THE ROAD AHEAD

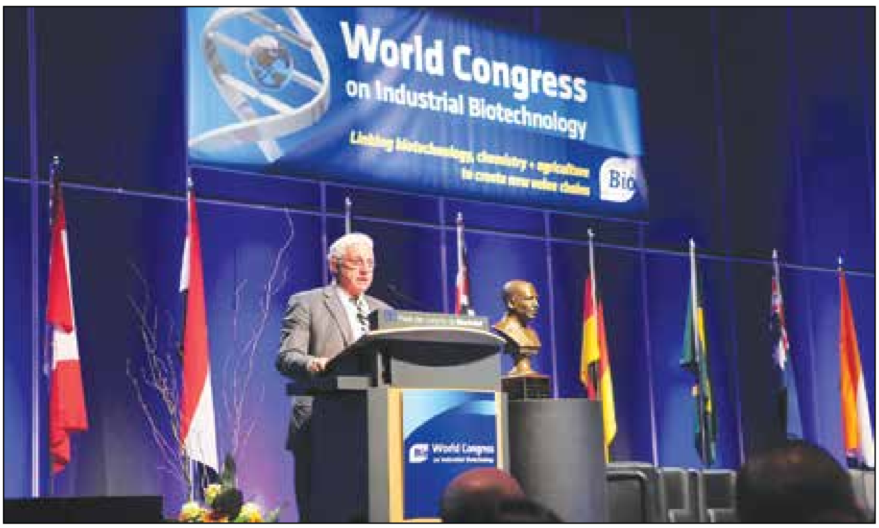
Challenging times for the bio-based chemical industry

The business of Industrial Biotechnology (IB) is at a critical moment in its history. Brilliant scientific discoveries are coming out of universities, research institutes and from industry, cutting across fuels, materials and chemicals, that promise to challenge the status quo. In the business of chemicals, IB offers not just novel routes to existing products, but ones based on renewable raw materials – sugars, starches, oil & fats and eventually cellulosic wastes & crops. Polymers produced by microbes promise biodegradability without compromising performance, and thus addressing a serious issue facing the petroleum-based plastics industry. Fuels like bio-ethanol can now be commercially produced from agricultural wastes and biomass, and promise to transform rural economies, even as they demonstrate favourable ecological footprint.

Several challenges

But the industry also faces several challenges, including from well-entrenched technology platforms and infrastructure, and from low oil prices. Challenges of scale-up of the several technologies being developed remain paramount, and not all approaches will succeed. The 'valley of death' between a great idea, demonstrated at a laboratory scale, validated at pilot plants and then taken to commercial scale, still remains a formidable obstacle that several companies will not cross. Government support for renewable biofuels is not as enthusiastic as it was in the era of high crude oil prices – although it has not disappeared – and this could not come at a worse time as the next-generation of plants using cellulosic wastes as raw material have just come online.

On a more positive note, the Conference of Parties (COP 21) meet in Paris in December this year, could be an inflexion point in tackling climate change and other related environmental concerns, and governments across the developed and developing world could push a sustainable growth agenda far more strongly than in the past. China, for example, has signed up for a climate change accord and its strategy will likely include a significantly enhanced portfolio of bio-based fuels and chemicals.



Mr. Brent Erickson

Bio-based products: Positive impacts on the economy

An economic impact analysis of the US bio-based product industry – the first federally sponsored economic report to examine and quantify the effect of the bio-based products industry from an economics and jobs perspectives – indicates several positive impacts.

In 2013, the bio-based industry contributed a total of $369-bn in value-addition to the US economy and 4-mn American jobs [direct (1.5-mn), indirect (1.1-mn) and induced (1.4-mn)].

Bio-based chemicals alone contributed $17.4-bn in value addition to the US economy and accounted for 133,000 jobs in 2013.

Bioplastic production in the US was approximately 0.3% of the total annual production of plastics, and the entire chemical sector was 4% bio-based. Estimates of the future penetration of the market vary – from as little as 6-10% for commodity chemicals, to 45-50% for speciality and fine chemicals.

Bio-based products also contributed positively to the environment – displacing about 300-mn gallons of petroleum per year, equivalent to taking 200,000 cars off the road.

