COVER STORY

FANTASTIC BIOPLASTIC

The growing use of bioplastics has huge implications for the waste industry. First, there is the potential to use organic wastes as a feedstock for their production, the second is their eventual disposal when they enter the waste stream themselves.

By Ben Messenger

COVER STORY

In many ways plastics are great. They've been one of the key materials enabling rapid technological and economic development since the Second World War. They have been engineered to fill ever more roles previously dominated by materials like metals and wood. They can be incredibly strong, supremely flexible and easily moulded – but they are not without their drawbacks.

Made from dwindling fossil fuel reserves, once they enter the environment as waste they often take many, many years to break down. The prospect of being able to create such materials from renewable feedstocks, and/or from feedstocks which are able to degrade at the end of their useful life, is a tantalising one.

It may therefore come as a surprise to many that bioplastics actually predate their fossil-based counterparts. In 1862 Alexander Parkes showed off the world's first manmade plastic, Parkesine, a bioplastic made from nitrocellulose. By the early 20th century, Henry Ford was exploring the possibility of using agricultural surpluses. The resulting bioplastics were used for components such as steering wheels and interior trim.

However, while bioplastics may have arrived first - it wasn't until 1907 that the first petroleum-based plastic was invented - today they represent just around 1% of the 300 million tonnes of plastics used globally each year. But in the not too distant future, that could be set to change.

According to the latest market data compiled by trade body European Bioplastics, global production capacity of bioplastics is predicted to quadruple in the medium-term, from some 1.7 million tonnes in 2014 to an estimated 7.8 million tonnes by 2019.

For the waste industry, one of the key applications is in compostable films. Globally the recognition of single-use plastic bags as an environmental hazard has grown dramatically over recent years. In many countries in Europe they have either been banned, or an arbitrary charge has been introduced for their use. In the US, California too is making a concerted effort to introduce a ban, albeit in the face of fierce resistance from lobbyists.

For many the solution is simple – make plastic bags from compostable plastics. Speaking with WMW, Christian Garaffa, waste management manager at Italian bioplastics manufacturer Novamont, explains that the benefits of doing so are many. Firstly it reduces the carbon footprint of manufacturing the bags in the first place. Secondly it improves the quality of compost and fertilisers produced from anaerobic digestion when those same bags are used to collect source separated food and organic waste.

MARVELLOUS MILAN

In Milan, a wet waste collection system has been implemented which uses compostable bags made of Novamont's compostable bioplastic, known as Mater-Bi. The material complies with European standard EN 13432, which describes a standard set of criteria for determining whether a material can be considered 'compostable'. All plastic bags used in the city are made from Mater-Bi and, having used them to carry their shopping home, residents then use those same bags to dispose of their food waste.

According to Garaffa, the system is working well, with over 98 kg of organic waste being collected for each of the city's inhabitants, and with a purity greater than 95%. Once collected there is no need to separate the waste from the bags in which it is contained, both can simply be digested or composted with no negative effect on the end product. The key, he says, has been a combination of technological developments in bioplastics and political will.

"The connections between these two developments over the years have set in motion a whole series of virtuous behaviour and collaboration initiatives between various stakeholders generating the ideal connective tissue to promote a change in the economic model centred around the efficient use of resources," says Garaffa.

With 2020 targets looming large on the horizon for European countries, better management of organic waste represents the last of the low hanging fruit. Making up the largest single fraction of MSW, up to 50%, the European Compost Network estimates that currently just 25% of organic municipal waste is collected and recycled.

Indeed, the recent draft report from MEP Simona Bonafè, Rapporteur for the European Parliament's Committee on the Environment, says that the "separate collection of biowaste from municipal waste should be made obligatory".

That's something which has been welcomed by François de Bie, Chairman of European Bioplastics, who says that it "sends the right signals to our industry and investors in the bioeconomy".

