Production of Bioplastics from Biological Wastewater Treatment: A sustainable approach

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Abstract

Bioplastics in the form of polyhydroxyalkanoates (PHA) are the alternative to synthetic plastics, and could lower the contribution of synthetic plastics to municipal landfills by about 20% of the total waste by volume and 10% by weight. PHA are the high molecular weight (50 –100 KDa) carbonaceous, cellular reserve products, synthesized by microbes as storage granules when cultured under specific nutrient and environmental conditions. PHA has attracted commercial interest as a substitute to plastic materials because of their similarities in physical properties with synthetic plastics. Recently, usage of PHA in various applications such as packaging, medical, agricultural and fisheries has increased. In this direction a detailed study was performed in our laboratory to evaluate bioplastics production in the form of PHA using both mixed and pure cultures as biocatalyst. To improve the PHA production, Taguchi DOE methodology was employed to optimize different critical factors i.e., substrate load, nutrients concentration (nitrogen, phosphorous and iron), pH, microenvironment and VFA composition. The potential of different types of substrates viz., synthetic wastewater, synthetic acids, food waste, spent wash, and acidogenic effluents from biohydrogen reactor on PHA production was evaluated. Microbial inventory analysis using PCR-DGGE and FISH was performed for the identification of organisms involved in PHA production. Seven pure strains were isolated from PHA producing reactor using nutrient agar media. Bio-electrochemical behavior of three pure strains (*Pseudomonas otitidis, Bacillus subtilis* and *Serratia urelytica*) during PHA production was evaluated using cyclic voltammetry. Extracted PHA was analyzed through UV-VIS, HPLC, FTIR and H^1-NMR spectroscopy for fractional composition. Fractional analysis of PHA showed the presence of co-polymer P(3HB-*co*-3HV) with higher hydroxy butyrate (HB) fraction than hydroxy valerate (HV). Bioprocess evaluation, substrate degradation and enzyme activities (dehydrogenase, phosphatase and protease) were also monitored during the process. PHA production using wastewater is considered to be both economically viable as well as environmentally sustainable.

Keywords: Polyhydroxyalkanoates, Waste treatment, P(3HB-co-3HV), PCR-DGGE, Bioplastics