'Future of energy and manufacturing'

According to Mr. Brent Erickson, Executive Vice-President, Industrial and Environmental Section, Biotechnology Industry Organisation (BIO), the IB economy is strong and growing stronger worldwide. "The work of the industry is the future of the energy and the manufacturing sectors," he said while speaking at a Plenary Session of the 12th Annual World Congress on Industrial Biotechnology organised by BIO in Montreal (Canada) from July 19-22, 2015.

Some numbers justify the optimism: nearly 100-mn gallons of cellulosic ethanol capacity is coming into commercial production, and the demand for bio-based polymers, estimated at 5.1-mt now, is expected to triple in five years. By 2021, the market for bio-based chemicals will increase by $12-bn.

Importantly, according to Mr. Erickson, "large brand owners understand the value and benefits of partnering and investing with the bio-world."

'Follow the technology'

According to Mr. Jonathan Wolfson, CEO, Solazyme, the world needs what the IB industry is now doing. "We will need to clothe, feed and fuel 9-bn people in a far more sustainable manner than now," he observed while speaking after receiving the 'George Washington Carver Award for Innovation in Industrial Biotechnology.'

He urged the industry to be prepared for the long haul. "Forget instant or even medium term gratification," he warned.

Solazyme, which leverages the power of micro-algae to make tailored oils, is selling to some of the largest companies in the world across markets – food & personal care ingredients, cosmetics, high performance oilfield chemicals, etc. But the company did not set out to develop such a broad portfolio, and was initially focussed on renewable fuels. The reason for the rethink? Cheap oil. "While fuel remains an important goal, feeding people with a heart healthy oil is just as important. There are a lot of ways to create value and following the technology is an important way to do so," Mr. Wolfson added.

APPROACH TO MARKET

Bio-based producers stress performance, not just 'green' tag

The petroleum-based chemicals industry is capital-intensive, but mature and efficient. The bio-based chemicals industry, in contrast, is still in the early stages of development, and while less capital-intensive, has, with few exceptions, some way to go as far as process efficiency is concerned. While the latter can attach a 'green' tag to many products, this is at best a conversation starter with customers and needs to be supplemented with a performance advantage.

Several companies are eyeing opportunities in this space by deploying biological and/or chemical technologies.

Metabolix: Commercialising novel bio-based products

Metabolix (Cambridge, MA, USA) leverages biological fermentation processes using renewable and sustainable agricultural feedstocks to produce polyhydroxyalkanoates (PHAs). PHAs occur naturally in a variety of organisms, but genetic engineering tools can tailor their production in cells. They represent the best candidates for broad replacement of petroleum-based plastics due to their durability in use and wide spectrum of properties – from strong, mouldable thermoplastics to highly elastic materials, to soft, sticky compositions. In addition, PHAs are biodegradable in aquatic environments and soil, and can be composted.

Metabolix has however shifted focus from market opportunities served by commodity polyolefins to unique, differentiated PHA co-polymers with controlled polymer structures and morphologies. New amorphous grades can be used as performance modifiers with other thermoplastics such as polyvinyl chloride and polylactic acid, for example to enhance recycling.

Metabolix has also developed a proprietary and cost-effective direct route for producing renewable gamma-butyrolactone, which can be converted cost-effectively to 1,4-butanediol via a standard catalytic process. A fermentation process for bio-based acrylic acid has also been demonstrated on a small scale and is claimed to be price competitive.

Green & cost effective

Itaconix Corporation (Stratham, NH, USA) is developing polymers derived from itaconic acid for industrial and consumer applications, but also emphasises high performance of the speciality ingredients as much as its green credentials.

With two functional acid groups and a vinyl bond, itaconic acid is a versatile monomer produced by fermentation of carbohydrates such as corn by using *Aspergillus terreus*. Polymers from

itaconic acid are 100% sustainable, as all of the carbon comes from renewable resources.

Itaxonix is developing a suite of products using this polymer including:

- *DSP 2K*, an excellent water conditioner for binding calcium, magnesium and other polycationic ions. This is targeted for use in detergents, industrial processes, water conditioning etc. According to Mr. John Shaw, CEO, Itaconix, the product is seeing broad acceptance, primarily in detergents.
- *Velasoft* improves foam stability and quality, enhances viscosity, and provides skin conditioning in liquid & emulsion products for personal & home care (liquid & bar soaps, body washes, shampoos, skin products, hand dish detergents, and home & bathroom cleaners). The first products using this ingredient will likely enter the US market early next year.
- *Zinador,* a low cost polymer for odour removal, which is 100% bio-based and biodegradable.

