CLEAN, GREEN TECHNOLOGY MAKES SUSTAINABLE RESINS FROM VEGETABLE OIL

Bio-resins made from vegetable oils could offer a sustainable alternative to petroleum-based thermoset resins. New research has developed viable ways of making them using cost-effective green technology.

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Thermoset resins are some of the most commonly used materials in the construction, furniture and automotive industries. Around 350,000 tonnes a year are currently produced in the UK to make a wide variety of composite materials from particleboard to glass fibre panels. At present all the raw materials are derived from petrochemicals, and the toxicity and volatility of starting materials such as formaldehyde require careful environmental, health and safety monitoring. But there could soon be a new, greener alternative on the market based on a new generation of 'bio-resins' – thermoset resins derived principally from vegetable oils such as rapeseed.

Research supported by the Sustainable Technologies Initiative shows how the renewable polymers could offer a commercially viable alternative that would help manufacturers to meet tighter environmental regulations and reduce consumption of finite petrochemical resources. They would meet growing demand for more environmentally friendly resins that are competitive in price and performance and adaptable to existing composite manufacturing processes.

In the REPLANT project, a research team from BC, the BioComposites Centre at the University of Wales, Bangor, who specialise in renewable plant technology, worked with industrial partners Cambridge Biopolymers, a contract manufacturer and a resin end-user. The project was supported by the DTI through the Sustainable Technologies Initiative, a programme to improve the sustainability of UK business. STI research aims to achieve economic growth and employment while safeguarding the environment and conserving natural resources.

'There is a clear place in the market right now for new, more environmentally friendly resins that are competitive in price and performance, and adaptable to existing processes for manufacturing composites,' says project manager Dr Paul Fowler. 'The growing interest reflects the demand for alternative, renewable sources of thermosetting resins that will begin to address the depletion of finite resources and reduce emissions.'

A key goal of the project was to develop a thermosetting resin system derived from vegetable oils such as rapeseed oil, which is widely grown in the UK. As well as being based on renewable resources and offering new markets for UK producers, the new generation of bio-resins have other important attractions. Their use would avoid health and safety issues arising from the present reliance on phenol and formaldehyde in making conventional thermoset resins. Emissions of these volatile chemicals are regulated in the workplace and there are concerns over the slow release of formaldehyde from products such as particle board at the point of use. An added bonus of a switch to bio-resins would be a cut in carbon emissions as the growing crops absorb greenhouse gases.

'Our clean and green chemical processing technologies make it possible to produce bio-resins from renewable resources,' says Dr Fowler. 'We've succeeded in developing a low effluent manufacturing procedure that's based on the use of vegetable oil, water, air and electricity and yields formaldehyde-free products with excellent performance characteristics.'

A key step was the development of a technique known as ozonisation to turn the vegetable oil into thermosetting resin. Patent applications have been made for the novel process technology, which is based on the use of ozone gas, and operates at ambient temperature. The clean, low effluent manufacturing process yields formaldehyde-free products with a high solids content of over 75%. Development of the new process is expected to appeal to thermoset manufacturers by making it easier for them to meet health and safety regulations in the workplace as well as demand from customers for greener products that are formaldehyde free.

In demonstration trials on factory production lines, the bio-resins performed well.

Sustainable Technologies Initiative

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Performance matched that of petrochemical resins. The trials demonstrated that the process is capable of working on an industrial scale and commercialisation is expected to follow. The first applications are likely to be in selected insulation products, with future potential in industries ranging from electronics to automotive, construction materials, furniture, foundry and engineered wood products.

'Our long-term aim is partial replacement with a bio-based alternative of the many hundreds of thousands of tonnes of petrochemical-derived thermoset resins that are currently used in the UK and rest of Europe every year,' says Dr Fowler. 'As well as helping us to develop the bio-resin technology, the STI project has demonstrated the sound economic, environmental and social gains that would accrue.'

For rapeseed growers, the project could open up a valuable potential market outside the food and biodiesel industries. The outcome should provide a significant advance in the industrial usage of agricultural crops, with a market for tens of thousands of tonnes of oilseeds per year.

Substituting bio-resins could also help to meet UK government targets on environmental CO2 by reducing greenhouse gases. Growing rapeseed has the effect of sequestering carbon dioxide from the air. For every tonne of bio-resin produced approximately 2.5 tonnes of carbon dioxide would be fixed.
Energy savings could be an added benefit as rapeseed meal, left over when oil is extracted, can be used to generate electricity. By producing oil on the same site as bio-resins the recovered energy could be used to power the ozonisation process.

Additional project information and background

What are thermoset resins?

They are key components in the manufacture of a wide variety of composite materials such a wood-based panels (e.g. MDF, plywood and building panels), lofted glass fibres used for insulation and interior fittings in the automotive industry. Thermosets become hard and rigid when heated or cured. They are one of the two main groups of adhesive materials – the other is thermoplastics.

What is so different about bio-resins?

Bio-resins are derived from a biological source such as vegetable oil instead of petrochemicals. As renewable polymers with low environmental impact, their principal advantages are that they reduce reliance on finite resources of petrochemicals, they sequester carbon from the atmosphere and they avoid reliance on volatile chemicals such as formaldehyde that have aroused health and safety concerns for some time.

How does the thermosetting process work?

The approach taken by the REPLANT project mimics the curing mechanism of the most widely used synthetic thermosetting resins such as phenol-formaldehyde and melamine-formaldehyde. Treating vegetable oils with ozone gas followed by reduction yields aldehydes that are suitable components for bio-resin formulations.

Aren't other formaldehyde-free resins already available?

Formaldehyde-free materials such as tannin resins are available but they take longer to process and reduce the strength of panel products, and can increase water absorption and swelling. The performance of bio-resins is designed to be comparable with existing phenol-formaldehyde resins.

Have bio-resins been tried before?

Some of the first bio-resins were patented in Germany in the 1930s and Ford made fibre-reinforced car body panels from a soybean-derived product in 1938. However their use has remained very limited. Recently a small number of new bio-resin materials have gone on the market but manufacturing costs and technical performance have prevented widescale use. As a result virtually all the thermoset resins for major applications are currently still supplied from petrochemical feedstocks.

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The STI is a programme of collaborative research and development aimed at improving the sustainability of UK business. The aim is to maintain high levels of economic growth and employment while protecting the environment, making better use of natural resources and working for the good of society as a whole. Companies are encouraged to work with the science base to develop and adopt new sustainable technologies. The Programme is sponsored by the Department of Trade and Industry (DTI), the Engineering and Physical Sciences Research Council (EPSRC), the Department of Environment, Food and Rural Affairs (Defra), the Biotechnology and Biological Sciences Research Council (BBSRC) and the Economic and Social Research Council (ESRC).

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