 70% of production costs. Being able to design and test this on scaled down equipment will enable full process design and testing with reduced investment needs.

Analytics investment will give CPI the ability to collect and assess data which is central to being able to perform process development. These assets expand the capacity of the analytical facility to support the new fermentation and product isolation capability.

This award will allow CPI to significantly upgrade capability to de-risk process development and scale-up/down projects, the organisation said. The new equipment will be installed during 2017 and provide employment for 3 full time research posts to support this new state-of-the-art equipment.

Click [here](#) for more information.

High yield bio-isoprene process developed

Catalytic hydrogenation of itaconic acid (obtained from glucose fermentation) yields 3-methyl-tetrahydrofuran (3-MTHF), which then undergoes catalytic dehydro-decyclization to isoprene. It is demonstrated that a one-pot cascade reaction converts itaconic acid to 3-MTHF at ~80% yield

with Pd-Re/C catalyst and 1000 psig H₂.

Subsequent gas-phase catalytic ring opening and dehydration of 3-MTHF with phosphorous-containing zeolites including P-BEA, P-MFI, and P-SPP (self-pillared pentasil) exhibits 90% selectivity to dienes (70% isoprene, 20% pentadienes) at 20-25% conversion.

Click [here](#) for more information.

Chitin-based plastic bags under development



Bioengineers at The University of Nottingham are trialling how to use shrimp shells to make biodegradable shopping bags as a 'green' alternative to oil-based plastics, and as a new food packaging material to extend product shelf life.

An expert in testing the properties of materials, Dr Nicola Everitt from the Faculty of Engineering at Nottingham, is leading the research together with academics at Nile University in Egypt.

The research is being undertaken to produce an innovative biopolymer nanocomposite material which is degradable, affordable and suitable for shopping bags and food packaging.

Chitosan is a man-made polymer derived from the organic compound chitin, which is extracted from shrimp shells. The dried chitosan flakes can then

be dissolved into solution and polymer film made by conventional processing techniques.

Chitosan was chosen because it is a promising biodegradable polymer already used in pharmaceutical packaging due to its antimicrobial, antibacterial and biocompatible properties.

The second strand of the project is to develop an active polymer film that absorbs oxygen. This future generation food packaging could have the ability to enhance food shelf life with high efficiency and low energy consumption, making a positive impact on food wastage in many countries. If successful, Dr Everitt plans to approach UK packaging manufacturers with the product.

Click [here](#) for more information.

Polymer-producing enzyme structure determined

Polyhydroxybutyrate (PHB) synthase (PhaC) catalyses the polymerization of 3-(R)-hydroxybutyryl-coenzyme A as a means of carbon storage in many bacteria. The resulting polymers can be used to make biodegradable materials with properties similar to those of thermoplastics and are an environmentally-friendly alternative to traditional petroleum-based plastics. A full biochemical and mechanistic understanding of this process has been hindered in part by a lack of structural information on PhaC. Here we present the first structure of the catalytic domain (residues 201-589) of the class I PhaC from *Cupriavidus necator* (formerly *Ralstonia eutropha*) to 1.80 Å resolution. We observe a symmetrical dimeric architecture in which the active site of each monomer is separated from the other by ~33 Å across an extensive dimer interface, suggesting a mechanism in which PHB biosynthesis occurs at a single active site. The structure additionally highlights key side chain interactions within the active site that play likely roles in facilitating

catalysis, leading to the proposal of a modified mechanistic scheme involving two distinct roles for the active site histidine. We also identify putative substrate entrance and product egress routes within the enzyme, which are discussed in the context of previously reported biochemical observations. Our structure lays a foundation for further biochemical and structural characterization of PhaC, which could assist in engineering efforts for the production of eco-friendly materials.

Click [here](#) for more information.

ε-caprolactone from bio-based terpene

A high-yielding 4-step process for converting a naturally occurring terpene, β-pinene, into a substituted ε-caprolactone is herein reported. Investigations into the ring-opening polymerisation and copolymerisation of this monomer are also described.

Click [here](#) for more information.

Computer memory successfully created from eggshells



Resistive random access memory (RRAM) devices have emerged as promising candidates for near future non-volatile information storage. Eggshells, a food waste, have not been focused and recycled

sustainably today. Eggshell-based devices have shown a large resistive-switching(RS) memory behaviours with favourable resistance ratio of $\sim 10^3$, larger memory window of ~ 3.5 V, and high endurance and retention performance. Redox-based Ag filament models involving the formation and rupture of the metallic conduction filaments between top and bottom electrodes are proposed to interpret the large non-volatile bipolar RS memory behaviours. This discovery provides for the possibility of an environmentally friendly, low-cost and sustainable material application in the next-generation non-volatile data storage device.