Value often in niches

According to Mr. Rick Hanson, Croda, the value of bio-based ingredients is often in niches.

Croda, for example, offers *O.D.A. White* (INCI name: Octadecenediodic acid), a skin-brightening ingredient that acts by reducing melanin synthesis. The ingredient, which was first made by a chemical route, is now produced by bio-fermentation of vegetable oleic acid. Likewise, *Resistem*, an anti-ageing 'bodyguard' of the skin, is based on plant stem cells.

Outside of the personal care industry, the *Perfad* range of friction modifiers are highly specialised esters – 99% bio-based – that yield industry leading friction modification in engines, thus improving fuel economy. For the plastics processing industry, a new anti-slip additive for polypropylene, based on isostearic acid, with improved oxidative stability compared to the oleamides and erucamides currently used, was launched last year under the tradename *Incroslip SL*. "But they will take 2-3 years to see commercial applications, indicative of the challenges when introducing a new functional ingredient especially for industrial applications," Mr. Hanson observed.

To ensure consistent supply of ethylene oxide (EO), a key raw material for surfactants, Croda is building captive capacity based on bio-ethanol as raw material. Rail movement of hazardous EO – produced mostly through the petrochemical route – is increasingly being restricted, forcing customers to either relocate adjacent to EO capacity, or develop non-EO based surfactants (a difficult proposition). Construction on the $170-mn EO plant in Atlas Point (Delaware, USA), which will use 10-14 mn gallons of ethanol annually, has begun and start-up is expected in 2017.

Market driven

The market for bio-based ingredients and raw materials is also getting up a leg-up from the product launches of some discerning consumer goods companies that are eyeing premium, niche markets for 'green' products. One such company is Seventh Generation (Burlington, VT, USA), which offers home care products (laundry detergents, dish & hand soaps, all-purpose cleaners etc.), besides diapers and wipes, all designed with human health and the environment in mind. Products like laundry detergents, for example, are designed to work better in cold water, and are free of fragrance, dyes, etc. Despite no mandate to list ingredients on the labels of home care products, the company does so voluntarily in a bid for greater transparency.

The products on offer from Seventh Generation have high bio-based content – up to 97% – although technical challenges limit this in some product categories. For example, automatic dishwashing powders still need EO-PO copolymers, to prevent spotting on washed dishes, and no non-petroleum based substitutes have yet emerged. "We need EO-PO with bio-based content above 20%, as well as bio-based preservatives, chelating agents and bleach activators," noted Ms. Chantel Bergeron, Manager of Research & Development, Personal & Home Care Products, Seventh Generation. Bio-based packaging – particularly flexible packaging for wipes – has also been challenging, but the company will shortly be reaching a 20% bio-fraction in this product category.

The company is also driving change down its supply chain. It is working with Rhodia, for example, to develop a 100% bio-based lauryl alcohol-EO condensate. By 2016, manufacturers of ingredients and finished products are being prodded to use renewable energy, while distributors will be asked to use biofuels in their transport fleet.

SYNTHETIC BIOLOGY

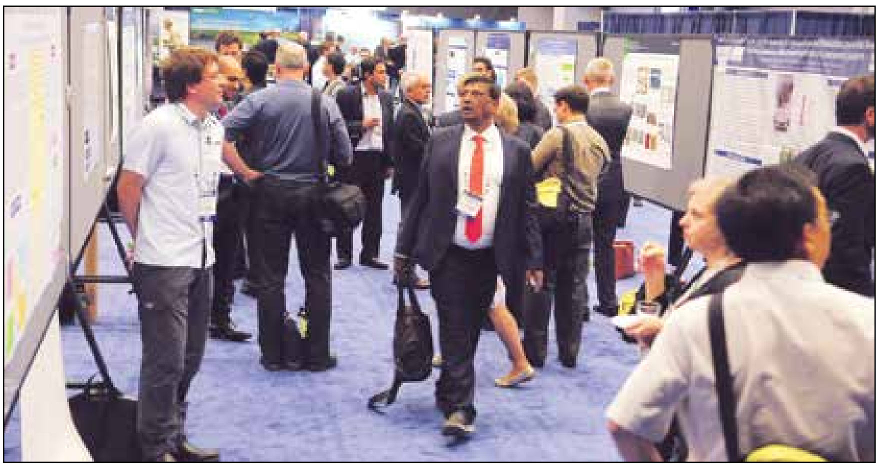
Coaxing bacteria, yeast & algae to synthesise chemicals and polymers

Several companies are coaxing bacteria, yeast, plant cells or microalgae, to take one of many carbon sources to synthesise chemicals and polymers. The most commonly used feedstock now is sugar, though it is not the only. The chemicals that can be produced – at least in the lab, if not at scale – range from commodities to specialties and some success stories have emerged.

