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Cost effective production of polyhydroxyalkanoate biopolymers using mixed microbial culture and industry waste water: an ecofriendly approach

Regina Nogueira, Aniruddha Bhalerao and **Rintu Banerjee**
Institute for Sanitary Engineering and Waste Management, Germany

Statement of the Problem: Plastic and plastic products have become integrated part of our daily life. Even after recycling 5.6 million tons of undegradable plastic waste is produced per year in India which will persist in landscapes. Polyhydroxyalkanoate (PHA) are biodegradable, biocompatible, and have thermoplastic features; and can substitute conventional plastics. PHA biopolymer cost is estimated to be ranging between US$2.25–2.75/lb which is significantly higher than the conventional plastics and is attributed to use of pure cultures, high price of high purity substrates, and usage of batch and fed-batch production modes, thus hampering the wide commercialization and industrialization. To make PHA production economical, cheap industrial waste water like yeast production industries, which are rich in volatile fatty acids can be used. This will serve purpose of reducing the cost of production and waste water conditioning to reduce VFA (volatile fatty acids) content. Use of PHA producing microorganism rich mixed microbial culture will allow bioreactor operation under non-sterile condition reducing costs further.

Objectives: The objective of current study is cost effective production of PHA namely PHB and PHV by using mixed microbial culture (MMC) by feeding yeast industry waste water.

Methodology: To produce MMC, activated sludge was subjected to ecological pressure of aerobic dynamic feeding, in sequencing batch reactor selecting the PHA accumulators. PHA accumulation capacity of MMC was evaluated using batch, fed batch and continuous mode of bioreactor operation using acetate and waste water as feed.

Results: Experiment with waste water produced 71.63 % PHA per dry cell weight (DCW) in batch mode and continuous mode produced 65.38 % PHA per DCW hence yielding 242.21 tons and 296.46 tons of theoretical possible production per year respectively.

Recommendation: We recommend using continuous reactor due to its simplicity and ease of operation and ability to handle large quantity of feed in very small reactor volume.

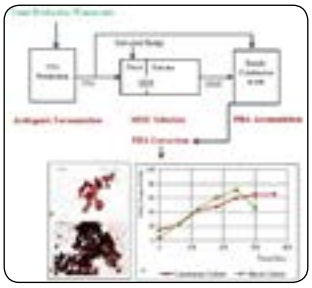

Figure 1: PHA production flow chart using Mixed Microbial Culture using Yeast industry wastewater. Fig a) and fig b) are respectively the microscopic images of PHA accumulation before and after feed, obtained after Sudan-black staining where PHA accumulating microorganisms are stained black and graph c) depicts the PHA accumulation per dry cell weight (DCW) for batch and continuous PHA accumulation experiment. (VFA: Volatile Fatty Acids; SBR: Sequencing Batch Reactor; MMC: Mixed Microbial Culture).

Recent Publications:

1. Althuri A et al. (2013) Microbial synthesis of poly-3-hydroxybutyrate and its application as targeted drug delivery vehicle. Bioresour. Technol. 145:290-296. Doi:10.1016/j.biortech.2013.01.106.
2. Bishai M et al. (2014) A comprehensive study on enhanced characteristics of modified polylactic acid based versatile biopolymer. 54(1):52-61. European Polymer Journal. Doi:10.1016/j.eurpolymj.2014.01.027.

3. Garlapati V K, Roy Lakshmishri and Banerjee R (2015) An Overview of Reactor Designs for Biodiesel Production. In book: Bioenergy: Opportunities and Challenges, Chapter: An overview of Reactor Designs for Biodiesel production. CRC Press. Page:221-240. Doi 10.1201/b18718-14.
4. Nogueira R, Alves C, Matos M and Brito A G (2009) Synthesis and degradation of poly-β-hydroxybutyrate in a sequencing batch biofilm reactor. Bioresource Technology. 100(7):2106-2110.
5. Tamang P, Banerjee R, Köster S and Nogueira R Comparative study of polyhydroxyalkanoates production from acidified and anaerobically treated brewery wastewater using enriched mixed microbial culture. (Submitted.

Biography

The main focus of Regina Nogueira research activities has been on the application of biological processes in water and wastewater treatment and their performance optimization. She has been involved in lab- and full-scale projects dealing with the diversity, dynamics and performance of different microbial populations for various reactor operation parameters, both for biofilms and suspended microbial populations. She has been implementing molecular methods like FISH and real-time PCR for the detection of key microorganisms in wastewater in order to give a fast response to the wastewater operators of the efficacy of their measures. More recently, she is working on the production of biopolymers using industrial wastewater from the brewery and yeast industries using microbial mixed cultures. Her aim is to contribute to the valorization of industrial wastewater and to bring to the market biopolymers with a competitive price.

nogueira@isah.uni-hannover.de

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