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RESEARCH PAPER

Novel chromatographic purification of succinic acid from whey fermentation broth by anionic exchange resins

Philip Isaac Omwene[1,2] · Zehra Betül Öcal[1] · Meltem Yağcıoğlu[3] · Ahmet Karagündüz[1] · Bülent Keskinler[1]

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Abstract

Replacement of the petroleum-based refineries with the biorefinery is regarded as an essential step towards a “zero” waste (circular) economy. Biobased succinic acid (SA) is listed by the United States Department of Energy among the top ten chemicals with the potential to replace chemicals from petroleum synthesis with renewable sources. Purification of biobased succinic acid from fermentation by-products such as alcohols, formic acid, acetic acid and lactic is a major drawback of fermentative SA production. This study addresses this issue through a novel chromatographic separation using three distinct anionic resins: Amberlite IRA958 Cl (strong base anion exchange resin), Amberlite HPR 900 OH (strong base anion exchange resin) and Amberlyst A21 (week base anion exchange resin). The influence of process variables such as flow rate (0.18 BV/h, 0.42 BV/h and 0.84 BV/h), eluent concentration (1%, 5% and 10% HCl) and temperature (20, 30 and 40 °C) were investigated. The results indicated SA separation efficiency of 76.1%, 69.3% and 81.2% for Amberlyst A21, Amberlite HPR 900 OH and Amberlite IRA958 Cl, respectively. As the regenerant HCl concentration increased from 1 to 10%, calculated succinic acid separation efficiencies decreased from 80.3 to 70.7%. Notably, as the regenerant strength increased from 1 to 10%, the total amount of organic acids desorbed from the resin sharply increased. At operation temperatures of 20, 30 and 40 °C, SA separation efficacies were 81.2%, 73.9% and 76.4%, respectively. The insights from this study will be of great value in design of chromatographic separation systems for organic acids.

Keywords Succinic acid · Whey · Resins · Chromatography

Introduction

Succinic acid (or butanedioic acid) has been identified by the US. Department of Energy as a top replacement for petroleum-based platform chemicals [1, 2]. Industrial applications of succinic acid include production of detergents, ion chelators, pharmaceuticals, antibiotics and cosmetics [3, 4]. Furthermore, many essential products such as adipic acid, 1, 4-butanediol, tetrahydrofuran, *N*-methyl pyrrolidinone, 2-pyrrolidinone, succinate salts and gamma-butyrolactone can be synthesised from SA. Hence, demand for succinic acid is expected to grow rapidly in the next few decades [5]. Succinic acid fermentation from renewable resources like whey, straw hydrolysate and sugarcane molasses is cost-effective and promotes environmental sustainability compared to petroleum-based synthesis [6, 7]. Nevertheless, fermentative production of SA presents by-products such as alcohol, acetate, formate and lactic acid which lessen succinate yield, and as well require efficient downstream purification processes. Although most studies have realised improved succinic acid production through gene sequencing of metabolic pathways, engineered SA-producing strains still generate minor products that require purification. In a study by [8], the concentrations of two by-products, lactic and acetic acids, were reduced from 3.47 to 0.27 and 4.96 to 0.85 g/L, respectively, through genome-based metabolic engineering of *Mannheimia succiniciproducens*. In another study by [9], fed-batch fermentation succinic acid by engineered strains of *Mannheimia succiniciproducens* LPK7 resulted in production of 52.4 g/L of SA with a yield and productivity of 1.16 mol/mol of glucose and 1.8 g/L/h,

✉ Ahmet Karagündüz
akaragunduz@gtu.edu.tr

1 Department of Environmental Engineering, Gebze Technical University, 41400 Gebze-Kocaeli, Turkey

2 Faculty of Agriculture and Environmental Sciences, Muni University, P.O.Box 725, Arua, Uganda

3 Institute of Earth and Marine Sciences, Gebze Technical University, 41400 Kocaeli, Turkey