Click [here](#) for more information.

Glue from mussel proteins and PLA



Adhesives releasing carcinogenic formaldehyde are almost everywhere in our homes and offices. Most of these glues are permanent, preventing disassembly and recycling of the components. New materials are thus needed to bond and de-bond without releasing reactive pollutants. In order to develop the next generation of advanced adhesives we have turned to biology for inspiration. The bonding chemistry of mussel proteins was combined with preformed poly(lactic acid), a bio-based polymer, by utilizing side reactions of $\text{Sn}(\text{oct})_2$, to create catechol-containing copolymers. Structure–function studies revealed that bulk adhesion was comparable to that of several petroleum-based commercial

glues. Bonds could then be degraded in a controlled fashion, separating substrates gradually using mild hydrolysis conditions. These results show that biomimetic design principles can bring about the next generation of adhesive materials. Such new copolymers may help replace permanent materials with renewable and degradable adhesives that do not create chronic exposure to toxins.

Click [here](#) for more information.

Dupont to begin research into Protein Medication production

Through a grant from the Bill & Melinda Gates Foundation, DuPont will apply its world-class capabilities in the areas of protein engineering, pathway engineering and cell factories to the field of protein drugs.

The DuPont Industrial Biosciences business is a world leader in the manufacture and scale up of industrial proteins. When applied to pharmaceutical protein production, this approach has the potential to enable rapid scale-up and lower costs at high volumes, making protein drugs such as monoclonal antibodies potentially suitable for infectious diseases, effectively managing outbreaks and providing affordable supply to people around the world.

Click [here](#) for more information.

Polymers

Solegear purchases LINDAR's bioplastic division

Solegear Bioplastic Technologies Inc. is pleased to announce that it entered into a definitive

agreement on December 22, 2016 with LINDAR Corporation to acquire 100% of LINDAR's bioplastic division for CAD\$845,000, comprising 4,225,000 common shares of the Company at a deemed price of \$0.20 per share.

Located in Minnesota, LINDAR has been producing thermoformed packaging since 1993 and is a recognized leader in packaging innovations, including single-serve and tamper evident food packaging.

Solegear & LINDAR have also agreed to negotiate and enter into an outsourced operating agreement under which LINDAR will provide certain management, operational, financing, marketing, sales, logistics, warehousing and other support services to the Company. The LINDAR team will continue to market and sell bioplastic packaging, making the transition seamless for LINDAR's existing bioplastic customers, which includes a wide range of US retailers and food producers.

The purchased assets generated over CAD\$1.3 million in revenue in 2015. Revenues generated from the purchased assets are expected to be accretive to Solegear during the current fiscal year. Issuance of the Shares to LINDAR is conditional upon execution of the Outsourcing Agreement, and completion of the Asset Purchase remains subject to TSX Venture Exchange approval. The Shares will be issued from treasury and subject to a 24 -month hold period from the signing date of the Outsourcing Agreement.

Click [here](#) for more information.

Automotive industry set to boost bio-polyamide market

A bio-polyamide is an amide polymer synthesized using renewable or bio-based raw materials.

Transparency Market Research report that the burgeoning automotive industry is expected to boost the bio-polyamide market. The use of bio-polyamides in the automotive construction contributes to fuel savings and reduction in carbon emissions. Fuel savings can be higher than 50% when bio-polyamide structures are used in the manufacturing process. The Asia Pacific region is driving the global automotive industry due to changing lifestyle and rising disposable income. Furthermore, environmental-related regulations across developed regions are expected to drive the market for bio-polyamides. For instance, the corporate average fuel economy (CAFE) standards in the U.S. and European Union's CO₂ limits would put intense pressure on the automobile manufacturers to reduce the weight of the vehicle in order to reduce emissions. The expected CO₂ limit in 2020 is pegged at 95g CO₂/ km as compared to 130g CO₂/ km in 2013. Furthermore, the growth of electrical & electronics industry across the globe is one of the major driving factors of the global bio-polyamide market.

However, factors such as availability of raw materials and their price volatility are expected to hamper growth of the bio-polyamide market. Castor oil is the major raw material used in the production of bio-polyamides. Sebacic acid and undecenoic acid are the primary components of castor oil used in the production of bio-polyamides. Increasing research & development activities are expected to expand the application area of bio-polyamides, which are likely to become an important opportunity during the next few years.

Click [here](#) for more information.

