IHS Markit®

ESG Research
26 March 2020
Issue 04

Contact
Kevin Bourne
Managing Director, Sustainable Finance
kevin.bourne1@ihsmarkit.com
Telephone +44 (0)20 315 93553

Authors
Marifaith Hackett
Research and Analysis Executive Director, Renewables & Nutrition, IHS Markit

Adam Bland
Executive Director - Solvents & Surfactants, IHS Markit

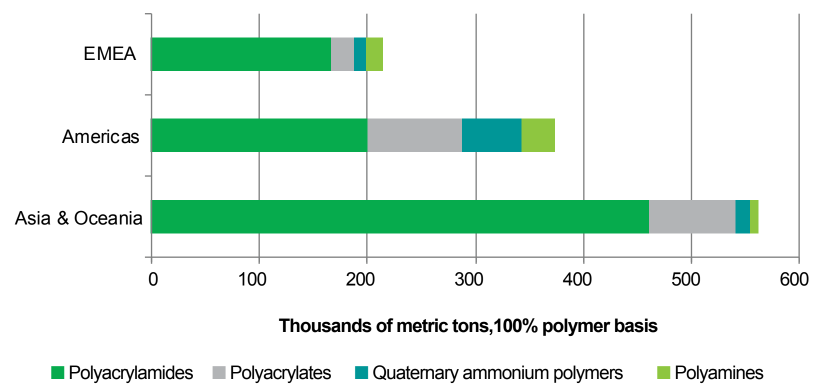
Climate and Sustainable Finance

Specialty chemicals: Enablers of sustainable development

We live in chemophobic times: The media and general public view chemicals as enemies of the environment. But this perspective is flawed because it overlooks the essential role of chemicals – particularly specialty chemicals – as enablers of sustainable development.

Produced responsibly - as the vast majority of chemicals are - specialty chemicals and polymers support key sustainable development goals, including clean water, clean energy, and the preservation of life below water. They enable society to satisfy its current needs without compromising the ability of future generations to meet their own requirements.

Chart 1: Consumption of water-soluble polymers in water treatment, 2018



Source: IHS Markit.
© 2019 IHS Markit

Clean Water

Clean water is the foundation of a healthy society. But clean water doesn't just happen. All water – even water from a pristine mountain reservoir – requires treat- ment before it is suitable for human consumption or industrial use. And water also requires treatment after use so it can be safely returned to the environment.

Specialty chemicals – and specialty polymers in particular – play important roles in a range of water treatment processes (see Figure 1). These processes include drinking water production, wastewater treatment, and industrial water treatment. Specialty polymers:

- Reduce turbidity and accelerate the settling of suspended particulates in the production of potable water
- Thicken and dewater sludge in wastewater treatment
- Inhibit the formation of scale (mineral deposits) in boilers and cooling towers

Worldwide consumption of specialty polymers in water treatment exceeds one million metric (mm) tons per year. Polyacrylamide, the largest volume water-soluble polymer used in water treatment, plays important roles in drinking water production and wastewater treatment. Polyacrylate, the second largest volume polymer, prevents scale formation in industrial equipment. Quaternary ammonium polymers and polyamines are used primarily in the production of potable water.

Clean Energy

Wind is crucial to today's global energy market, and its importance as source of clean, renewable energy continues to grow. In 2010, wind made up less than 4% of global power capacity. In 2018, wind accounted for more than 8%.

The turbines that transform wind into clean electricity depend on specialty materials. Each wind turbine incorporates 25 to 100 metric tons of specialty resins and reinforcements. Unsaturated polyester resins, epoxy resins, glass fiber, and carbon fiber are standard construction materials for wind turbine blades.

Size matters in wind energy. Turbine height, blade length, and power output are increasing, and so is the amount of resin and reinforcements required to produce a wind turbine. The largest turbine blades in commercial production are more than 88 meters long (about the length of a football field) and require more than 100 metric tons of resins and reinforcements.

Economics is driving this trend. Larger wind turbines are more efficient, resulting in lower power generation costs. Energy from a modern wind farm with large turbines is cost-competitive with energy from conventional sources such as coal and natural gas.

Preserving Life Below Water

Nutrient pollution is the enemy of underwater life. Surplus nutrients, typically nitrogen or phosphorus, lead to algae blooms in lakes, rivers, and coastal waters. Excessive algae growth creates dead zones – depleting oxygen and blocking sunlight from underwater plants – making life below water untenable. Some algae blooms also produce toxins that are harmful to humans.

