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Investigation into PHA synthase stereoselectivity for the production of PHB with improved material properties

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PURPOSE OF THE ABSTRACT

The transition to a sustainable future requires decarbonization in all sectors. This comprises the plastics industry that heavily relies on petroleum-based resources. An alternative to petroleum-based plastics is poly-3-hydroxybutyric acid (PHB), which is obtained by microorganisms via fermentation of renewable feedstock. However, the major two challenges in the production of PHB are its high manufacturing cost and inferior material properties compared to similar but petroleum-based plastics such as polyethylene [1]. As a highly crystalline material, PHB is brittle and breaks easily, limiting its range of applications. Additionally, a small window between melting and degradation temperature makes processing of PHB without thermal degradation challenging.

It is commonly believed that PHB is an isotactic polymer made exclusively from (R)-3-hydroxybutyric acid (HBA) repeating units, which contributes to its poor material properties. However, it was shown that as the content of (S)-HBA increases, brittleness decreases and the processing window between melting and degradation temperature widens [2]. Introducing (S)-HBA into PHB could therefore be an unexplored approach to enhance its material properties. Despite that, no investigation into the stereoselectivity of the PHB-producing enzymes, poly-3-hydroxyalkanoate (PHA) synthases, has been performed yet.

In our study, we investigated stereoselectivity of various wildtype PHA synthases by producing PHB from racemic substrate in vitro. From structural comparison of PHA synthases, we hypothesized that hydrophobicity of the active site pocket played a role in stereorecognition. Increased hydrophobicity could result in PHB with higher contents of (S)-HBA. Furthermore, size of the lower part of the active site pocket might also influence stereoselectivity by providing a larger volume for the recognition of unnatural substrates. This study could help to aid further work into the stereoselectivity of PHA synthases with a final goal to produce PHB with enhanced material properties.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS

Bioplastics | Sustainability | Polyhydroxybutyrate | Stereoselectivity

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