Bioplastics: A sustainable alternative to plastics

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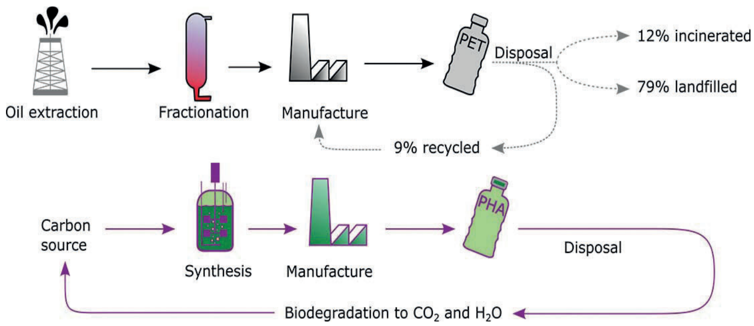
From mobile phones to clothing, plastics have become an integral part of our lives. Their low cost, ease of manufacture, durability and wide range of applications has led to a steady increase in plastic production, with over 370 million tonnes produced in 2019. More than 99% of plastics are derived from fossil resources, the reserves of which are rapidly depleting. Additionally, fossil-based plastics e.g., the commonly used polyethylene terephthalate (PET) are not biodegradable or readily recyclable, causing significant environmental damage. As such, alternative materials are needed, which are either biodegradable and/or recyclable, and can be produced from renewable resources. This is where bio-based plastics or "bioplastics" such as polyhydroxyalkanoates (PHAs) can step in [Fig. 1].

Fig. 1 Comparison of life cycles between traditional plastics and PHAs



Discovered in 1926 by French researcher Maurice Lemoigne, PHAs possess properties like those of traditional fossil-based plastics with additional advantages of being biodegradable, non-toxic, recyclable and obtainable from renewable sources. There are many types of PHAs based on their structure, allowing a wide range of material applications. PHAs could replace single-use plastics such as packaging and plastic utensils and in agriculture as mulch film bags. In medicine, PHAs have been used as biodegradable sutures, drug delivery capsules and tissue scaffolds for use in regenerative medicine. Current research has a strong focus on making the production of PHAs cheaper by using waste carbon sources and altering the properties of the PHAs to better replicate those of traditional plastics.

SBRC-NOTTINGHAM is a UKRI BBSRC/EPSRC funded, Synthetic Biology Research Centre led by Professor Nigel P. Minton at the University of Nottingham, UK. SBRC–Nottingham aims to provide new technologies in the form of engineered bacteria and processes that together can be used at scale by industry to transform our energy intensive economy into a sustainable and more carbon neutral bioeconomy. The Centre is collaborating with industry to optimise and commercialise the production of low carbon fuels and everyday chemicals using gas fermentation.

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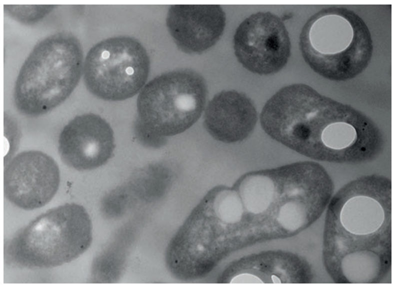
PHAs are naturally produced by various species of bacteria. While these bacteria save the PHAs for use as an energy source, they can be extracted from bacteria and processed in much the same way as traditional plastics. Bacteria can produce PHAs from a range of carbon sources, from sugars to waste gases such as carbon dioxide (CO_2). PHAs biodegrade to form CO_2 and water (H_2O), which can be reused to make new PHAs directly by certain gas-fermenting bacteria, such as *Cupriavidus* spp. [Fig. 2]. These bacteria allow renewable production of plastics from waste compounds without the need for fossil resources. Additionally, the biodegradability of PHAs reduces the environmental damage associated with traditional plastics.

Fig. 2 Electron micrograph showing PHA granules in Cupriavidus spp.



About us

With a PhD in Microbial Biotechnology and Biochemistry, ***Victor Irorere's*** *research mainly focuses on optimising the production of sustainable and green platform chemicals. He joined SBRC in 2019 as a Research Fellow, working on upstream process development for the biosynthesis of a range of chemicals with focus on Bioplastics from C1 gases. He has over 16 publications and in the future plans to work with industries to develop processes for bioproduct manufacturing that minimises waste and optimise productivity.*

Callum McGregor *completed his PhD at SBRC-Nottingham, in which he worked on the production of biodegradable plastics using bacteria. His research now focuses on the metabolic engineering of bacteria for the sustainable production of chemicals and polymers from C1 gases.*

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