Nanocellulose from oil palm's empty fruit branches

MYBiomass and API announced a Joint-Development Work (JDA) for production of nanocellulose and cellulosic sugars from oil palm

empty fruit-bunches (EFBs) into material as enhancing additives in textile, paper, and automotive parts amongst others. The JDA is funded by MYBiomass and harnesses MYBiomass' strength in oil palm biomass supply, technology adaptation, market development, and combines this with API's technical and material development expertise. MYBiomass's goal is to be a pioneer in setting up commercial biorefineries with potential participation from technology providers, off-takers and investors. This is in-line with the Malaysian Biomass Initiative (MBI) as it addresses the potential of moving up the value-chain, promotes sustainable feedstock supply, and shifts focus to higher-value downstream production.

Click [here](#) for more information.

Chemicals

Avantium acquires Liquid Light

Avantium, a leading chemical technology company and forerunner in renewable chemistry has announced it has acquired the assets of Liquid Light Inc. (Liquid Light) a renowned developer of electrochemical processes. Liquid Light has developed proprietary process technology to make major chemicals from low-cost, globally-abundant carbon dioxide (CO₂). The acquisition combines the technologies of both Liquid Light and Avantium to develop a world leading electro-catalysis platform and to commercialize new process technologies using CO₂ as feedstock to produce sustainable chemicals and materials.

Liquid Light, which was spun out from Princeton University in 2008, has invested more than US\$35 million on low-energy electrochemistry technologies to convert CO₂ to major chemicals. It has filed over 100 national patent applications of which more than twenty have been granted. Its

patent portfolio includes filings on producing multiple chemical building blocks used in large existing markets, including oxalic acid, glycolic acid, ethylene glycol, propylene, isopropanol, methyl-methacrylate and acetic acid for the production of polymers, coatings and cosmetics.

The technology and patent portfolio of Liquid Light will be integrated in Avantium's Renewable Chemistry business unit and its existing R&D program in electrochemistry. The combination of Liquid Light's expertise in electrochemistry with Avantium's expertise in catalysis and process engineering will be the basis of an unrivalled technology platform to develop novel production technologies for converting CO₂ to chemicals and materials.

The development of electrochemistry has the potential to use CO₂ as a feedstock for the sustainable production of chemicals and materials, and is seen as a 'game-changer' for the chemical industry. The result is that greenhouse gas is sequestered into products that can replace plastics and chemicals that are now produced from fossil feedstock.

Click [here](#) for more information.

Bio-butadiene market set to grow thanks to tyres – Transparency Market Research

Butadiene is one of the primary petrochemicals used as a monomer in the production of various industrial chemicals such as synthetic rubbers, resins, plastics, and other polymers. Butadiene is either employed as a principal monomer or in combination with other monomers such as styrene. Currently, butadiene is being derived by using bio-based raw material sources such as non-food biomass in order to reduce dependency on petroleum feedstock.

The global demand for synthetic & bio-based butadiene market is likely to be driven by global tire and automotive end-user industries. Following the economic slowdown in 2008, the automotive industry was chiefly responsible for boosting growth in the developed and developing regions, thus helping them regain their economies. The automotive industry increased production from 2010 in various countries across the globe such as China, Brazil, and Germany. Majority of butadiene is consumed in producing synthetic rubbers and coatings that are required in the manufacture of tire and other automotive accessories. Thus, growth in production of automobiles is expected to spur growth of the synthetic & bio-based butadiene market by the end of 2023. Butadiene and its derivatives are preferably used as chemical intermediates in this end-user industry as they provide better grip and high wear and tear resistance to finished automotive components. Rise in demand for acrylonitrile butadiene styrene (ABS) in Asia Pacific, especially in China and India, is anticipated to be another major factor driving the global synthetic & bio-based butadiene market.

Click [here](#) for more information.

Consumer Products

BanBao produces 100% biobased toy blocks

BanBao is committed to build a better tomorrow, and for this reason will start producing sustainable and environment-friendly building blocks made of new biobased materials. The educational toy brand with its headquarters in China will start its production in the Netherlands.

Regulators increasingly warn of unsafe toys that fail to meet safety requirements. The controls have been tightened with more recalls as a result. The desire for environment-friendly and safer toys is greater among parents, according to research.

The new 'green' bio-based building blocks contain 0% oil-based chemicals. BanBao also do not add any oil-based chemicals during the manufacturing process to 'enhance' the performance or colour of our product. The packaging, stickers, instructions and glue will also be 100% biobased.

The sustainable and environmental friendly product line will consist of over 13 toy boxes suitable for children in the age of 1,5 to 6 years old. The new product line will be available in stores in the autumn of 2017.

Click [here](#) for more information.

Unibio develops high protein animal feed from biogas

A high-protein feed converted from natural gas by bacteria is now replacing fermented soya and fishmeal in commercial Danish pig rations.

