Abstract: PHAs are biogenic polyesters that can be naturally accumulated in microbial cultures as their energy reserves to overcome the environmental stress which is also be biodegradable polymers. The medium- chain -length PHA mcl-PHA) polymers composed of C6 to C16 hydroxyl fatty acids or aliphatic carbon sources.

1. Introduction

Landfills and floating plastic debris are major concern for environment .An alternative to petrochemical plastics are PHAs being biogenic polyesters that can be naturally accumulated in microbial cultures as their energy reserves to overcome environmental stress. Naturally adapted microbes in situ field trial is considered as an important approach in bioremediation. Polyhydroxyalkanoate (PHA)

2. Degradation and its Properties

Mechanical integrity of plastics invariably depends on their high average molecular-weight, any significant extent of degradation the average molecular weight of the polymer where degraded fragile surface inevitably weakens the material and is susceptible to fracture by stress induced by humidity or temperature changes and abrasion against sand .Extensively degraded plastics become brittle enough to fall apart into powdery fragments on handling which not visible to the naked eye and can undergo further degradation (generally via microbial-mediated biodegradation) with the carbon in polymer being converted into CO2 (and incorporated into marine biomass) by breaking it up into monomer .When this process goes onto completion and all the organic carbon in the polymer is converted, it is referred to as complete mineralisation .

Natural biodegradable polymers next generation polymers as they are biodegradable, eco-friendly(Non petroleum based biological polyesters ) and biocompatible( important in the natural resources) PHAs are biogenic polyesters that can be naturally accumulated in microbial cultures .In order to overcome the environmental stress a large number of bacteria remain in contaminated environment which can accumulate PHA as their energy reserves.PHA properties are also similar to those of polyethylene (PE) and polypropylene (PP) . PHA are classified on the basis of number of repeating units in the polymers. Short-chain-length PHA (scl-PHA) is the polymer that contain monomers of C3 to C5 hydroxyl fatty acids e.g.polyhydroxybutyrate (PHB) and hydroxyvalerate (PHV). The medium- chain -length PHA mcl-PHA) polymers composed of C6 to C16 hydroxyl fatty acids or aliphatic carbon sources .

Many microorganisms accumulate PHA as intracellular energy reserve of carbon inclusions when the carbon is in excess to the other nutrients such as nitrogen, sulfur, phosphorus and oxygen . Microbial degradation of plastics is caused by enzymatic activities that lead to a chain cleavage of the polymer into monomers The lipase, proteinase K, extracellular and the intracellular dehydrogenases involved in biological degradation of plastics by a thermophilic bacterium (Bacillus brevis) and Pseudomonas putida . The occurrence of biodegradation is mainly due to the PHA degrading enzymes which is known as PHA depolymerase that are secreted by microorganisms to hydrolyze water-insoluble PHA into water-soluble forms so that it can be utilized by these microorganisms . PHA depolymerase is an enzyme made up of a catalytic domain and a substrate-binding domain. Both these domains are connected by a linker domain. The substrate binding domain of the enzyme binds to the crystalline PHA material. Subsequently, the catalytic domain starts to cleave the polymer chain . PHA-degrading consortia, the regulatory mechanisms of various ring-structured PHA biodegradation as well as the catabolic biodegradation of PHAs from environmental samples a variety of microorganisms . The new approach of advancements in molecular biology can aid in the detection of PAH-degrading DNA–DNA hybridization has been directly applied to detect and monitor the crucial populations recovered from the environment . Laurie and Jones detected two distinct PAH catabolic genotypes from aromatic hydrocarbon-contaminated soil using quantitative (i.e. microorganisms swim away from the compound). Both cases require concentration gradients of the attractant or repellent for a chemotactic response to occur. Some toxic organic compounds are chemotaxant for different bacterial species, such as Pseudomonas sp. and Ralstonia sp. , which could lead to improved degradation.

The conversion of styrene to polyhydroxyalkanoate (PHA) by Pseudomonas putida CA-3 provides a new and unique link between an aromatic environmental pollutant and aliphatic PHA accumulation. Due to its biodegradable nature, PHA has a broad range of applications, including medical applications such as wound management, drug delivery, and tissue engineering . Furthermore, PHA is composed of chiral hydroxy acids that have potential as pyriones for anti-human immunodeficiency virus drugs, anticancer drugs, antibiotics, and vitamins .

Investigations into the biodegradation of styrene have resulted in the elucidation of biochemical pathways and molecular control of styrene degradation . P. putida CA-3 is capable of the complete mineralization of styrene. It does so by epoxidation of styrene and isomerization of the epoxide to phenylacetaldehyde, which is further oxidized to phenylacetic acid. Phenylactic acid is converted to
phenylacetyl-coenzyme A (CoA), which is further oxidized to acetyl-CoA.\(^{29,27}\)

The chemotaxis of Pseudomonas putida towards naphthalene and salicylate is a plasmid-encoded phenomenon, encoded by the catabolic plasmid NAH\(^{7}\) residing within this strain. A chemotaxis gene region has been identified from P. putida that was found to be homologous to chemotaxis, flagellar and mobility genes from some other bacteria.\(^{31}\)

Genetically Engineered Microorganisms (GEM) in India as well as due to inability of the microbial genome to degrade all the components of pollutants in different environments and climatic conditions, seeding of naturally adapted microbes in situ field trial is considered as an important approach in bioremediation.\(^{7}\)

References

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