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Grow your own plastic

When our oil runs out, we'll lose more than just petrol. So how will we make pens, PCs and iPods? **Simon Usborne** speaks to the bio-pioneers who are cultivating Plan B

When a Belgian chemist named Leo Hendrick Baekeland ended his diary entry for 11 July, 1907, with the words "I know this will be an important invention", he could not have dreamt of the extent to which his brainchild would shape modern life.

Having emigrated to the US with a chemistry degree, Baekeland had spent five years in a converted barn at his New York home experimenting with a resinous gunk – the by-product of a reaction between formaldehyde and phenol – and an oven he named "The Bakelizer". The result: a hard, light substance that could take on any shape.

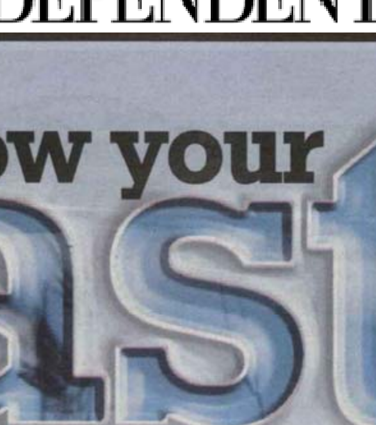
A hundred years on, Bakelite, the world's first fully synthetic material, has spawned a plethora of plastics that have moulded our world. Look around you: your mobile phone; your computer; your credit card; even your contact lenses – they all rely on some variant of plastic, or "the material of a thousand uses", as Baekeland marketed his creation.

At his death in 1944, the US was producing 400,000 tons of plastic a year. Today, annual production worldwide has rocketed to 100 million tons – the equivalent of 60,000 two-litre drink bottles every second – and in the UK consumption is still rising by 4 per cent a year.

But as we increasingly rely on the polymer, plastic could not exist without one ingredient: oil. For every barrel of oil that goes into making plastic, another is required to fuel the process. In total, plastics account for seven million barrels of petroleum per day – that's 8 per cent of global supply. With reserves expected to last mere decades, the race is on to find an alternative.

The solution could lie in plastics made from raw ingredients found growing in fields. So-called bioplastics are not new. Celluloid, which is made from wood and cotton, was developed as an alternative to ivory in billiard balls in the 1850s. But, like other early renewable plastics, it lacked the versatility and viability of synthetic polymers; today, it is more often used to make shirt collar stiffeners and ping-pong balls.

Bioplastics made from crops such as maize or sugar cane have become more widespread, turning up in products such as biodegradable shopping bags and tomato trays, but many are expensive to produce, or melt at low temperatures.



That could change if an American bioscience company has its way. Last month, the Massachusetts research firm Metabolix announced plans to mass-produce a plastic made using only bacteria, sweetcorn and air. Jim Barber, the company's chief executive, says the biodegradable polymer, called Mirel, can handle boiling water and is the greenest plastic on the market.

"Mirel cuts by two-thirds the greenhouse gases released by the manufacture of petroleum-based plastics," he says. "And because it's not made using oil, we cut petroleum use by about 80 per cent."

But what's really clever about Mirel is the way it is "grown". Most modern bioplastics are manufactured by extracting starch from maize or other crops and fermenting it to produce an acid, which then undergoes a series of chemical treatments to create a plastic polymer.

The scientists at Metabolix have engineered microscopic bacteria to do all that work for them. They add sugar from the maize, as well as oxygen, and watch the microbes swell as tiny plastic particles form inside them. Using a secret process, the particles are then harvested to create the pellets that can be moulded into a range of products.

"Mirel has the physical properties to be a useful alternative to most traditional plastics," says Barber. "But initially we're focusing on disposable items, such as razors, plastic bags and packaging, which use so much plastic and just get thrown away."

In the UK, we bin nearly three million tons of plastic a year, more than half of which comes from packaging. And less than 10 per cent of that is recycled – the rest ends up in landfill, or strewn along beaches and roadsides, where it can remain for decades or even centuries.

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Mirel is different. "It will break down in almost any environment, including soil, in industrial or domestic compost, or even in rivers and seas," says Barber.

Its green credentials are clear, but can Mirel and other renewable materials ever hope to satisfy our enormous appetite for plastic? Dr John Williams, a scientist at the UK's National Non-Food Crops Centre, says rapid growth in the past two years has given bioplastics great potential.

He says: "People often say to me, 'Look, there are millions of tons of polypropylene in the world – how the heck are you going to replace all that?' But let's go back to the 1940s when polypropylene was just a waste material – nobody could have imagined we would be producing it on such a huge scale today. I believe renewable plastics can go the same way."

Back in the US, Metabolix is starting small. The company is building a plant in the "Tall Corn State" of Iowa that will churn out Mirel at an annual rate of 50,000 tons – a fraction of the demand for plastics. But Metabolix scientists are on the verge of a breakthrough: using a process that sounds more like science fiction than fact, they plan to transfer the machinery used to produce Mirel from the stainless-steel vats of the processing plant into the leaves and stems of the plants themselves.

Rather than take the sugar from corn and add it to microbes in a fermenter, Metabolix will cultivate a grass already loaded with the bacteria. The modified microbes take some of the sugar produced by the plant every day via photosynthesis and transform it into natural plastic that grows inside the leaves and stems. This "plastic plant" can then be harvested and the polymer extracted for conversion into pellets.

Metabolix has already "farmed" plastic in trials using a plant called switchgrass, a prairie grass that grows naturally across swathes of North America. The company hopes to get the grass into the field in the next three or four years.

Barber says the key to producing large quantities of bioplastics is to combine plastic making with the manufacture of biofuels in multipurpose refineries. Once the plastic is harvested from switchgrass, the rest of the plant – about 90 per cent of its biomass – can be used to produce ethanol fuel, or even burned to generate electricity.

And the process will not be restricted to climates where switchgrass thrives. A grass called miscanthus is already used in parts of Europe to produce biofuels, and could be engineered to make plastic at the same time. In warmer parts of the world, other crops such as sugar cane could do the job just as well.

"Using this method you really can look at natural plastic as an alternative to a substantial portion of petroleum-based polymers – I would say around half," says Barber.

On a global scale, that would equate to 50 million tons a year, and an increasingly vocal band of environmentalists is expressing concerns about the impact that will have on land. In Brazil, where ethanol derived from corn and other crops has replaced 40 per cent of the gas guzzled by cars, millions of acres of savannah and rainforest have been turned over to bio crops. Last week, a UN report warned that if not managed carefully, growing crops for biofuels can do more harm than good.

"It is an issue," says Barber. "But this year about 90 million acres of corn will be grown in the US, which is enough to meet current needs, and in the future there are substantial amounts of set-aside land that could take switchgrass and other crops."

John Williams admits the industry is still "dipping its toe in the water" but he is confident that bioplastics will soon catch up with their oil-based counterparts. "I can't see them being 50 per cent of the market 20 years from now, but it might be 20 per cent, and that was unthinkable only two years ago."

What would Baekeland, whose iron Bakelizer was at the cutting edge of technology 100 years ago, make of plastic farms and biorefineries? "I think he would have been really excited and intrigued," says Dr Susan Mossman, author of *Early Plastics: Perspectives, 1850-1950*, and curator of Plasticity, an exhibition which opens at the Science Museum this month. "Before he died he said that if he could lead his life again, he would do something for the good of mankind, so I think he'd be fascinated by the idea of plastics actually helping the environment."

Plasticity: 100 years of Making Plastics opens at the Science Museum on 22 May. www.sciencemuseum.org.uk