Calculated at 72.9% crude protein, the pinkish dry powder (UniProtein) is produced by a methanotrophic bacterium and will be targeted mainly at the pig and poultry sectors.

The methanotrophic process relies on bacterial culture using natural gas as a carbon and energy source, producing "clean water" as a waste product. It has been approved as an animal feed in the EU since 1995 and was added to the EU feed catalogue in 2011 for all animals and fish.

Denmark is acting as the cradle for the technology, which has doubled biogas production since 2012 to 8 petajoules with the Danish Food and Agriculture Council hoping to soon turn the gas sector into a totally "fossil-free energy

system". This also enables Unibio to use certified biogas in its production process.

Further to protein production, Finnish scientists at the VTT (Technical Research Centre of Finland) are developing small, farm-scale biogas fermenter units that can also produce bioplastic, although they are still yet to reach the commercial stage.

VTT principal scientist Juha-Pekka Pitkänen said plastic accumulates when the nitrogen source (nitrate) starts to run out in a batch process.

Click [here](#) for more information.

Patents

Improved copper-containing multimetallic catalysts, and method for using the same to make biobased 1,2-propanediol

Copper-containing, multimetallic catalysts with either a zirconia or carbon support are described which have improved utility for the hydrogenolysis of a glycerol or glycerol-containing feedstock to provide a biobased 1,2-propanediol product. Especially, improved carbon-supported examples of such catalysts are described for this reaction as well as for other processes wherein hydrogen is used, with methods for maintaining the activity of these catalysts. Related treatment methods in the preparation of these improved catalysts enable the use of carbons with a desired mechanical strength but which previously lacked activity, for example, for the conversion of a glycerol or glycerol-containing feed to produce 1,2-propanediol, so that copper-containing, multimetallic catalysts may be employed for making a biobased propylene glycol using carbon supports that previously would have not been suitable.

Click [here](#) for more information.

Methods for production of terephthalic acid and styrene from ethylene oxide

The present invention provides methods for the production of terephthalic acid and derivatives thereof using ethylene oxide, carbon monoxide and furan as feedstocks. The process is characterized by high yields and high carbon efficiency. The process can utilize 100% biobased feedstocks (EO via ethanol, CO via biomass gasification, and furan via known processes from cellulosic feedstocks). In one aspect, processes of the invention coproduce biobased terephthalic acid and biobased styrene.

Click [here](#) for more information.

Bio-based binders for insulation and non-woven mats

An aqueous binder composition is provided that includes a carbohydrate and a crosslinking agent. In exemplary embodiments, the carbohydrate-based binder composition may also include a catalyst, a coupling agent, a process aid, a crosslinking density enhancer, an extender, a moisture resistant agent, a dedusting oil, a colorant, a corrosion inhibitor, a surfactant, a pH adjuster, and combinations thereof. The carbohydrate may be natural in origin and derived from renewable resources. Additionally, the carbohydrate polymer may have a dextrose equivalent (DE) number from 2 to 20. In at least one exemplary embodiment, the carbohydrate is a water-soluble polysaccharide such as dextrin or maltodextrin and the crosslinking agent is citric acid. Advantageously, the carbohydrates have a low viscosity and cure at moderate temperatures. The environmentally friendly, formaldehyde-free binder may be used in the formation of insulation materials and non-woven chopped strand mats. A

method of making fibrous insulation products is also provided.

Click [here](#) for more information.

Events

ORG Conference 2017, 23rd March 2017, Rocester, United Kingdom

Organics Recycling 2017 is the most important meeting place for anyone working in, or associated with, the organics recycling sector. This established one day conference, exhibition and Gala Dinner will once again bring the sector together to foster debate and interaction with peers and key decision makers.

Click [here](#) for more information.

Bio-Based Live, 31st May - 1st June 2017, Amsterdam, The Netherlands

We understand that in an emerging industry the journey from lab innovation to commercialisation can be a difficult one. It is a convoluted ecosystem and all actors are required to collaborate and work together to ensure a productive future for the bio-based industry.

The 2nd annual meeting of our European community offers an interactive and intimate environment to make bio-based innovations a key part of future sustainable strategies. Bringing together the CEOs, senior R&D, Process Heads, and BD Heads, with the sustainable professionals

brand marketing specialists and end users, we create a unique platform to do business and create practical takeaways to ensure long-term success.

Click [here](#) for more information.

13th International Conference on Renewable Resources and Biorefineries, 7-9th June 2017, Wrocław, Poland

Delegates from university, industry, governmental and non-governmental organizations and venture capital providers will present their views on industrial biotechnology, sustainable (green) chemistry and agricultural policy related to the use of renewable raw materials for non-food applications and energy supply.

