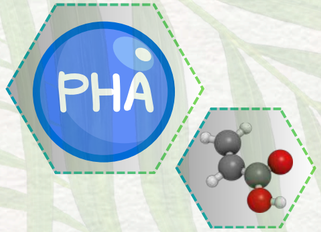
POLYHYDROXYALKANOATES : FROM MICROBES TO MARKET

DEFINITION

Polyhydroxyalkanoates (PHA) are a class of biodegradable thermoplastic polymers produced by microbial fermentation.

They are synthesized by various bacteria as intracellular carbon and energy storage compounds.

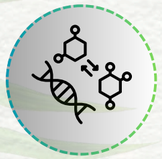
PHAs are linear aliphatic polyesters mainly composed of R-(-)-3- hydroxyalkanoate units, where R is an alkyl group that can vary in length.



There are over 150 different monomers that can be combined within this family, giving PHAs a wide range of properties.

Thermoplastics were first invented in 1926, and since then, PHA have attracted substantial commercial and research interest due to its eco-friendly nature.

SUSTAINABLE PRODUCTION



Enzymatic Synthesis

Process of producing PHAs using enzymes, primarily PHA synthase, that catalyze the polymerization of hydroxyalkanoate monomers.

Chemical Synthesis

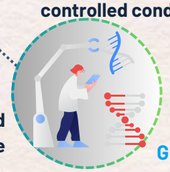
Process of producing PHAs through polymerization of chemically synthesized monomers under controlled conditions.

Microbial Fermentation

Microbial cultures are forced under stress conditions like lack of nutrients like oxygen, nitrogen, phosphorous, sulphur, etc. with excess carbon sources, which will start to produce PHA for its energy.

Bacterial Fermentation

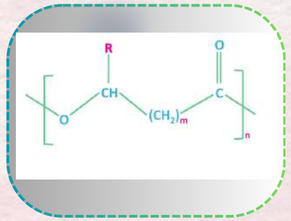
Common bacteria such as Cupriavidus necator, Azotobacter sp, Pseudomonas putida, Alcaligenes latus are used.



Genetic Engineering

To enhance the yield and to tailor polymer properties, genetically modified organisms are often employed.

STRUCTURE OF PHA



PHAs are linear polyesters of 3-hydroxy fatty acid monomers, where an ester bond ties the carboxyl group and the hydroxyl group of two repeating units.

PHAs are formed in short, medium and long length composition based on the carbon chain length of the monomers.

Short chain length PHAs consisting of 3-5 carbon atoms

Medium chain length PHAs consisting of 6-14 carbon atoms

Long chain length PHAs consisting of 15 or more carbon atoms

KEY PROPERTIES

Biodegradability

PHAs are biodegradable because of their natural origin and the presence of ester bonds in their backbone.

Biocompatibility

PHAs are biocompatible and non-toxic because of their natural composition which imitates the natural biomolecules found in living organisms.

Thermal properties

PHAs exhibit a wide range of thermal properties, including melting temperature and glass transition temperature, depending on the types of monomers used to synthesize them.

Mechanical properties

PHAs exhibit diverse mechanical properties, ranging from high-strength, hard, brittle to low-strength, soft and elastic.

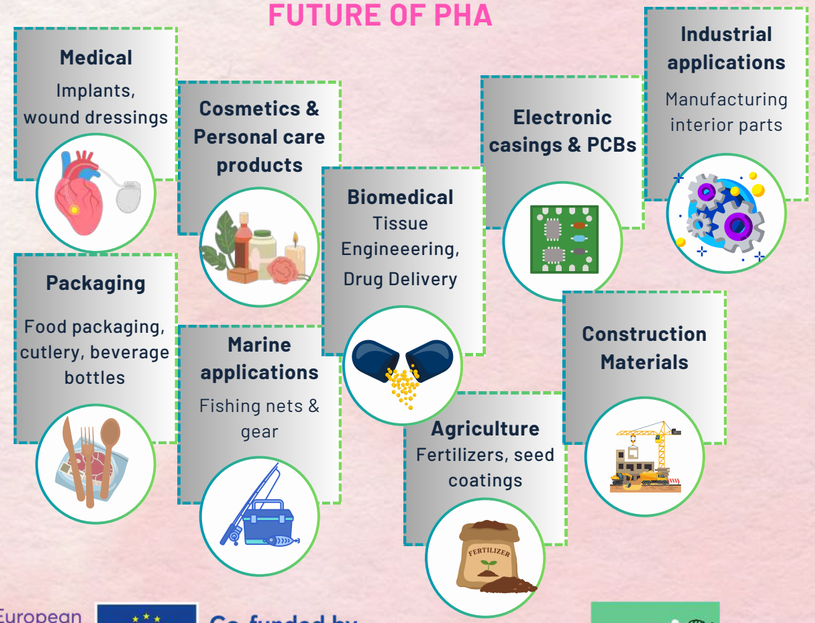
Chemical Resistance & Barrier properties

PHAs exhibit good barrier properties to gases like O_2 and CO_2, and are resistant to wide range of chemicals like hydrocarbons, oils and solvents.

Processability

PHAs have similar thermal and rheological properties to petroleum plastics that allow them to be processed at the conventional plastic manufacturing equipment such as injection moulding, extrusion & film blowing, etc.

FUTURE OF PHA



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ENVIRONMENTAL IMPACTS

Less Carbon Footprint

PHA bioplastics has the potential to generate less carbon footprint compared to the petroleum based plastics such as PE and PP.

Biodegradability

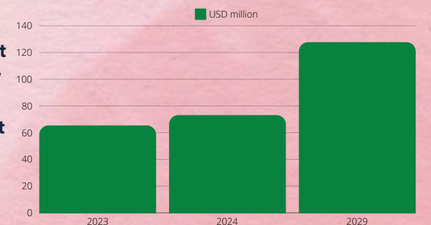
PHA is 100% biodegradable which does not pollute the environment, whereas PE and PP do not fully degrade.

Reduce GHG Emissions

PHA bioplastics have positive impacts on climate and environment as they can reduce greenhouse gas emission and microplastics pollution owing to their renewable feedstock origin and biodegradability.

GLOBAL PHA MARKET SIZE

PHA market forecast is expected to grow at a CAGR of 11.8% (Approx.) in the next decade



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3. https://www.marketdataforecast.com/market-reports/polyhydroxyalkanoate-market