The Effect of Temperature upon Foam Fractionation

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Abstract

An experimental investigation is presented of the effect of temperature on the foam fractionation of the ethylhexadecyl(dimethyl)ammonium bromide-water system. Two feed concentrations, two foam heights, and a temperature range of 14–34°C are included. For each fixed set of values of feed concentration and of foam height, the greater and lesser coefficients of fractionation are both increasing functions of temperature. The effect of a variation in temperature on the greater coefficient is more pronounced for more dilute feed solutions, and at greater foam heights. The effect of a temperature change on the lesser coefficient is more pronounced for more concentrated feed solutions and is not related to foam height. At any fixed temperature, an increase in feed concentration at constant foam height generally decreases the greater coefficient and decreases the lesser coefficient. An increase in foam height at constant feed concentration increases both coefficients. The greater and lesser coefficients may be related to temperature by power equations with 5% accuracy. The above results may be explained qualitatively on the basis of the response of foam stability and drainage to temperature.

Introduction

Foam fractionation has been utilized by chemists, biochemists, and engineers for the separation of organic and inorganic materials from dilute aqueous solutions. Applications of the process include the separation of enzymes, the transfer of organic solutes which by themselves have little foaming ability, the separation of non-biodegradable organics. Several extensive reviews of the process have appeared in the literature (1,11,12). Recently, a number of studies have been made of the operating and system variables affecting the process. Grieves et al. have determined the influence of foam height and foam column diameter (7), the influence of surfactant, feed concentration, and feed rate (5,6,8), the effect of liquid solution height (7,8) and the effect of feed position (5,8) upon the continuous foam fractionation of anionic and cationic surfactants. Other studies of this nature have been conducted by Kevorkian (9), by Kishimoto (10) and by Brunner and Lemlich (2).

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REFERENCES


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Results and Discussion

Results of the experiments are presented in Figures 1-4 in which the greater and lesser coefficients of fractionation are related to temp. Temp investigated ranged from 14-54°C. The greater coefficient is defined as \( y_f/x_i \) and the lesser coefficient as \( x_r/x_i \), in which \( x_i \) (mg/liter) is the conen of EHDA-Br in the feed solution, and \( y_f \) and \( x_r \) are the conen in the collapsed foam and residual solution, respectively. For each experiment, the following material balances may be written:

\[
V_i = V_r + V_f \tag{1}
\]

\[
x_iV_i = x_rV_r + y_fV_f \tag{2}
\]

\( V_i, V_r, \) and \( V_f \) are the volumes in ml of feed solution, residual solution and collapsed foam, respectively. \( V_i \) was held constant at 2000 ml. For given \( x_i \) and \( V_i, y_f \) may be computed from experimental values of \( x_r \) and \( V_r \), using Equations 1 and 2.

Figure 1 shows the effect of temp on the greater coefficient for 87.5 mg/liter feed solutions, with parameters of foam height (\( H_f \), cm). Figure 2 presents similar relations for 125 mg/liter feed solutions. For each fixed set of values of \( x_i \) and \( H_f \) (i.e., for each curve), an increase in temp always provides an increase in the greater coefficient of fractionation. The effect of a variation in temp, \( [(x_r/x_i)@t_1/(x_r/x_i)@t_2] \), is most pronounced for \( x_i = 87.5 \) mg/liter and \( H_f = 77.8 \) cm. For constant \( x_i \), the influence of a variation in temp in always greater at the larger foam height, particularly at higher temp. The slopes of the \( y_f/x_i \) vs. temp curves sharply increase at high temp for \( H_f = 77.8 \) cm, while they tend to decrease slightly or become constant for \( H_f = 15.2 \) cm. Comparing results for both feed conen (at constant \( H_f \)), the effect of temp variation is greater for the more dilute feed solutions, but only at \( H_f = 77.8 \) cm. At \( H_f = 15.2 \) cm, the effect is minimal; however some of the response may have been shielded by the higher nitrogen flow rate that was used with the more dilute solutions. It has been shown previously (5) that an increase in gas rate with all other variables held constant provides a less rich foam. Considering both figures, at 15°C \( y_f/x_i \) ranges from 1.41-2.44, while at 48.5°C \( y_f/x_i \) ranges from 2.43-7.21. Thus at higher temp, variations in feed conen and foam height have a more marked influence on the greater coefficient of fractionation.

Figure 3 presents the variation of the lesser coefficient with temp for a foam height of 15.2 cm; the parameters are feed conen. Figure 4 shows similar relations for a foam height of 77.8 cm. For each fixed set of values of \( x_i \) and \( H_f \), an increase in temp always brings about an increase in the lesser coefficient. For any fixed temp, an increase in \( x_i \) decreases \( x_r/x_i \) (at constant \( H_f \)), which is more pronounced.

**Fig. 1.** Relationships between the greater coefficient of fractionation and temp for 87.5 mg/liter feed solutions.

**Fig. 2.** Relationships between the greater coefficient of fractionation and temp for 125 mg/liter feed solutions.

**Fig. 3.** Relationships between the lesser coefficient of fractionation and temp for a foam height of 15.2 cm.

**Fig. 4.** Relationships between the lesser coefficient of fractionation and temp for a foam height of 77.8 cm.