Production of Succinic Acid from Arundo Donax Hydrolysate for Bio-based Polymers Synthesis

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Abstract

The US Department of Energy (DOE) included succinic acid (SA) in the "Top 10" list of biomass-derived compounds, considering its high potential as building block in the field of the industrial chemistry. In fact, this dicarboxylic acid with four carbon atoms (1,4-butanedioic acid) represents an important precursor molecule for many chemical derivatives, used for food and pharmaceutical products, solvents, biodegradable polymers, surfactants and detergents. Nowadays SA is mainly produced by crude oil, starting from n-butane/butadiene via maleic anhydride. Due to its independence of petroleum, environmental benefit and reduction in CO_2 emissions, biotechnological production of SA from renewable feedstocks is gaining increasing attention in the last years. SA is an intermediate of the tricarboxylic acid cycle and one of the end products of the anaerobic metabolism. Extensive efforts have been made to optimize the SA biotechnological production, and they have principally concerned the development of biocatalysts to improve the productivity and the optimization of the downstream process to separate SA from the fermentation broths to minimize the process costs. The downstream purification costs affect about 60% of the total production costs. Furthermore, very high purity is often required in these cases. To this end, several methods of purification and separation, including electrodialysis, precipitation and extraction, have been studied and developed. Many companies such as Myriant, Everdia, BioAmber and Succinity established bio-based production platforms for the conversion of purified sugars to SA.
This work aims to provide an integrated process based on the biotechnological production of SA using a lignocellulose biomass (*Arundo Donax*) as raw material, for the synthesis of a biodegradable plastic, i.e. poly(butylene succinate) (PBS). The novelty lies in the type of raw material used, a harvested waste, to produce added value chemicals such as PBS. SA separation and purification procedure was developed and integrated to the fermentation process by a vacuum distillation at pH=4 to remove the volatile byproducts after a treatment with activated charcoal, followed by a final crystallization from mother solution. PBS was synthesized using SA, recovered and purified directly from its fermentation broth through the downstream protocol developed and optimized in this study. The synthesized polymers showed physical and mechanical properties comparable with a commercial PBS derived by crude oil, so highlighting the suitability of the proposed process.