FILMED IN CHINA

It's not just bags where plastic films have found favour over recent decades. Both HDPE and LDPE are widely used in agriculture as a plastic mulch to improve water retention in soils and reduce the prevalence of weeds and pests. China alone consumes some 1.42 million tonnes of agriculture mulch films each year. With the wide application of ultra-thin plastic mulch films and the lack of technology and mechanisms for residue recycling,

"More than 200 pounds of synthetic polymers are consumed per person each year – plastics probably the most in terms of production volume. And most of these polymers are not biorenewable. The big drive now is to produce biorenewable and biodegradable polymers or plastics. That is, however, only one part of the solution, as biodegradable polymers are not necessarily recyclable in terms of feedstock recycling."

Dr Eugene Chen
Professor of Chemistry at CSU

It's founder Henry Ford was one of the early pioneers of using plastics in automobiles, now with its use escalating the company is returning to the renewable feedstocks of those pioneering early days.

FORD'S GIRL POWERED PLASTIC REVOLUTION

DEBBIE MIELEWSKI, FORD'S SENIOR TECHNICAL LEADER OF MATERIALS SUSTAINABILITY, JOINED THE COMPANY IN 1986 AND QUICKLY ROSE THROUGH THE RANKS. IN A MALE-DOMINATED INDUSTRY, SHE BUILT A LARGELY FEMALE TEAM.

In the late 1990s, and by then the technical leader of plastics research at Ford, Mielewski predicted a time when oil prices would soar, customers would feel the pinch, and Ford would need a solution. In her lab, she led the charge to reduce the amount of petroleum the company used to produce plastic parts.

"When I first started, there was 300 lbs (136 kg) of plastics in a typical vehicle, now there is over 400 lbs (181 kg)," explains Mielewski. "We originally started with soy because there's a huge excess in the US. Sometimes the farmers don't even harvest it they just plough it back in because there's no market for it."

Those first forays into renewable materials resulted in the development of a polythene foam which is now incorporated into every Ford vehicle built in North America.

"We then moved onto Ontario Canada," Mielewski tells WMW, "because it's too cold there to compost wheat straw. They harvest the wheat for the grain but the rest of the plant is generally burned. We thought that instead of burning it and releasing CO_2, why don't we use the fibre as a reinforcement for plastics."

The material developed from this project enabled Ford to have components manufactured in Ontario using materials produced from locally grown crop residues instead of shipping materials internationally. It was a win-win situation and prompted the company to begin thinking about what it could do in Mexico, where it also has manufacturing facilities. Realising that Jose Cuervo is the largest producer of tequila in the world, and that production of tequila creates a lot of waste by-products, Ford made the approach to form a partnership.

"As the world's population continues to swell and resources become scarce, my gut is telling me that providing sustainable options to petroleum-based plastics is heading in the right direction," concludes Mielewski. "We can make cars that are better for the planet and we can change the way the world moves."

the recycling rate of mulch films in China is less than two thirds.

However, according to German chemicals giant BASF, trials have shown that mulch films made from its biodegradable plastic ecovio® outperform conventional technologies, especially in demanding conditions. The company started the largest trial in the Xinjiang Urghur Autonomous Region with the local partners Xinjiang Production and Construction Corps.

Over 31,300 square km of Xinjiang's farmland are covered with plastic mulch, making up almost one-seventh of the country's total film-mulched land. After 30 years of aggressive use of mulch films and inadequate attention to the problems of film residue, cotton fields have been severely eroded by plastic pollution.

"While producing huge benefits, plastic film mulch technology has also brought on a series of pollution hazards," explains Professor Yan Changrong of the Chinese Academy of Agricultural Sciences. "The plastic, which is mostly made of polyethylene, doesn't degrade in soil. The problem is worsened by the low rate of plastic film mulch recovery due to mechanised cultivation and very thin film. Large amounts of residual plastic film have detrimental effects on soil structure, water and nutrient transport and crop growth.

According to BASF, field tests of its biodegradable plastic films show good yields without the soil pollution caused by conventional polyethylene based films.

