# A SIMULATED MOVING-BED ADSORBER WITH THREE ZONES FOR CONTINUOUS SEPARATION OF L-PHENYLALANINE AND NaCl

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## Introduction

A simulated moving-bed adsorber has been successfully used for the continuous separation of binary components.[1-4] As shown in **Fig. 1**(a), a simulated moving-bed adsorber usually consists of four zones, each of which has an inherent function. Zone I functions to adsorb the less adsorptive component, to recover it in the raffinate stream at a high concentration, and to make the liquid emerging from the zone contain neither of the components. This zone is, however, not always necessary when only the more adsorptive component emerging into the extract stream is to be recovered and the less adsorptive one is not needed. For such a case, a simulated moving-bed adsorber consisting of three zones, shown in Fig. 1(b), may be effective for the following reasons: (1) the absence of zone I facilitates the operation; and (2) since the liquid from the raffinate never returns to the desorbent stream (see Fig. 1(b)), the purity of the component emerging into the extract stream is guaranteed even when the flow rate of the liquid in zone II may be changed.

In fermentation industries, desalination of amino acids is an important process in downstream treatment. In the desalination process, it is necessary to recover only the amino acids since the salts are less valuable and are disposable. Therefore, employment of the simulated moving-bed adsorber with three zones may be possible for the recovery of amino acids. The purpose of this work was to examine experimentally the usefulness of the simulated moving-bed adsorber with three zones for this separation system.

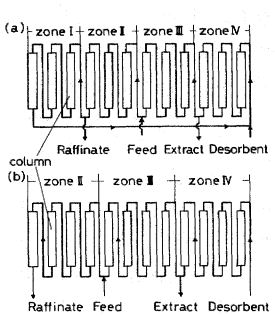


**Fig. 1.** Schematic representation of a simulated moving bed adsorber with four zones and that with three zones

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## 1. Experimental

The experimental apparatus and the operating method were described in the previous paper.[4] Four columns were located in each of three zones. Distilled water was used as a solvent. The apparatus was kept in a thermostatic chamber at 298 K. Amberlite XAD-7 (from Japan Organo Co., Ltd.) was adopted as adsorbent. L-Phenylalanine was adsorbed on the hydrophobic resin much more than NaCl due to its hydrophobicity.

The concentration of L-phenylalanine was determined from the absorbance at 272 nm with a spectrophotometer (Shimadzu UV-240, Japan). The concentration of NaCl was determined with a conductivity meter (M & S Instruments Inc. CD-35MII, Japan). Both the chemicals used were of analytical grade (Wako Pure Chemicals Co., Ltd., Japan).

The adsorption isotherms were determined from breakthrough curves. Since the isotherm of L-phenylalanine had been found to depend on the concentration of NaCl, its isotherm was determined as follows: 1) The bed was saturated by NaCl solution of a certain concentration. 2) L-phenylanaine solution of a certain concentration, which was mixed with NaCl of the same concentration as that in the bed, was introduced to the inlet of the bed column, and the concentration change was observed at the outlet of the column. 3) the concentration of L-phenylalanine was changed, and the same experiments were repeated. 4) The NaCl concentration in the bed and the solution was changed.

The bed voidage was determined by measuring the response curve of a pulse input of 1% Dextran T-500 (Pharmacia Co., Ltd.: $M_w = 5.1 \times 10^5$) solution. The apparent density of the resin was pycnometrically measured.

## 2. Results and Discussion

The apparent density of Amberlite XAD-7 is 1063 kg/m$^3$, and its mean diameter is 370 $\mu$m. No bed shrinkage by contact with NaCl solution was observed.

The adsorption isotherms of L-phenylalanine solutions having different concentrations of NaCl and the isotherm of NaCl onto the resin at 298 K are shown in **Fig. 2**. The isotherm for NaCl is linear, independently of the concentration of L-phenylalanine. The equilibrium relation of L-phenylalanine is presented by a Langmuir type equation. The dependency of the coefficient $k_A$ in the isotherm on the concentration of NaCl was empirically represented by the following parabolic equation.

$$\rho q_p = \frac{1.14 k_A C_p}{1 + K_A C_p} \quad \text{(for L-phenylalanine)}$$

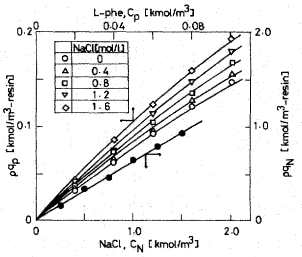


**Fig. 2.** Adsorption isotherms of L-phenylalanien and NaCl on Amberlite XAD-7 at 298 K

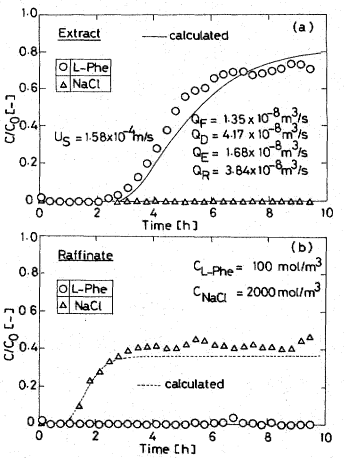


**Fig. 3(a).** Transient changes in concentration of L-phenylanine and NaCl in the Extract stream

**Fig. 3(b).** Transient changes in concentration of L-phenylalanine and NaCl in the Raffinate stream

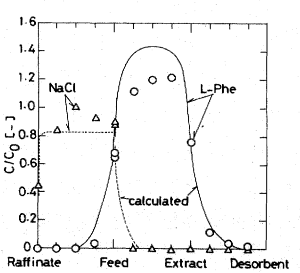


**Fig. 4.** Concentration profiles of L-phenylalanine and NaCl in the simulated moving-bed adsorbed with three zones at steady state

$$K_A = 0.0975 C_N^2 + 0.199 C_N + 1.470$$

$$\rho q_N = 0.636 C_N \quad \text{(for NaCl)}$$

Subscripts $p$ and $N$ denote L-phenylalanine and NaCl, respectively. $\rho$ is the apparent density of the bed.

The overall volumetric mass transfer coefficients were determined by matching the calculated breakthrough curves with the observed ones, yielding about 0.02 s$^{-1}$ and 0.03 s$^{-1}$ for L-phenylalanine and NaCl respectively.

**Figures 3**(a) and (b) illustrate the transient changes in the concentrations of L-phenylalanine and NaCl in the extract and raffinate streams respectively. The operating conditions are also presented in the figures. **Figure 4** shows the concentration profiles at steady

state in the adsorber. The solid and dotted lines in Figs. 3 and 4 indicate the calculated concentration changes of L-phenylalanine and NaCl, respectively, which were obtained by calculation based on an extended version of the intermittent moving-bed model.[4)]

L-Phenylalanine was exclusively recovered in the extract stream as predicted by the calculation, and its purity based on weight was confirmed to be higher than 0.998. The amino acid with very nearly 100% purity was obtained constantly throughout the experimental period, though its concentration in the raffinate changed slightly as shown in the Fig. 3(b) because of unexpected changes of the flow rates of the liquid in Zones II and IV.

This indicates that the high purity of the more adsorptive component in the extract stream is guaranteed irrespective of a slight change of the liquid flow rate in Zones II and IV. The validity of a simulated moving-bed adsorber with three zones was experimentally confirmed.

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