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Supercritical Carbon Dioxide Extraction of Polyhydroxyalkanoate from Activated Sludge and Biopolymer Characterization

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Abstract

Polyhydroxyalkanoates (PHA) are biodegradable in nature with the potential to substitute for fossil-fuel based polymers due to their similar properties. Many studies have been conducted on the production of PHA, but the extraction/purification processes have received less attention. Mostly, solvent extraction has been studied, as has the effect of different solvent types on separation processes. A better extraction method for PHA makes it a viable alternative to polymers derived from fossil fuels. A new protocol for extracting PHA from activated sludge using supercritical carbon dioxide disruption (sCO_2) and recovering biopolymers from disrupted cells was proposed in this study.

Keywords: Polyhydroxyalkanoates; Carbon dioxide; Biopolymer

Introduction

Waste valorisation is gaining popularity as a means of achieving more prosperous future and corporate sustainability goals. Biopolymers such as polyhydroxyalkanoates (PHAs), which are bio based, biocompatible, biodegradable, and non-toxic, are among the waste valorisation products (Yadav et al., 2021). PHAs are synthesised by a wide range of microorganisms under optimal conditions of excess carbon and nutrient limitation. Extraction experiments with sCO_2 were carried out at various pressures, temperatures, times, biomass amounts, and modifier volumes. The operation yield was calculated using the efficiency of polyhydroxybutyrate (PHB) release. The biomass used in the extraction experiments came from a PHA production reactor in which activated sludge was fed anaerobically pre-treated yeast industry wastewater [1-3].

Biomass materials

PHA accumulation experiments were conducted in a 3 L sequencing batch reactor (SBR) under a feast-famine regime. As a substrate for activated sludge, anaerobically pre-treated YWW was used. During the SBR operation, dissolved oxygen (DO) was monitored, and slurry was withdrawn when the DO increased, indicating the end of the feast. The slurry was centrifuged at 9000 rpm for 5 minutes before being freeze-dried. PHB concentration was determined using gas chromatography (GC-FID) as mg PHB per mg cell. By disturbing 2 g of biomass at a density of 57 g/L (biomass/volume) with sCO_2 at 200 bar pressure for 15 minutes at 40°C, 80% PHB releasing efficiency was achieved. Biopolymer PHB purity and molecular weight (Mv) were 80% and 0.27•106, respectively [4, 5] Methanol was used as a modifier during the sCO_2 disruption, which increased the Mv to 0.37•106. Fourier transforms infrared spectroscopy (FTIR) and thermal degradation analysis (TGA) revealed that the biopolymer recovered with this extraction protocol was comparable to commercial PHB. The operationally fast and simple extraction procedure achieved a clear advantage over the other extraction protocols. [6, 7].

Discussion

The sCO_2 process was used to study PHA recovery from microorganisms, as well as sCO_2 disruption, biopolymer recovery, and biopolymer characterization. [8].

Conclusion

This study shows how to extract PHA from activated sludge using a new protocol based on cell disruption with sCO_2 and biopolymer recovery from disrupted cells with chloroform. On Yrel, the effects of CDW, time, pressure, temperature, and volume of Me OH as a modifier were studied. 0.13 g biopolymer/g biomass was extracted with 80% releasing efficiency and 80% PHB content by disrupting 2 g of biomass at 200 bar pressure for 15 minutes at 40°C. [9, 10].

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Conflict of Interest

The authors declare that they are not aware of any personal relationships or competing financial interests that might have appeared to have influenced the work reported in this paper.

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