Chapter 18
Polyhydroxyalkanoates:
An Indispensable Alternative

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ABSTRACT

Human dependence on number of chemicals or chemical derivatives has increased alarmingly. Among the commodity chemicals, plastics are becoming independent for our modern lifestyle, as the usage of plastics is increasing worryingly. However, these synthetic plastics are extremely persistent in nature and accumulate in the environment, thereby leading to serious ecological problems. So, to build our economy sustainably, a need of replacement is necessary. Biomaterials in terms of bioplastics are an anticipated option, being synthesized and catabolized by different organisms with myriad biotechnological applications. Polyhydroxyalkanoates (PHAs) are among such biodegradable bioplastics, which are considered as an effective alternative for conventional plastics due to their similar mechanical properties of plastics. A range of microbes under different nutrient and environmental conditions produce PHAs significantly with the help of enzymes. PHA synthases encoded by phaC genes are the key enzymes that polymerize PHA monomers. Four major classes of PHA synthases can be distinguished based on their primary structures, as well as the number of subunits and substrate specificity. PHAs can also be produced from renewable feedstock under, unlike the petrochemically derived plastics that are produced by fractional distillation of depleting fossil fuels. Polyhydroxybutyrate (PHB) is the simplest yet best known polyester of PHAs, as the PHB derived bioplastics are heat tolerant, thus used to make heat tolerant and clear packaging film. They have several medical applications such as drug delivery, suture, scaffold and heart valves, tissue engineering, targeted drug delivery, and agricultural fields. Genetic modification (GM) may be necessary to achieve adequate yields. The selections of suitable bacterial strains, inexpensive carbon sources, efficient fermentation, and recovery processes are also some aspects important aspects taken into consideration for the commercialization of PHA. PHA producers have been reported to reside at various ecological niches with few among them also produce some byproducts like extracellular polymeric substances, rhamnolipids and biohydrogen gas. So, the metabolic engineering thereafter promises to bring a feasible solution for the production of "green plastic" in order to preserve petroleum reserves and diminish the escalating human and animal health concerns environmental implications.

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INTRODUCTION

In the today's world it is generally unquestionable that alternatives for innumerable fossil-resource based products such as plastics are needed in our society. Plastics, a group of non-natural polymeric materials, are presently produced at growing quantities, currently exceeding 300 Mt per year. Especially in strongly emerging economies, such as in China, India, Brazil and many other countries, plastic production and consumption is increasing almost exponentially. Plastics find their in almost every aspect as human beings have relied upon them mostly. Plastics are very much advantageous as their structure can be chemically manipulated to have a wide range of strengths and shapes. Plastics can be easily moulded into almost any desired shape including fibres and thin films. Their molecular weights range from 50,000 to 1,000,000Da (Madison and Huisman, 1999). The synthetic polyethylene, polystyrene and polyvinyl chloride are mostly used in the plastics manufacture. They are popular as disposal goods and as packaging materials, owing to their high chemical resistance and more or less elastic nature. Other molecular components can be incorporated into these structures, resulting in inorganic polymers thus dictating altered properties and creating a seemingly limitless variety of useful end-products. Not surprisingly, petroleum-derived plastics are ubiquitous in the modern world globally; plastic production in 2011 reached 280 million tons (Plastics Europe, 2013)

They are one of the greatest inventions and have been developed into an indispensable commodity for mankind. Petroleum use trends suggest that plastic is not only a huge industry nationally and globally, but also an integral part of modern society (U.S. Department of Energy, 2013).In 2006, petroleum-based products were responsible for 390 million tons of CO_2 emissions (Snell & Peoples, 2009). Furthermore, 1.8 tons of oil create one ton of plastic and 1.9 tons of CO_2 (Snell & Peoples, 2009). Activities related to extracting petroleum directly disrupts many natural habitats; this loss of habitat cascades to affect humans and animals via loss of biodiversity, spread of pathogens, and changing climate that will most noticeably affect food production (Butt *et al.*, 2013). These concerns are not simply restricted to the changing environment.

The difficulty posing in disposal of plastics is what makes them undesirable. Plastics being xenobiotic are recalcitrant to microbial degradation (Flechter, 1993). In the recent years, there has been increasing public concern over the harmful effects of petrochemical-derived plastic materials in the environment. This has prompted many countries to start developing biodegradable plastic. According to an estimate, more than 100 million tonnes of plastics are produced every year. Forty percent of the 75 billion pounds of plastics produced every year is discarded into landfills. Several hundred thousand tonnes of plastics are discarded into marine environments every year and accumulate in oceanic regions. Incineration has been one of the options in dealing with non-degradable plastics, but besides being expensive it is also dangerous. Emission of some harmful chemicals like hydrogen chloride and hydrogen cyanide during incineration occurs (Johnstone, 1990). Recycling also poses difficulties as in sorting the wide variety of plastics and there are also changes in the plastic material due to which its further application range is limited (Johnstone, 1990; Flechter, 1993). Subsequent to the above mentioned limitations, replacement of non-biodegradable by degradable plastics is of major interest both to decision-makers and the plastic industry (Song et al., 1999).

As the natural environment is continuously polluted by these hazardous plastics, the development and production of environmental-conserved biodegradable plastics are rapidly expanding in order to trim down our reliance on synthetic plastics