Speciality surfactants from bacteria

Massachusetts-based biotech company, Modular Genetics, Inc., has engineered *Bacillus subtilis* strains to convert cellulosic sugar into a surfactant consisting of a fatty acid linked to an amino acid.

According to Dr. Kevin Jarrell, CEO, Modular Genetics, conventional surfactants suffer from problems of sustainability of raw materials, intensive manufacturing, contamination by harmful products and even carcinogenicity. In contrast, fermentative processes make biodegradable surfactants from a sustainable raw material – cellulosic sugars – with no potential for contamination with carcinogens.



While the technology enables custom design and synthesis of a virtually limitless array of surfactants by specifically linking nearly any fatty acid to nearly any amino acid, the current focus is on fatty acids linked to glutamic acid. The lead product is acyl glutamate, initially targeted to the personal care market. These superior products, at a comparable price, have favourable production economics and have been tested in target markets for personal care. They have excellent foaming without need for secondary surfactants, are clear in solution, odour-free, three times more water soluble and have a 10-fold lower critical micelle concentration (CMC).

These surfactants have already found markets in some well-known brands and are seen by companies such as Unilever, Proctor & Gamble and Henkel as a significant advance in meeting their sustainability goals.

Tailoring yeast to make natural ingredients

Evolva, headquartered in Basel (Switzerland), is engineering yeast to give it the ability to make ingredients normally found elsewhere in nature, but by using production methods that would be recognisable to any brewer. According to Mr. Stephen Herrera, Vice-President, Strategy & Public Affairs, Evolva, hundreds of natural ingredients have supply chain or sustainability issues, and could be targets for production by leveraging synthetic biology. "Affordable products with dependable supply will allow greater traditional use and expand the markets significantly," he added.

The company is currently focussed on a handful of products including:

- Vanillin, a flavour, 98% of which comes from synthetic chemistry, and the balance from vanilla pods;
- Resveratrol, sourced primarily from knotweed roots (from China) with issues of quality and supply;
- Nootkatone, used in the fragrance & flavour industries (aroma of grapefruits), but also known to kill insects like ticks, mosquitoes, bed bugs etc.
- Rauboside, the best tasting molecule present in stevia, a plant-derived sweetener; and
- Saffron, the world's most expensive spice, with 95% of world production in Iran and a lot of adulterated product on the market.

Diacids using yeast

Verdezyne (Carlsbad, CA, USA), which has investments by DSM, BP and Sime Darby, besides venture capital investors, is also using engineered yeasts to metabolize multiple non-food-based renewable feedstocks to produce a number of widely used, high value chemicals.

The first products being developed are diacids, including dodecanedioic acid (DDDA), sebacic acid and adipic acid. DDDA, which is currently produced from butadiene and alkanes, is used for making thermoplastic polyurethanes that find use as foams, paints, etc.

According to Mr. Matt Engler, Director, Corporate Strategy & Business Development, Verdezyne, the current DDDA market of about 40-ktpa, is seeing 8% growth, while the sebacic acid market of about 70-ktpa is largely met by castor oil based production in China.

The process has been validated at MBI International, a technology development institute, and tens of tonnes have been produced via a toll manufacturing arrangement. The plan is to break ground on the first plant this year in BioXcell in Johor (Southern Malaysia). Full financing for the commercial plant has been secured.

Engineering microbes

Amyris (Emeryville, CA, USA) has developed innovative microbial engineering and screening technologies that modify the way microorganisms process sugars into renewable molecules for multiple applications.

