포스터 발표 P-36

탈염전기투석에 의한 모사발효액으로부터의 암모늄 락테이트의 회수

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Recovery of ammonium lactates from simulated fermentation broth by desalting electrodialysis

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Abstract

An experimental study was carried out on the recovery of ammonium lactate from simulated fermentation brothby desalting electrodialysis (DSED). All experiments, using AM-1 and CM-1 membranes, were operated in a constant current and a subsequent constant-voltage mode, and the switching point was determined based on the previous results. The effects of operating conditions such as operating current, initial feed concentration, and initial feed pH were investigated. Increased operating current resulted in a decreased operating time but an increased energy consumption per unit amount of ammonium lactate recovered. As the initial feed concentration was increased, the operating time increased while energy consumption decreased. The operating time and energy consumption slightly decreased as the initial feed pH was increased up to 6.0. However, no significant influences on the recovery of ammonium lactate were observed over 6.0. The rejections of acetate, glucose, and proteins were 10 %, 93%, and 98%, respectively. Sulfate was not rejected at all.

1. Introduction

Lactic acid is a commodity chemical utilized in the food, chemical and pharmaceutical fields. Lactic acid can currently be manufactured either by fermentation or by chemical synthesis. While chemical synthesis route produces only a racemic mixture of lactic acid, a fermentation process can produce a stereoisomer of lactic acid. A number of processes for lactic acid recovery from fermentation broth without precipitation have been studied: solvent extraction, adsorption, direct distillation, and electrodialysis. Electrodialysis is an attractive process in the point of fast treatment, effective removal of non-ionic molecules, concentration of product and no by-product generation. Electrodialysis is based on electromigration of ions through cation or anion exchange membranes that permit the passage of positive or negative ions, respectively.

In this study, the effects of various operating conditions were investigated on lactate recovery, current efficiency, and energy consumption. Based on these preliminary experiments, ammonium lactate was recovered from simulated fermentation broth.

2. Materials and methods

Materials

Preparation of simulated fermentation broth

Lactic acid in a concentrated form was purchased from Purac (Spain). Lactic acid solution was prepared by dilution and boiling over 12 h to break down lactic acid oligomers. Synthetic feed solutions of ammonium lactate for desalting were prepared by adding ammonium hydroxide to lactic acid solution until pH of lactate solution reached 5.5. Simulated fermentation broth wasprepared by adding glucose (15.60 g/L) and protein (BSA 0.26 g/L), acetate (0.58 g/L), sulfate (0.17 g/L) to ammonium lactate solutions (1.5 M).

DSED equipment

The DSED unit (Model TS3B-2-5, Tokuyama, Japan) consisted of a membrane stack with 5 cell pairs, a power supply (max. 35V, 20A), three pumps, three solution tanks, and heat exchanger for conserving 30oC. In the membrane stacks of DSED, anion exchangemembranes (Neosepta AM-1, Tokuyama) and cation exchange membranes (Neosepta CM-1, Tokuyama) were arranged alternatively.

Methods

Effects of operating conditions

To examine the effects of initial operating current, currents were verified from 8 to 12 A. Initial feed pH was verified from 5.0 to 7.0 to know the effects of initial feed pH. To investigate the influences of initial feed concentration, concentrations were changed from 1.0 to 2.0 M. Under otherwise specified, DSED was performed under the following conditions; initial pH, 5.5; initial feed concentration, 1.5 M; initial current, 12A; flow rate, 1.6 L/min.

Ammonium lactate recovery from simulated fermentation broth

In recovery of ammonium lactate form simulated fermentation broth, the pH was fixed at 5.2 that is same as real fermentation broth and feed concentration was 1.5 M. DSED wasoperated at 12A (the constant-voltage mode) and switched to theconstant-current mode at the point determined from our previous results.

3. Results and discussion

Effects of operating conditions

As the initial current was increased, time to recovery 98 % of lactic acid was getting shorten, however, energy consumption was increased. (table 1). The operating time and energy consumption decreased in small quantities as the initial feed pH was increased up to 6.0. However, no significant influences on the recovery of ammonium lactate were observed over 6.0. (table 2) An increase in the initial feed concentration resulted in a increased operating time and a decreased energy consumption per 1 mol ammonium lactate. (table 3)

Table 1. Effects of initial current on DSED

Operating current [A]	Operting time [min]	Recovery [%]	Current efficiency [%]	Energy consumption [Wh/mol]	Recovery rate [mol/m^{2}h]
8	360	99	91	10.1	6.4
10	320	98	93	13	7.9
12	240	99	92	14.7	9.6

Table 2. Effects of initial feed pH on DSED

Operating concentration [M]	Operating time [min]	Recovery [%]	Current efficiency [%]	Energy consumption [Wh/mol]	Recovery rate [mol/m^{2}h]
1	140	98	89	18.7	8.2
1.5	190	98	90	15.4	9.1
2	240	99	92	14.4	9.6

Table 3. Effects of initial feed concentration on DSED

pH	Operating time [min]	Recovery [%]	Current efficiency [%]	Energy consumption [Wh/mol]	Recovery rate [mol/m2h]
5	265	95	91	16	8.7
5.5	260	98	90	13.9	8.9
6	247	98	90	13.1	9.4
7	240	98	90	13.5	9.4
8	255	98	90	13.1	9.3

Ammonium lactate recovery from simulated fermentation broth

Fig. 1 shows that the results of lactate recovery from simulated fermentation broth. Lactate was recovered over than 96 %, effectively. Rejection of acetate was 10 % and sulfate was not rejected at all. It suggests that ionic materials can migrate to the permeate. On the other hand, nonionic materials such as glucose and protein rejected over 93 %, efficiently. The results of experiments show that the DSED have the benefits to separate ioninc materials (lactate, sulfate, and acetate) and nonionic materials (glucose and protein).

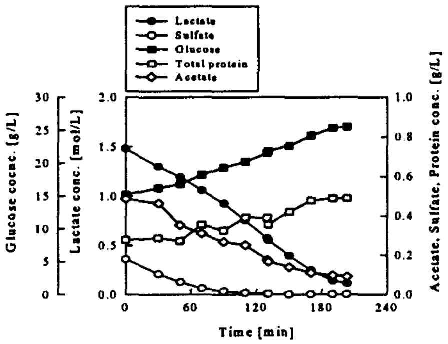

Fig. 1 Recovery of ammonium lactate from simulated fermentation broth by DSED

4. References

1. Eun Gyo Lee, Seung-Hyeon Moon, Yong Keun Chang, Ik-Keun Yoo, Ho Nam Chang, *Journal of Membrane Science* (1998) **145** 53-66

2. Boniardi, N. *et al.*, *Separations technology*,(1996), **6** (1), 43-54