Chapter 7

Biodegradation of Natural and Synthetic Polymer: A Microbial Approach for a Sustainable Environment

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ABSTRACT

Polymer contamination with the advent of fast industrialization has become one of the serious threat to the natural environment. Due to lack of proper knowledge, poor waste management practice and unavailability of potential microbial strains, preference toward the biodegradable manmade and natural polymers. The prevalent occurrence of synthetic polymers is related to industrialization and domestic practices which affect the marine and terrestrial ecosystems. Scientific approaches exploited for polymer degradation include physical, chemical and biological treatments. Among them, biodegradation serves as eco-friendly approach to remediate polluted environment using living organisms. In this chapter biodegradation of natural (cellulose, hemicelluloses and lignin), synthetic (polyurethane, polyethylene succinate, polycaprolactone, polyvinyl alcohol and polyethylene) polymers and associated factors that influence the polymer biodegradation process have been discussed.

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INTRODUCTION

Soil is consisted of a mixture of minerals and organic material that constitute fertile platform on the earth surface for the growth and development of living system. It consists of different zones of soil layers. Composition of the upper layer is continuously fluctuating with time to time. Different soil layers serve as natural habitat for number of microbial groups including bacteria, fungi etc. Microbial population varies with the nature of soil and availability of the nutrients. These microorganisms contribute significantly to maintain the soil fertility. In the current scenario, soil fertility is largely affected by polymer contaminants as a result of environmental pollution (Shimao, 2001; Premraj and Doble, 2005; Sivan, 2011). Natural polymers include proteins, nucleic acids and polysaccharides (cellulose, hemicellulose and lignin, starch, chitin etc.), while synthetic polymers include polyurethane, polyethylene succinate, polylcaprolactone, polyvinyl alcohol, polyethylene etc. (Chandra and Rustogi, 1998; Nwachukwu et al., 2010). Natural polymers serve as major source of carbon and renewable energy for the growth of microorganisms. Annually 30% natural polymers are degraded or consumed by the activities of animals and plants. Rest 70% natural polymers are degraded by microorganisms. Similarly, synthetic polymers are also present in natural environment and in the absence of proper disposal practices, linger in the environment for a long time and contaminate the natural environment (Arutchelvi et al., 2008).

Different approaches are exploited for polymer degradation. Surface destruction is one characteristic of polymer deterioration process in addition to structural alteration through chemical bonding and formation of intermediates (Premraj and Doble, 2005; Usha et al., 2011). Biodegradation is one of the most suitable approach for environmental protection, remediate the polymer contamination sites and does not have adverse effect on natural system. In this process microorganisms utilize these polymers as the substrate for their growth depending upon the physical and chemical properties of the polymers. Changes in the physical and chemical properties of the polymers are exploited as evaluating parameters for biodegradation (Tokiwa et al., 2009). In the last three decades, researchers have focused on biodegradation of polymers and tried to exploit them, in practices for environmental acceptance. Biodegradation efficiency of the polymer can be improved by using the appropriate microbial strains. Some polymer degrading potent microorganisms have been reported by scientists. These microbes are Pseudomonas, Micrococcus, Staphylococcus, Streptococcus, Moraxella, Aspergillus niger, A. glaucus and actinomycetes (Swift, 1997). The biodegradability of a polymer material is influenced by to physical (treatment like photo oxidation) and chemical treatments (chemical hydrolysis). These treatments make polymer susceptible to biodegradation (Sivan, 2011). In preliminary degradation, microplastics are formed with low tensile strength. In addition to physical and chemical treatments some additives like enzymes (lignin peroxidase, manganese peroxidase) and nanoparticles are also reported to enhance the biodegradation of polymer (Kapri et al., 2010; Sivan, 2011). Detailed characterization of these microorganisms in relation to polythene degradation is still to be carried out.

POLYMER

Polymers are long chain of hydrocarbons which are made up of renewable and non-renewable feedstock. These polymers are well known for their diverse applications e.g. industries, domestic appliances, transportation, construction, shelters, storage and packaging practices. Polymers are differentiated ac-
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