The first product leveraging this technology was artemisinic acid, a precursor of artemisinin, a highly effective anti-malarial therapeutic that suffered from all kinds of supply chain issues. In 2008, Amyris made available these yeast strains to Sanofi on a royalty-free basis, and the latter is now using this technology at large-scale to produce artemisinin and distributing the drug on a "no profit, no loss" principle.

Amyris' business strategy is also focused on the production of *Biofene*, its brand of renewable farnesene, a long-chain (C15) branched hydrocarbon. Building on the expertise from farnesene production, Amyris is developing, and in some cases producing, a range of other molecules including squalane (by dimerization), farnesane (by full hydrogenation) and myralene (by partial hydrogenation). These serve as platforms for a portfolio of renewable specialty chemicals and fuels, ranging from cosmetic emollients & fragrances, to fuels & lubricants and even biopharmaceuticals. Squalane, for example, is used as an emollient, but is traditionally sourced from sharks or from olives. Amyris is currently supplying the ingredient to more than 100-mn final consumers through ~400 brands.

Amyris' diesel is a low sulphur fuel that has a 70% lower carbon footprint compared to the petroleum-derived counterpart.

"Each product benefits from knowledge gained in previous cycles. Efficiencies are rapidly improving," noted Mr. Darren Platt, Vice-President, Amyris.

Retrofitting ethanol plants

Green Biologics Ltd. (Oxon, UK) has developed a *Clostridium* fermentation platform to convert a wide range of sustainable feedstocks to produce renewable n-butanol and acetone. In December 2014, Green Biologics Inc., a wholly owned U.S. subsidiary of Green Biologics Ltd., acquired the assets of Central MN Ethanol Cooperative LLC (CMEC), which includes a 21 million gallon per year ethanol plant, to produce renewable n-butanol and acetone.

The company's technology has also been retrofitted in two facilities in China since 2012.

Engineered cyanobacteria

Photanol (Amsterdam, The Netherlands) is using engineered cyanobacteria that turn carbon dioxide directly and efficiently into predetermined products, such as acetic acid and butanol, when exposed to light. By genetically introducing properties of fermentative bacteria into these cyanobacteria, Photanol's technology enables these bacteria to produce and excrete valuable compounds.

According to Mr. Dirk den Ouden, Director of Corporate & Business Development, Photanol, cyanobacteria are more prone to genetic modification, making them amenable to produce a wider breadth of products compared to microalgae which are mainly grown for their biomass.

The company, which has a partnership with AkzoNobel, is currently in pilot production (swimming pool size closed bio-reactors) and by 2017 expects to be in the demonstration scale (size of a soccer field) and eventually commercial production by 2020.

PLATFORM CHEMICALS

Succinic & levulinic acids make it to the markets; others could follow

Successful commercialisation of bio-based chemicals and materials are still few and far between, although several initiatives are still in the early stages of development – either in the laboratories where the ideas were nurtured, or in the pilot plants for technology validation. Two important products – deemed platform chemicals, due their ability to spawn a broader derivatives industry – are levulinic acid (LA) and succinic acid (SA).

World's first plant for LA from biomass

In July 2015, GF Biochemicals became the first company to produce LA from biomass at a commercial scale. The biomass is converted by thermo-chemical methods to produce LA, with char (from lignin) available as by-product for energy production.

The technology has been proven on a large scale at a plant in Caserta (Italy), and according to Mr. Marcek van Berkel, Chief Commercial Officer, GF Biochemicals, can reach lower prices than current methods of producing LA (from furfuryl alcohol). While the plant has a nameplate capacity of 10-ktpa, it will start producing at 2-ktpa, which will be scaled up to 4.5-ktpa next year and to nameplate in the following year.

LA is a versatile, keto acid that can be converted to several derivatives. These include diphenolic acid (DPA) – a potential replacement for bisphenol-A; Delta-aminolevulinic acid (DALA) – a suitable replacement for traditional herbicides and pesticides; LA esters – for use in flavours & fragrances and as addition to transportation fluids; gamma-valerolactone (GVL) – a solvent and monomer for polyesters; and methyltetrahydrofuran (MeTHF) – a 'green' solvent that can be used in environmentally benign strategies to replace blacklisted chlorinated solvents and THF.

Advancing SA technology

SA technology is even more established and a number of companies, including BASF, BioAmber, Myriant, Purac and Reverdia, are now producing SA via the fermentation of sugars. The availability of bio-based SA at commercial quantities is expected to expand markets for the platform chemical, and continuing technical efforts could see further improvements in efficiencies and the use of cellulosic biomass – instead of sugars – as feedstock.

