EFFECTIVE METHOD FOR ETHANOL SEPARATION FROM FERMENTATION BROTH

Nadaphast Koomklang, Bundit Leelasart and Pairoje Kijjanapanich
Department of Chemistry, Faculty of Sciences, Chiang Mai University, Chiang Mai 50200, Thailand

The aim of this work was to improve the ethanol separation from fermentation broth using extractive distillation technique. Anhydrous ethanol could be obtained from fermentation broth via extractive distillation with potassium acetate. Two processes with pre-concentration of ethanol from fermentation broth were proposed. In the first method, ethanol was separated from fermentation broth by conventional distillation. Then, the concentrated ethanol was dehydrated by salt extractive distillation. In the second method, ethanol was separated from fermentation broth by low pressure distillation and then followed by salt extractive distillation. Results showed that the second process was more effective in terms of energy and salt consumptions. Furthermore, it would be practical for industrial application because low-pressure distillation and salt extractive distillation techniques were easy to control and offer high selectivity and good separation.

Keywords: ethanol separation, salt extractive distillation, anhydrous ethanol

*corresponding author: Nadaphast Koomklang (E-mail: jaja_biot@hotmail.com)

Introduction: Nowadays, production of fuel ethanol from biomass has potential as an alternative energy source (James, 1996). The ethanol that is used for gasohol must be concentrated over 95%. Extractive distillation with liquid separation agents such as benzene, pentane and toluene is the most frequently used method for ethanol separation in industry because of high selectivity and good separation. Several authors (Ligero and Ravagnani, 2003, Pinto et al, 2000) have demonstrated that it is possible to separate ethanol with high purity level by using proper salts. The salt is lower toxicity level, cost and safety comparing with liquid separation agents. In addition, the salt is non-volatile component. So, anhydrous ethanol from salt extractive distillation is free from the separation agent. The salt chosen is very important to be successful in ethanol separation. The salt, that used in the both processes in this study was potassium acetate. Because of, it is able to completely eliminate ethanol-water azeotrope under atmospheric pressure (Ligero and Ravagnani, 2003). In this study, concentrated ethanol was separated from fermentation broth by using low pressure distillation to remove the large amount of water compared with using conventional distillation.

Methods: Ethanol fermentation was obtained in a batch system using pineapple juice with Saccharomyces cerevisiae. The composition of this culture solution was as follows (per liter): pure water 500 mL, pineapple juice 500 mL, sucrose 30-50 g. This culture solution was autoclaved at 394 K for 20 min. Fermentation was carried out in batch fermenter at room temperature. After 24 h. of fermentation, ethanol concentration in the broth was 11-14 (v/v) %.

1. Process with pre-concentration ethanol using conventional distillation.

In this process, fermentation broth was distilled by conventional distillation. The temperature was controlled between 348 K and 363 K. From this step, ethanol was separated from fermentation broth. This concentrated ethanol was then, distilled in two distillation columns, which operated in the present of various potassium acetate concentration (30, 50, 70, 90 (wt.) % respectively). Concentrated ethanol from the first salt extractive distillation column was re-distilled by the second salt extractive distillation column, which produce anhydrous ethanol.

2. Process with pre-concentration ethanol using low pressure distillation.

The second process, pre-concentration ethanol step using low pressure distillation. The temperature and pressure was controlled at 323 K and 85 milibar, respectively. This concentrated ethanol from low pressure evaporation was then,
distilled in two distillation columns, which operated in the present of various potassium acetate concentration as first process.

Results and Discussion:
Pre-concentration of fermentation broth

Ethanol concentration from conventional distillation was 36.0 (v/v) %, while ethanol concentration from low pressure distillation was 72.0 (v/v) %.

The first salt extractive distillation column

1. Concentrated ethanol from conventional distillation.
After, concentrated ethanol from conventional distillation was distilled by the first salt extractive distillation column. From this step, ethanol concentration at 70 (wt.) % of potassium acetate was 90.75 (v/v) %. It to be close to ethanol concentration at 90 (wt.) % of potassium acetate, which ethanol concentration was 91.56 (v/v) %

2. Concentrated ethanol from low pressure distillation.
The result clearly supported the 2.5 fold decrease in quantity of potassium acetate of low pressure distillation compared to conventional distillation at 93.5 (v/v) % of ethanol concentration. Until the potassium acetate concentration was 70 (wt.) %, the distilled purity from both process was not be difference as show in Fig 1.

The second salt extractive distillation column

The most ethanol concentration from both processes (91.56 (v/v) % and 93.5 (v/v) % from first process and second process, respectively) was chosen to re-distillate using the second salt extractive distillation column with various potassium acetate concentration as the first salt extractive distillation column. In this step, the distilled purity from both processes was adjacent ethanol concentration at the same quantity of potassium acetate. The most of ethanol concentration from the first, which using conventional distillation in pre-concentrating step was 96.77 (v/v) %, while the most ethanol concentration from the second, which using low pressure distillation in pre-concentrating step was 99.1 (v/v) % as show in Fig 2.

Fig 1. Show the effect of salt concentration in first salt extractive distillation column on distillated purity.

Fig 2. Show the effect of salt concentration in second salt extractive distillation column on distillated purity.

These results show that, the pre-concentration ethanol using low pressure evaporation with salt extractive distillation can produce 99.1 (v/v) % ethanol and using of low pressure evaporation in pre-concentration of fermentation broth requires lower quantity of potassium acetate than conventional distillation.

References:

Authors take full responsibility for the contents of their paper.