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Bio-based succinic acid recovery by ion exchange resins integrated with nanofiltration/reverse osmosis preceded crystallization

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ABSTRACT

Succinic acid is a key platform chemical for production of various products such as biodegradable polymers, pharmaceuticals, fine chemicals and foods. In the present study, bio-based succinic acid was recovered through two processes. Process I consisted of chromatographic separation with anionic exchange resin followed by direct crystallization, whereas process II sequentially consisted of cationic exchanger, activated carbon, NF/RO membrane, vacuum distillation, and crystallization. The highest chromatographic separation efficiency for succinic acid by Amberlite IRA900 Cl column was calculated as 69.3% at flow rate of 0.42 BV/h. Rejection of succinic aid (SA), lactic acid (LA), formic acid (FA) and acetic acid (AC) by NF90 membrane was 53.1, 51.8, 46.6 and 39.8%, respectively at pH less than 2. However, at pH 6.8 the respective rejections increased to 96.8, 90.6, 71.3 and 70.5%. Double pass with BW30 or HP reverse osmosis membranes achieved retention of SA, LA, FA and AC of 95.9%, 95.8%, 65.4% and 46.9%, respectively. Analysis of generated SA crystals by X-ray diffraction technique (XRD) and Fourier transform infrared (FTIR) showed the crystallinity of recovered SA as conformable to standard grade crytsals. The purity of generated succinic acid crystals was recorded as 98.5% and 96.7% for process I and process II, respectively. The calculated succinic acid yield was 78% for process I and 65% for process II. Herein, we demonstrated two alternative systems for bio-based succinic acid recovery, which will set a stage for research in efficient downstream purification of SA.

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1. Introduction

Global consumption of succinic acid ($(CH_2)_2(CO_2H)_2$) is projected to grow owing to increasing demand in industrial production of biodegradable polymers, pharmaceuticals, fine chemicals and foods (Jusoh et al., 2020; Li et al., 2010; McKinlay et al., 2007). Currently, researchers are focused on bio-based succinic acid (SA) fermentation as a sustainable alternative to traditional production from petroleum synthesis. Many microorganisms have been identified to produce succinic acid at high titers and yield. These include; *Anaerobiospirillum succiniciproducens*, *Actinobacillus succinogenes*, *Mannheimia succini-ciproducens*, *Basfia succiniciproducens* and *Escherichia coli* (Olajuyin et al., 2016; Shen et al., 2018). Moreover, large quantities of liquid and solid wastes (food processing residues) from food industry have been successfully demonstrated for bio-based succinic acid production (Lam et al., 2014). However, formation of by-products during SA fermentation remains a major drawback in fermentative SA production. Furthermore, other impurities originate from nutrients supplements such as peptones and yeast extract which are added to enhance growth of micro-organism in fermentation broth. The costs associated with downstream SA recovery and purification are estimated to be 50–70% of the total SA production costs (Li et al., 2010; McKinlay et al., 2007).

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