Excess nutrients can come from many sources, including laundry detergents. Traditionally, laundry detergents included phosphate "builders" for improved performance, especially in hard water. Phosphate builders are inexpensive and effective, but they also serve as nutrients. In contrast, specialty chemical builders – zeolites, citric acid, and polyacrylates – enhance detergent performance without causing algae growth. These specialty chemicals do everything that builders are supposed to do – soften water (by sequestering calcium and magnesium ions), disperse dirt, and prevent soil redeposition – without nourishing algae blooms.

Global consumption of zeolites, citric acid, and polyacrylates in laundry detergents is about two mm tons per year. Developing markets are driving demand growth for these specialty builders. In contrast, demand for specialty builders in the mature markets of North America, Western Europe, and Japan is expected to be flat, in part because these regions

are moving on to new and greener formulations. Increasingly, mature markets are turning to liquid and unit-dose formats instead of powder laundry detergents. The new formats rely on greener builders, such as sodium gluconate and the sodium salt of glutamic acid, N,N-diacetic acid (GLDA). These chelating agents are both biodegradable and bio-based, as their raw materials include glucose and glutamic acid, respectively.

Looking Ahead: Opportunities for Green Innovation

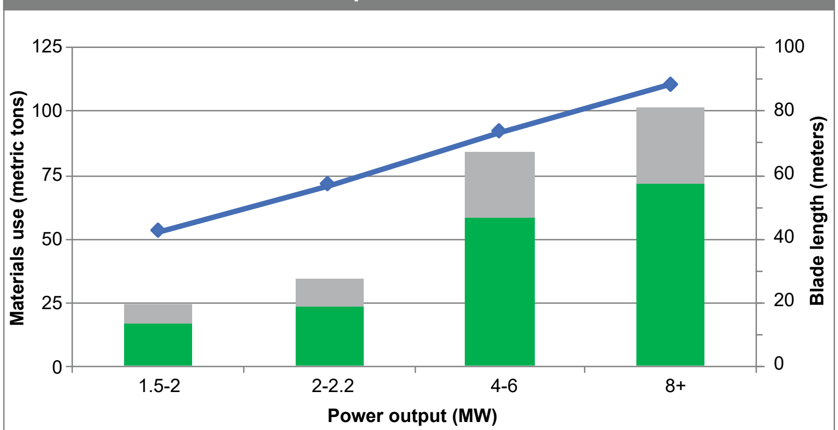
Specialty chemicals may play an even larger role in sustainable development in the future. Opportunities for green innovation are substantial. Specialty chemicals are sold on the basis of performance or function, not chemical composition. Consequently, price is important but not imperative. In addition, specialty chemicals are closer to the consumer than commodity chemicals. Products that include "green" specialty chemicals can tap into consumer interest in the environment and bio-based ingredients.

Paths to greener specialty chemicals include the use of:

- Sustainably produced renewable feedstocks. In general, bio-based materials have smaller carbon footprints (cradle-to-factory-gate greenhouse gas emissions) than their petrochemical counterparts. But there is a caveat: Feedstock provenance matters. Land use changes can have a major negative impact on carbon footprint. Specifically, the drainage and deforestation of peatland to make way for oil palm plantations increases the environmental burden of palm oil, palm kernel oil, and their methyl ester derivatives. Because of land use change, these materials have large positive carbon footprints. In contrast, coconut oil and coconut methyl ester have negative carbon footprints – that is, their produc- tion removes carbon dioxide from the environment.

- Biocatalysts and biotechnology. Biotechnology offers a sustainable route to value-added products. A case in point is stevia sweeteners.

Chart 2: Blade materials use per wind turbine



Notes: Combined materials use for all three blades of the wind turbine.
Source: IHS Markit.
© 2019 IHS Markit

First-generation stevia sweeteners are extracted from the leaves of the stevia plant. The extracts contain many components but only traces of the best tasting sweeteners. Next-generation stevia sweeteners (such as Reb M and Reb D) are produced from corn or sugarcane by yeast fermentation. Reb M and Reb D are intensely sweet with zero calories and no aftertaste. They show great promise as sugar replacements in soft drinks and other beverages.