IT CAN'T BE DONE

Moving away from films, over in the US researchers at Colorado State University (CSU) claim to have made a completely recyclable, biodegradable polymer, suitable for more rigid applications such as containers.

The researchers explain that while there are several biodegradable plastics on the market which are suitable for compostable cups, cutlery and packaging, they're not truly recyclable. Once made, products produced from starch-based materials made from polylactic acid (PLA) can't be completely reconstituted into their original monomeric states without forming other, unwanted by-products.

In CSU's Chemistry Department, Professor of Chemistry Dr Eugene Chen has developed processes to convert small molecules derived from nonedible plant biomass into bioplastics. The starting feedstock is a biorenewable monomer that had been considered non-polymerizable, i.e. could not be bonded into large molecules.

"'Don't even bother with this monomer,'" Chen had been told. "'You cannot make a polymer out of it because the measured reaction thermodynamics told you so.' We suspected that some of the previous reports were probably incorrect."

According to Chuck Henry, chair of CSU's Department of Chemistry, Chen's work is an important step in converting common renewable materials into functional molecules and creating biodegradable materials by "developing novel atom-economical green pathways". Chen was also recently honoured with a Presidential Green Chemistry Challenge award for his efforts.

FORD

It may have been a long time since Henry Ford was experimenting with the use of bioplastics in automobiles, but his Michigan-based company is once again exploring the possibilities presented by the new renewable materials. For the past 15 years Ford Research has been working to develop bioplastics for use in its cars.

The latest product of that research is a new partnership with Mexican spirits producer Jose Cuervo®. The project will see waste from the agave plants used in the production of Tequila being developed into more sustainable bioplastics for use in vehicle components such as wiring harnesses, HVAC units and storage bins.

The growth cycle of the agave plant takes a minimum of seven years. Once harvested, the heart of the plant is roasted, before grinding and extracting its juices for distillation. Jose Cuervo uses a portion of the remaining agave fibres as compost for its farms, and local artisans make crafts and agave paper from the remnants.

FACTS

4 %
of the petroleum consumed worldwide each year is used to make plastic, and another 4% is used to power plastic manufacturing processes.

86 MILLION
Europeans use Novamont's compostable Mater-Bi bags for organic waste collection.

60,000
Meals to be served each day at the Athlete's Village for the Olympic Games in Rio - all on biodegradable plastic plates.

160,000
High-skilled jobs that could be created in the European bioplastics sector.

"The measures and actions proposed by MEP Bonafè will help the bioplastics industry and the entire European bioeconomy to unfold its full environmental, social, and economic potential to provide new business opportunities and to create quality and long-term employment in Europe while protecting the environment, and foster the efficient and sustainable use of our resources."

Hasso von Pogrell
Managing Director of European Bioplastics

While still in development, Mielewski has high hopes for the material. The waste agave fibres have properties which could replace fiberglass, with the added benefit of reducing weight. The researchers are also looking into the possibility of using it in high temperature applications, for instance in the engine bay.

THE FUTURE

The use of bioplastics across almost all industries and in a multitude of applications is set to skyrocket. In July this year, Research and Markets published its 'Global Bioplastics Market 2016-2020' report, in which it forecast the global bioplastics market to grow at a CAGR of 29.3% during the period 2016-2020.

One of the key drivers of the growth will be legislation. An increasing number of countries will implement single-use bag bans, such as the one that came into force in France in July this year. It is hoped by many in the industry that such bans will also follow in France's footsteps by exempting biobased, biodegradable and home-compostable bags from those ban.

In other areas of bioplastic development advances will occur for financial and technical reasons. As Mielewski notes, with the oil price so low there is less incentive to fund research. For Ford one of the key drivers is the fact that the materials they are developing are lighter than their traditional counterparts.

For some materials the decision to use bioplastics is made not just because they are cheaper, or 'greener', but simply because they are better for a given application. —