Recent Advances in the Production, Recovery and Applications of Polyhydroxyalkanoates

A. M. Gumel · M. S. M. Annuar · Y. Chisti

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Abstract  Polyhydroxyalkanoates (PHAs) are biodegradable and biocompatible polyesters that can potentially replace certain plastics derived from petroleum. PHAs can be produced using a combination of renewable feedstocks and biological methods. Native and recombinant microorganisms have been generally used for making PHAs via fermentation processes. As much as 90 % of the microbial dry mass may accumulate as PHAs. A range of PHAs has been produced using fermentation methods, including copolymers and block copolymers. Alternative production schemes based on genetically modified plants are becoming established and may become the preferred route for producing certain PHAs. Production in plants is likely to be inexpensive compared to production by fermentation, but it does not appear to be as versatile as microbial synthesis in terms of the range of products that may be generated. Cell-free enzymatic production of PHAs in vitro is receiving increasing attention and may become the preferred route to some specialty products. This review discusses the recent advances in production of polyhydroxyalkanoates by the various methods. Methods of recovering the polymer from microbial biomass are reviewed. Established and emerging applications of PHAs are discussed.

Keywords  Biopolymers · Bioplastics · Polyhydroxyalkanoates · Polymerization · Applications

Abbreviations

ATRP  Atom transfer radical polymerization
CALB  Candida antarctica lipase B
CSTR  Continuous stirred tank reactor
DO  Dissolved oxygen
DNA  Deoxyribonucleic acid
DW  Dry weight
cPHB  Complexed poly-(R)-3-hydroxybutyrate
EDTA  Ethylenediaminetetraacetic acid
FNL  Fervidobacterium nodosum lipase (FNL)
HACoA  HydroxyalkanoylCoA
HB  Hydroxybutyrate
3HB  3-Hydroxybutyrate, or 3-hydroxybutyric acid
4-HB  4-Hydroxybutyrate
HEC  Hydroxyethyl cellulose
HEMA  2-Hydroxyethyl methacrylate
HHx  Hydroxyhexanoate
HOPG  Highly oriented pyrolytic graphite
HV  Hydroxyvelarate
mcl-PHA  Medium-chain-length PHA
NAD  Nicotinamide adenine dinucleotide
NADH  Reduced form of nicotinamide adenine dinucleotide
P3HB3HV  Poly(3-hydroxybutyrate-co-3-hydroxyvalerate)
PANi  Polyaniline
PCL  ε-Caprolactone, or polycaprolactone
PDH  Pyruvate dehydrogenase
PDL  ω-Pentadecanolate
PEG  Polyethylene glycol
PEO  Polyethylene oxide
PHA  Polyhydroxyalkanoates
PHB  Polyhydroxybutyric acid
PHBHHx  Poly-3-hydroxybutyrate-co-3-hydroxyhexanoate

A. M. Gumel · M. S. M. Annuar
Faculty of Science, Institute of Biological Sciences, University of Malaya, 50603 Kuala Lumpur, Malaysia
e-mail: suffian_annuar@um.edu.my

Y. Chisti
School of Engineering, PN 456, Massey University, Private Bag 11 222, Palmerston North, New Zealand

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