Click [here](#) for more information.

EFIB, 9th – 11th October 2017, Brussels, Belgium

The 10th European Forum for Industrial Biotechnology and the Bioeconomy (EFIB) returns to Brussels October 2017 and will attract industry executives committed to a shift towards renewable, biologically-based manufacturing. EFIB is organised by EuropaBio, Europe's largest and most influential biotechnology industry group and Smithers Rapra, global leader in rubber, plastics, polymer and composites information products.

Click [here](#) for more information.

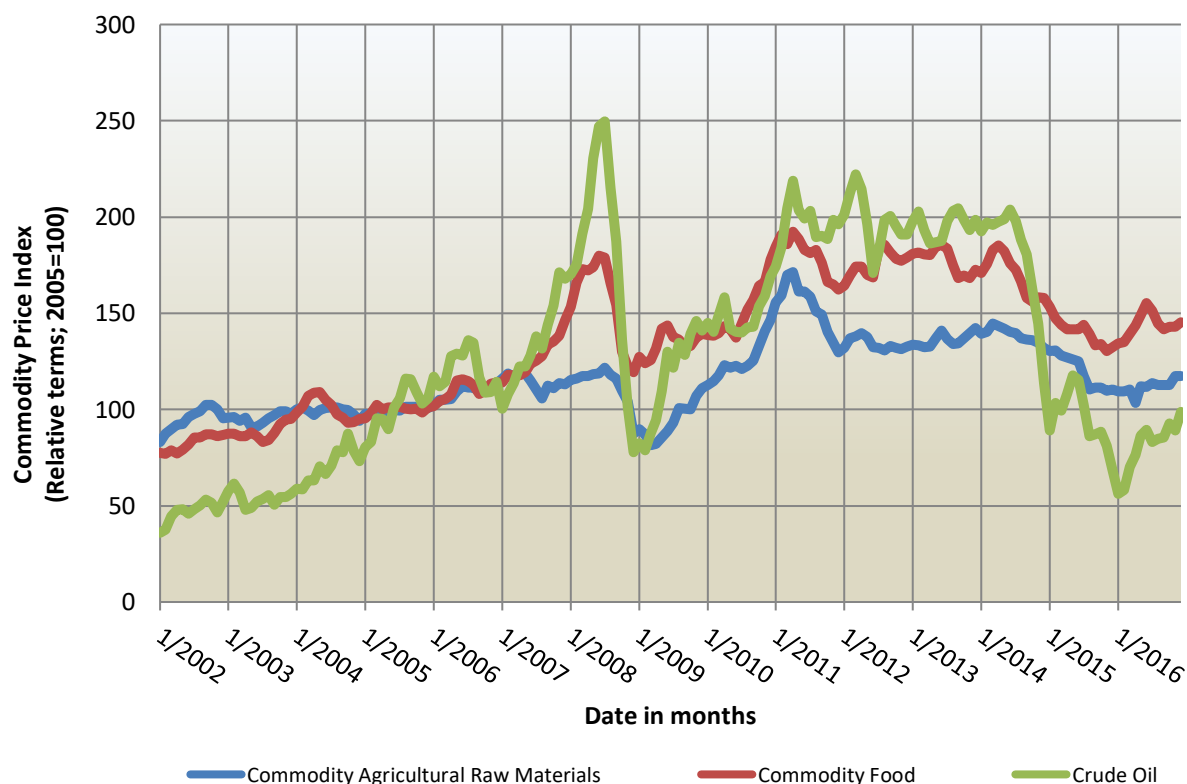
Price Information

Spot Prices of feedstocks as of today, and five years ago, with percentile price change. Arrows indicate rise (↑), constant (→) or fall (↓) from previous month.

Item	Price, US\$ (Dec 11)	Price, US\$ (Dec 16)	% Price Change
Crude oil (petroleum, barrel)	104.26	52.61 (↑)	-50%
Maize (corn, metric ton)	258.44	152.67 (↑)	-41%
Sugar (pound)	0.2342	0.1883 (↓)	-20%
Rapeseed oil (metric ton)	1,244.43	917.34 (↑)	-26%
Soybean oil (metric ton)	1,103.04	800.26 (↑)	-27%
Ethanol (gallon)	2.49	1.70 (↑)	-32%

For details on indexes please see www.indexmundi.com/commodities; Ethanol prices from Govt of Nebraska at www.neo.ne.gov/

Raw materials 15-year Price Indices



For details on the nature of these commodities please see www.indexmundi.com/commodities

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