- Waste materials as feedstocks. Using waste materials as feedstocks supports the circular economy by recycling "waste" into useful products. Examples of specialty chemicals that can be produced from waste materials include polyols from waste gas (such as flue gas from steel mills and off gases from refineries); furfural from biomass (such as corn stover, corn cobs, and sugarcane bagasse); and polyhydroxyalkanoates – biodegradable polymers – from biogas (through anaerobic digestion).
- Sustainable development matters. To paraphrase Moses Henry Cass: We have not inherited this planet from our parents – we have borrowed it from our children. Specialty chemicals can help us preserve this world for future generations.

Assessing the sustainability and performance of green surfactants

As sustainability targets have become integral to corporate strategies and consumers take a greater interest in the impact of formulations on themselves and the environment, we're often asked about the market for green surfactants. The answer is usually "it depends," based on your understanding of the term "green." The concept of green chemistry encapsulates various elements of natural, bio-based, renewable, bio-degradable, and sustainable concepts, both in terms of raw materials and production processes.

Surfactants are an important class of chemicals with applications in household detergents and cleaners, personal care and cosmetics, industrial and institutional cleaning, and an array of industrial processes. The 2019 global market for surfactants, worth an estimated $39 billion, is expected to grow at 2.6% per annum over the next five years to reach $46 billion by 2024. The industry produces over 17 million metric tons of surfactants annually, some of which comes into personal contact with consumers and much of which is ultimately discharged as effluent. Considering this volume, addressing green issues is an important topic for an industry facing increasing legislation and consumer concern.

A vast array of surfactants is available, produced from natural and petroleum-based feedstocks and combinations of both. In this highly competitive market, price and efficacy remain key drivers. Therefore, renewable feedstocks and process economics must compete with petroleum feedstocks that often serve multiple markets beyond surfactant production. Fatty alcohols and acids derived from natural fats and oils – such as soya, palm and palm kernel, rapeseed, sunflower, tallow, and coconut oils – are a major source of feedstocks for the manufacture of surfactants. They also form the cornerstone of the green contribution to the industry.

How Green is Green Enough?

There is much concern regarding the sourcing of natural oils, especially tropical oils. While producers have joined organizations such as the Roundtable on Sustainable Palm Oil (RSPO), there remains considera-

ble debate on the true cradle-to-gate impact of land use for renewable chemical feedstocks. Interestingly, Clariant launched its GlucoPure Sense surfactant in 2017 that uses European sunflower oil rather than tropical-sourced oils. BASF has also commercialized amphoteric betaine surfactants that use microalgae oils derived from fermentation of sugar instead of coconut oil-derived cocamidopropyl betaines for use in hair care formulations.

In 2019, detergent alcohols using bio-based renewable feedstock accounted for 80% of the 3 million metric tons produced. Synthetic alcohols, produced predominantly from ethylene but also from n-paraffins and coal-based Fischer Tropsch processes, still provide cost-effective alternatives to natural feedstocks, especially in regions where ethylene feedstocks are economical, such as the United States. Companies are still investing in synthetic alcohol capacity. For example, Sasol will start up a 160 kilo tons per annum (kta) total capacity facility for Ziegler, alumina, and Guerbet alcohols by early 2021. Recent expansions of linear alpha olefin capacity in the United States and planned expansions in the United States (ExxonMobil) and Saudi Arabia (INEOS) will seek value from the full range of C4-C20+ olefins produced, including the C12-C18 mid-cuts used for detergent alcohol production.

So, does this mean all renewable-based surfactants are green? Most applications require further processing of biobased feedstocks to include moieties that provide the functional properties of the surfactant, resulting in a range of anionic, cationic, nonionic and amphoteric products. Most of these processes involve the incorporation of petroleum-based feedstocks or moieties that would not necessarily be considered green. To help assess individual green qualities, the European Commission of Standardization has devised classifications for biosurfactants, including >95% wholly biobased; 50-94% majority biobased; 5-49% minority biobased; and <5% nonbiobased.

Consumer Demand Drives Change

Anionic and non-ionic surfactants together account for 88% of total global surfactant consumption. Nonionic surfactants are dominated by alcohol ethoxylates (AE), which are used across the spectrum of household, personal care, institutional, and industrial applica- tions. Sorbitan esters, such as sorbitan monostearate, are produced from fatty acids and sorbitol. They represent an important class of non-ionic surfactants derived from renewable feedstocks that are typically used in food and cosmetic applications for their emulsifying properties. Anionic surfactants are dominated by petroleum-based linear alkyl benzene sulfonates, but they also include major products such as alcohol sulfates (AS) and alcohol ether sulfates (AES). AS and AES are produced by sulfation of the corresponding alcohol or its ethoxylate with sulfur trioxide or chlorosulfonic acid followed by neutraliza- tion. A fatty alcohol sulfate consequently may have a renewable carbon index of 100% but may not be considered by consumers to be particularly natural or green. Alcohol ether sulfates are predominantly used in personal care and household dishwashing liquids, where the ethoxylation is milder than the alcohol sulfates that are known to irritate skin. Despite this, consumers are increasingly looking to formulations that are completely sulfate-free.

