Energy Efficient Extractive Distillation of Acetonitrile-Water mixture by Combining Preconcentration Column and Entrainer Recovery Column

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Introduction

The chemical acetonitrile may be separated using ethylene glycol as an entrainer from acetonitrile-water mixture. Conventionally, it was being separated by using three different columns: Preconcentration column, Extractive Distillation column and Entrainer Recovery column. Because of three columns the energy consumption is more. In this study, an innovative energy efficient as well as lower capital investment distillation process is described [1]. The development based on a classic three-column conventional system by combining preconcentration column and entrainer recovery column. Here we have tried to simulate the proposed flowsheet with DWSIM.

Development of Flowsheet in DWSIM

All the specifications of the unit operations and thermodynamics are elaborated in the literature. So we have used all the specifications as they are. Here, we have used UNIFAC as the thermodynamic property package instead of NRTL (used in literature), because the prediction of the azeotrope point is matching in both cases.

For more details about the unit operation specifications and the stream properties, please refer to the flowsheet and literature.

Purpose of Study

In the last study, we can observe that two product streams with almost pure water are obtained from the bottom of the preconcentration column and from the top of the entrainer recovery column, which gives us an opportunity to save energy with lower cost. Instead of cooling the overhead vapor of the entrainer recovery column, the vapor can be directly fed to the bottom of the preconcentration column, which provides part of the vapor required for the preconcentration column. Thus, the vapor flow provided by the reboiler of the preconcentration column can be reduced and thereby provide a significant decrease in reboiler heat duty and heat transfer area. Part of the internal liquid in the bottom of the

preconcentration column can be directly fed to the top of the entrainer recovery column as the liquid phase flow, thus saving one condenser as well.

Description of Flowsheet

This new model consists of two columns instead of three. These two units are: Combined Preconcentration/Entrainer Recovery column and Extractive Distillation column. In this simulation, two pure water product streams (in our last simulation) are merged as one pure water stream is withdrawn as a liquid side stream of the first stream. The first column can be divided into two sections: Preconcentration section and Entrainer Recovery section that correspond to the preconcentration column and the entrainer recovery column in the conventional distillation system respectively. It is worth noting that the intermediate the heat exchanger is optional for this side stream of pure water. If the vapor flow rising from the top of the entrainer recovery section is not sufficient, a side stream reboiler can also be installed to provide the rest of the vapor required.

A stream of flow rate 500 kmol/h containing 20 mol% acetonitrile and 80 mol% water is fed to preconcentration section of combined preconcentration/entrainer recovery column. From the top of the preconcentration section a distillate product approaching the azeotropic concentration of MeCN-H_2O mixture (minimum boiling azeotrope of 68% MeCN at 1 atm) and sent to the extractive distillation column. EG is also fed in this column as an entrainer. The addition of EG will alter the relative volatility between MeCN and H_2O, causing MeCN as to be more volatile. Therefore, MeCN as a pure product is recovered from the top of the column while the mixture of H_2O and EG is withdrawn as the bottom product. This bottom product is fed to entrainer recovery section of the first column to recover pure EG in the bottom and pure H_2O is withdrawn from the side stream as said before. This EG stream is again recycled to the extractive distillation column. A small makeup steam of EG is added to balance tiny entrainer losses. A heat exchanger is also employed between extractive distillation column and entrainer recovery section to reduce the temperature to 72 ^{o}C of recycle stream.

Result

Object	Feed	Pure Water	Pure Acetonitrile	Pure Ethylene Glycol	Make-up Ethylene Glycol	Unit
Flow Rate	500	400.032	97.9701	144.938	0.00048	**kmol/h**
Acetonitrile	0.2	0	0.9999	0	0	**mol/mol**
Water	0.8	0.9999	0	0	0	**mol/mol**
Ethylene Glycol	0	0	0	0.9999	1	**mol/mol**

References

[1] W. L. H. L. M. X. a. C. X. Kai Liang, “Energy-Efficient Extractive Distillation Process by Combining,” *Industrial & Engineering Chemistry Research,* 2014.