Feature

Biofpr Biofuels Bioproducts & Biorefining

How will the changing biofuels market affect the development of bio-based chemicals?

The growth of the global market for biofuels has had a profound impact on the development of bio-based chemicals. Not only has the growth of biofuels helped to create new markets for bio-based chemicals, it has also led to new opportunities for co-development and helped drive down costs by commercializing new technologies. **Matthew Aylott** and **Adrian Higson** from NNFCC consider how the market for biofuels is changing and what the implications might be for the future development of bio-based chemicals.

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The biofuels industry was worth around $83 billion in 2011,[1] this was a 47% increase from the previous year, but these figures reflect the rising cost of fuel and hide the fact that growth in biofuels production has stalled. In fact, between 2010 and 2011 global biofuels production rose by just 0.7 billion (US) gallons, from 27.2 billion gallons to 27.9 billion gallons.

This was in part due to poor harvests and poor margins in Brazil and the USA, which saw sugarcane and maize being diverted from biofuels production to feed or food markets. The US also phased out a tax credit for blending biofuels, which was worth around $6 billion to US biofuels producers in 2011.

Production in Europe – a key biofuels market – was also below expectations, as a result of delays in implementing higher fuel blends as well as higher than anticipated food prices. To offset the slow growth in 'developed' markets, many biofuels producers have looked to sell into developing markets like China and India, but even these countries have scaled back plans because of concerns over increasing food prices.

However, many countries have binding targets to decarbonize their transport network. While the infrastructure and costs of electrification remain prohibitive for road transport and there are markets like aviation where electrification is not possible, biofuels are likely to play a crucial role in reaching these targets. The OECD-FAO calculate that biofuels production will nearly double between now and 2020, to reach around 52 billion gallons.[2] The way we produce these fuels, however, is changing.

In Europe there is increasing pressure on biofuel supply chains to ensure they are sustainable and deliver greenhouse gas savings without causing negative land-use change. This is resulting in a shift away from making fuels from food crops toward making advanced biofuels from wastes, agricultural residues, and algae that do not create additional demand for land.

Likewise in the USA there is considerable support for the development of advanced biofuels. Policies like the Renewable Fuel Standard, California's Low Carbon Fuel Standard, as well as federal funding programs and tax breaks are driving the growth of the advanced biofuels sector, which in the USA alone is predicted to grow from a production capacity of 0.4 billion gallons in 2011 to between 1.6 and 2.6 billion gallons by 2015.[3]

New feedstocks

With key markets, like Europe and the USA, moving away from crop-based fuels, there is likely to be less competition

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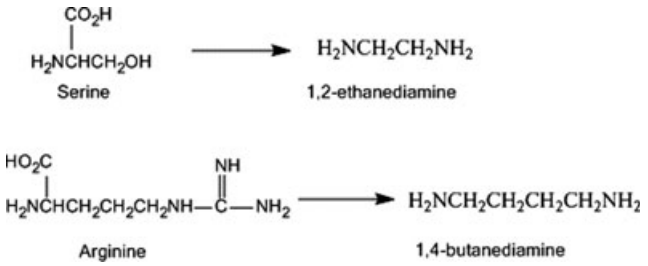

Figure 1. Bio-based chemicals made from amino acids (adapted from Sanders *et al.*[4]).

for food crops in the future and this could benefit the bio-based chemicals industry by bringing down feedstock costs.

However, the costs of traditional bio-based chemical feedstocks, like sugarcane and maize, will remain sensitive to rising food and oil prices. Furthermore, chemical companies and the brands that use those chemicals are increasingly being judged on the sustainability of the products they produce. As a result, we are likely to see greater production of bio-based chemicals from non-food feedstocks in the future.

But using more lignocellulosic materials and fewer food crops to make fuel will have an impact on the entire bio-based supply chain. For example, current production of first-generation biofuels produces a protein rich co-product which is used in food and feed markets, while processes are also being developed to split protein to make amino acids for the chemicals industry (Fig. 1).

In contrast, lignocellulosic feedstocks do not contain high levels of protein but instead they produce lignin as a co-product – which can be used in low value markets like heat and power production and could in future be used to make aromatic compounds.