MBI International, a technology development company working closely with Michigan State University, is developing a more efficient route for SA, using *A. succinogenes*, and has achieved much better yields, approaching 80% of the theoretical. It is also developing an integrated process starting from biomass. "Several companies are making SA, but none of these use cellulosic biomass as feedstock. Several potential consumers of SA derived products are very interested in non-food sugar technology," noted Dr. James Wynn, Director, MBI International.

Opening up markets for lactic acid

Plaxica Ltd., a technology licensing company founded in 2008 as a spin-out from Imperial College, London, is focussed on lactic acid as a low cost platform chemical. Its' *Versalac* technology produces lactic acid from a variety of bio-feedstocks, via a continuous chemi-

Dr. James Wynn

cal process with fast reaction time and in a closed loop. Unlike fermentation, the process is tolerant of many chemical impurities including lignin and other materials.

According to Mr. Philip Goodier, CEO, Plaxica, the technology addresses the key issues with many 'green' chemicals. "It uses chemical processes, low cost sugars, and chases high value, high volume markets. The raw material of choice is waste from the pulp industry and the focus is on hemicellulose, which is much easier to work with it. The technology can integrate with other peoples infrastructure."

While lactic acid producers have so far been focussed on polylactic acid (PLA) markets, Mr. Goodier observed that the monomer can be converted to several high volume chemicals including propylene glycol and acrylic acid – applications that have so far been limited by costs and by the acceptance of use of food grade sugars as chemical feedstock.

Plaxica has entered into a partnership with Invista Performance Technologies to develop and accelerate commercialisation of this technology. Under the deal, Invista will provide engineering, technical and commercial support to Plaxica.

Glucaric acid as platform chemical

Rennovia (Santa Clara, CA, USA) is using carbohydrates as feedstock source and chemical catalysts to produce drop-in products such as adipic acid (via glucaric acid) ($6-bn market), 1,6-hexanediol ($500-mn) and 1,6-hexamethylenediamine ($5-bn).

The company has an agreement with Johnson Matthey Davy Technologies Ltd. to develop, demonstrate and commercialize catalytic process technologies for the production of bio-based glucaric acid and adipic acid, and a strategic investor in Archer Daniels Midland Company, a leading producer of refined carbohydrates.

According to Mr. Tom Boussie, Co-founder & Vice-President for Corporate Development, Rennovia, Phase 1 of the pilot plant to produce glucaric acid has just started up at the Johnson Matthey Process Technologies R&D Center in Stockton (England), and the company hopes to soon have a full technology package available for licensing.

Cheap fatty acids

Earth Energy Renewables (Bryan, TX, USA) is developing a hybrid biological/chemical process to make cheap fatty acids from biodegradable raw materials. The biological step is the same process that occurs in the rumen of cattle, termite guts, or methanogenic anaerobic digesters where a mixed culture of naturally occurring microorganisms converts biomass into carboxylic acids (i.e., short- and medium-chain fatty acids such as acetic, propionic, butyric, valeric, caproic, heptanoic and octanoic acids). These carboxylic acids are recovered using patented and proprietary technologies, including liquid-liquid extraction, and can be chemically converted into other desired products. Short chain acids like acetic acid are recycled for chain extension. The non-sterile process is thermodynamically favoured, uses no GMOs or extraneous enzymes, and produces pure acids without need for extensive separations.

The feedstock flexible technology is being deployed currently in a demo plant at a scale of 100,000 gallons per annum, according to Mr. Cesar Granda, CTO, Earth Energy Renewables, and the next plan is to build a 8-tpd (tonnes per day) facility to serve the fragrance & flavour industry and eventually move on to a 30-tpd plant to cater to agricultural and industrial markets. "The technology can produce these acids at a price of less than $500 per tonne, compared to $2000 for traditional methods."

C4-C6 chemicals

Visolis (Cambridge, MA, USA) is focused on C4-C6 chemicals, which could be in short supply globally due to the shift to lighter feedstocks at ethylene crackers. The initial emphasis is on monomers (*Ecolate*) for making unsaturated polyester resins (UPR) – a $10-bn market opportunity, according to Dr. Deepak Dugar, President, Visolis, but the technology that uses microbes to convert sugars, can also be used for making commodity chemicals like methyl isopropyl ketone and isoprene.

