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Microalgae: a low-cost, sustainable solution to plastic production?

Scientists have discovered a novel way to produce bioplastic, which could be more cost-effective on a commercial scale than current techniques. The new technique, which uses microscopic algae to synthesise a widely used polyester, has the potential to revolutionise plastic production, say the researchers.

Some bacteria and plants can produce plastics naturally, for example, for use as a storage material. These 'bioplastics' are not dependent on fossil fuels for production and are easily degraded in the environment, making them an environmentally friendly alternative to synthetic plastics. Certain bacteria are already used to produce a polyester known as PHB (poly-(R)-3-hydroxybutyrate) on a commercial scale by fermenting starch, corn or sugar.

A new pilot study has revealed for the first time how microalgae could provide a low-cost alternative to bacteria. The scientists injected microalgal cells (*Phaeodactylum tricornutum)* with three enzymes found naturally in bacteria, which together synthesise PHB: ketothiolase, acetoacetyl-CoA reductase and PHB synthase. The cells were then cultured in the laboratory for 7 days, allowing PHB to accumulate in the cells. Analysis using fluorescent proteins, electron microscopy and gas chromatography revealed that PHB accumulated in granule-like structures in the liquid part of the cells, known as the cytosol.

Although the efficiency of PHB production using microalgae is currently lower than bacteria-based systems (PHB yield equivalent to 10.6% of dry weight compared to 80% in bacteria), the operational costs are significantly lower, making it an interesting prospect for many industrial, therapeutic and diagnostic applications, say the researchers.

Small flowering plants, such as *Arabidopsis thaliana*, have also been tested as low-cost alternatives to bacterial PHB production, with potential yields of up to 40% of dry weight. However, stunted growth and infertility means this species is impractical for large-scale production. Today, the highest yielding plants produce PHB levels of about 18% of dry weight. This has the potential to be improved, however, there have also been ethical concerns over direct competition with subsistence crops for agricultural land and an inability to control the spread of genetically-modified species.

Microalgae share the low-cost advantage of plants but without these limitations say the researchers. The production time is also much faster for *P. tricornutum* microalgae, taking two weeks to accumulate the same amount of PHB as produced by plants over a three month period. This makes the microalgal process more profitable overall.

Despite these encouraging results, the cost of producing petroleum-derived plastics is still lower than bioplastic alternatives, making the latter less economically favourable on a commercial scale. However, production of synthetic plastic at the current rate requires 150 million tonnes of fossil fuels to be processed annually and generates huge amounts of non-biodegradable waste, which accumulates in the environment and poses a range of environmental hazards, including ingestion by wildlife and leaching of toxic chemicals.

The study does not include research into the environmental impacts of large scale algae culture. Thus research leading from this pilot study could investigate possible environmental impacts of large-scale algal PHB production and various ways to enhance the cost-efficiency, in order to directly compete with bacteria, say the researchers. For example, by targeting other regions of the microalgal cells as locations for plastic production, such as the plastids. Synthesising other complex molecules and biologically active substances in this group of microalgae (diatoms) could also have important applications in other fields, such as nanotechnology and the production of renewable fuels.

Source: Hemplel, F., Bozarth, A.S., Lindenkamp, N., *et al*. (2011). Microalgae as bioreactors for bioplastic production. *Microbial Cell Factories*. 10: 81-86.

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