New markets

Advanced technologies are only just beginning to be commercialized and in the meantime we are facing stagnation in the market for biofuels from existing feedstocks. This is already having an impact on the market for bio-based chemicals.

As growth in first-generation biofuels stalls and markets become saturated, prices are likely to fall and biofuel producers will have to look at alternative end-uses for their products. A number of companies have changed their focus from producing fuels to high-value chemicals.

In February 2012, leading biotechnology company Amyris took the decision to concentrate its business efforts on higher-value chemical products, such as cosmetics, polymers, and flavorings rather than lower-value biofuels. Amyris has not left biofuels altogether but its future development of renewable fuels will be through risk-offsetting partnerships with companies like Total and Cosan, with whom they have existing joint ventures.

Amyris are not the only company to switch to high-value chemicals, others like Gevo and LS9 are targeting high-value chemical markets and evidence suggests that in the near-term this is a more financially viable model. These companies could eventually return to biofuel production but this is unlikely to happen unless the bio-based chemicals market becomes saturated and there is little immediate evidence of this.

The global bio-based chemical and polymer market was worth an estimated $3.6 billion in 2011[5] and key markets like bioplastics are showing annual growth rates in excess of 10%. By 2021, the market for bio-based chemicals and polymers is predicted to more than triple in value to around $12.2 billion.[5] This growth has largely been made possible thanks to biofuels and many bio-based chemicals in production today owe their existence to first generation biofuels (Fig. 2). In Brazil, a successful polyethylene-based chemicals industry has grown around the production of fuel ethanol, benefiting from existing logistical infrastructure as well as decades of research funding into sugarcane cultivation and processing for ethanol production.

Since 2007, the USA alone has allocated more than $1.1 billion in R&D programs to facilitate increased production of biofuels.[6] This funding has allowed US companies like Amyris to commercialize new technologies for the production of bio-based chemicals and even though US biofuels R&D investment has not always led to greater production of biofuels, it has ultimately created jobs and reduced US reliance on fuel imports – a key political objective.

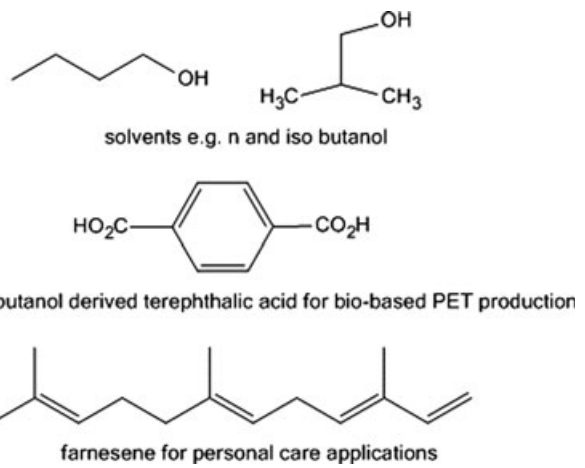

Figure 2. Examples of bio-based chemicals that have benefitted from biofuels investment.

New technologies

Investment in advanced biofuel technologies is likely to create new opportunities for the production of bio-based chemicals. For example, syngas produced from the gasification of waste is currently being used to make ethanol fuel by INEOS Bio. However, the technology can also be used to produce bio-based chemicals.

The concept of fermenting syngas to produce different chemical molecules is a relatively new process but in the future it could be used in more lucrative markets. Lanzatech and Invista are currently developing a technology based on fermenting syngas to make 1,3 butadiene, an intermediate in the manufacture of nylon 6,6.

There is also the potential to integrate processes for improved efficiency. Biorefineries are being developed that focus on the production of a large volume product to maximize economies of scale, with the co-products being used in niche markets to derive added value.

The biofuels market has sufficient scale to support a biorefinery but even with subsidies, margins remain small. The European project BIOREF-INTEG investigated the feasibility and economic impact of integrating chemical production with biofuel production in several biorefinery configurations[7] and found that co-production with chemicals could significantly reduce the costs of fuel production.

Conclusions

Over the next decade, biofuels will remain an important tool for decarbonizing the road transport network; they will also be vital in marine and aviation sectors, where electrification is not possible. The continued importance of biofuels and their transition from crop-based fuels to more advanced fuels made from non-food feedstocks will create new opportunities for synergies with bio-based chemicals production through technological development and greater integration of processes.

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