The technology has been validated on a lab scale, and pilot studies – at 300-litres – are ongoing for process validation and for providing samples to potential customers.

Bio-based nylon

Cathay Industrial Biotech Ltd. (Shanghai, China) is producing long-chain diacids from paraffin through fermentation followed by purification, rather than the traditional multi-step chemical process and have also begun trial production of certain diacids from fatty acids, a renewable feedstock. The product range includes C11-16 diacids, in particular C12 dicarboxylic acid for which the company accounts for half of world demand; besides 1,5-pentamethylene diamine produced from 100% renewable carbon, to make bio-based nylon 56, marketed under the tradename, *Terryl*.

According to Mr. Paul Caswell, President, Cathay Industrial Biotech Ltd., *Terryl* dyes better, absorbs water at a molecular level, has a 15% lower weight than nylon 66 and inherent flame retardance. A 20-ktpa plant for the nylons is currently operational in China with the fibre being used for making military fabrics. "China is also looking to nylon polyester blends and that could open a new market," he added.

CHANGE OF PLANS

Oil at $50 forces rethink of plans and portfolios

With oil at $50, economics have turned unfavourable for several bio-chemical producers targeting the commodity end of the markets, and forced them to rethink plans and portfolios. A major oil & gas company, for example, has divested its cellulosic ethanol plant, while two others are focussing on optimising processes rather than ramping up volumes of advanced biofuels. One of the largest players focussed on algae has diversified its product line away from fuels to a broader portfolio spanning food & personal care ingredients, oilfield chemicals and nutraceuticals.

The industry is seeing a huge move to higher value molecules (e.g. adipic acid and p-xylene) to leverage higher margins on feedstock, while avoiding the challenges of intense market development needed for commodity functional replacements like PHAs or PLA.

According to Ms. Julia Allen, Research Analyst, Lux Research, as of late 2014, start-up companies with several years of work ahead of them have not let the drop in oil prices disrupt their investment and scale-up plans. "But if you are producing butanol or isobutanol, life is tough out there."

Horns of a dilemma

Mr. Joshua Velson, Senior Analyst, Nexant, a consultancy, observed that innovators in the bio-chemicals space face a dilemma: the most potentially profitable and exciting opportunities will be in more valuable, smaller volume chemicals; however, the commercial and technical feasibility of addressing these markets are unclear. Individually, many represent minor revenue sources, and especially for small companies, there is a significant opportunity cost associated with pursuing them. In addition, many opportunities are currently served by bio-based products made using traditional methods. "While the most valuable and most exciting opportunities are in the domain of speciality chemicals, the markets are less transparent, have significant barriers to entry, and product value may depend on macroscopic properties rather than molecular compositions," he observed.

While many companies started out in commodities, they are moving up the value chain. But there is no one formula that works. While some are leveraging their engineering and technical capabilities with a single platform to produce speciality chemicals, others are eyeing high value components priced at more than $5/lb or even addressing markets at a price point of $2/lb.

Finding the sweet spot

The challenge is to find a sweet spot – a white space that affords significant opportunities, but is unconstrained by cost pressures posed by competing products coming especially from the mature and well-entrenched petrochemical industry.

One such product could be enantiomerically pure L-tartaric acid, used as a flavour and acidulant. It is currently produced from wine grapes and output is cyclical, but a biotech route, via ascorbic acid, could potentially offer greater reliability of supply and at lower cost. According to Mr. Velson, this could be open up a $300-mn to $500-mn market opportunity, as the average price of $2/lb hides high price volatility and has significant upside potential. "This is truly white space, and no efforts are currently underway," he added.

Likewise, IB has the potential to offer a lower cost and consistently higher quality route to beeswax substitutes – composed of monoesters of long chain fatty acids (15-18) and alcohols. Efforts have been made by several companies (Croda, Elevance and Koster Keunen, to name a few) to develop beeswax substitutes, but they have not been able to match all properties or compositions. This represents an $80-mn to $90-mn addressable market, at a price of $1.5-5.0/lb, depending on colour and desired application.

According to Mr. Velson, IB can provide a functional substitute rather than a perfect substitute, but it really does not matter. "Imperfect substitutes can capture significant market share," he added.