Cationic surfactants such as fatty amines and quaternary compounds are largely used in fabric softeners, while mild amphoteric surfactants such as cocoamidopropyl betaines are mainly used in personal care products. Together they only contribute 12% of the total surfactant consumption by volume.

AE and AES are produced by reacting alcohols, most commonly in the C12-C16 range, with ethylene oxide (EO). They provide products with a wide range of molar ratios of EO to detergent alcohol. Obtaining a 100% renewable carbon index for AE and AES requires the EO moiety to be derived from bio-ethylene oxide, which in turn is derived from bioethanol that is usually produced from sugar cane, via bioethylene.

Numerous bio EO plants exist, although they represent less than 2% of the total EO global production. The largest plants have traditionally focused primarily on the manufacture of bio ethylene glycol. In 2017, Croda International commissioned the first bioethylene oxide unit in North America at Atlas Point and began offering its so-called “ECO range” of ethoxylated surfactants. However, the company has not operated the bio-EO unit consistently since its commissioning. There are several bioethylene oxide plants in China of similar design and scale (30-75 kta EO) as the Croda unit. These plants were mostly built to eliminate long and expensive supply chains for EO, but they also can tout the benefit of offering bio-based products. It is important to note that bioethylene oxide has higher cash cost of production than petrochemical-based processes, due to smaller unit scale and generally higher-cost raw material, bio-ethanol.

High Demand, Low Availability

Personal care applications represent 14% of the total volume consumption of surfactants but will experi- ence higher than average global growth rates of 3.1% over the next five years. They also can offer greater opportunities for green surfactant solutions. Consum- ers are increasingly discerning regarding products that contact skin, such as shampoos, shower gels, soaps, cosmetics, hand dishwashing products, and household cleaners. Personal care applications also offer greater opportunities for producers to meet consumer demands for more natural ingredients.

The use of glucose moieties in combination with fatty alcohols offers a range of surfactants that have found commercial success, particularly in the personal care and hand-dishwashing markets. Alkyl polygluco- sides (APGs) produced by companies such as BASF, Nouryon, and SEPPIC and alkyl glucamides produced by companies such as Clariant have shown tremen- dous growth over the last five years. Their natural appeal, low toxicity, and effective surfactant proper- ties boosted growth rates above those seen for traditional surfactants. In November 2019, BASF announced expansion of its production capacity for APG at Jinshan, China. Further expansions are planned to meet growing domestic demand and relieve pressure on its facility in Germany. Total global consumption of APGs is now estimated at around 140kmt (100% active).

Sugar feedstocks also provide the basis for a range of amino acid-based surfactants, such as disodium cocoyl glutamate. These anionic surfactants are used in cosmetic and personal care products where mild, natural, sulfate-free ingredients are increasingly valued by consumers. Ajinomoto, a major producer of amino acid-based surfactants, this year announced expansion of its Amisoft® glutamates capacity at a new plant in Brazil, to be commissioned in 2020.

Green surfactants offer an important, growing contribution to the industry – although the size of the contribution can vary depending on perceptions what is natural, bio-based, and sustainable. Furthermore, while many personal care and consumer goods companies have expressed interest in 100% bio-based surfactants, the market has not so far tested consumers’ willingness to pay premium prices for otherwise commodity products. This is due to lack of widespread availability of green commodity surfactants to date as much as any other consideration. It is clear that global demand for both petroleum- and bio-based surfactants will continue to grow with increasing hybridization of formulations to meet consumer, legislative, and sustainability demands – all while challenging manufacturers to balance cost-effective formulations with the ability to perform effectively.

IHS Markit Customer Care

CustomerCare@ihsmarkit.com
Americas: +1 800 IHS CARE (+1 800 447 2273)
Europe, Middle East, and Africa: +44 (0) 1344 328 300
Asia and the Pacific Rim: +604 291 3600

483900723-0320-PB-IIC-ESG Research Note 4