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Enhancement in Separation Process of Ethanol-Water by Using Surfactant

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Abstract*: This paper shows the investigation done in distillation of ethanol-water mixture which is necessary while yielding ethanol from fermentation process. The aim of this paper is to study time required and energy consumption in distillation process of ethanol-water mixture by addition of surface active agents. Here SDS (Sodium Dodecyl Sulfate) and SLBS (Sodium laurylbenzenesulphonate) two types of surfactant in different concentration were used. The concentration of these surfactant varied from 1600 ppm to 2800 ppm. Result shows that as concentration of the surfactants increases up to 2000 ppm time required and energy consumed decreases. After 2000 ppm time required and energy consumption increases but remains below than that of without addition of surfactant. Result also shows that SLBS gives better separation purity of ethanol than SDS.
***Keywords*: Distillation, Ethanol-Water separation, Sodium Dodecyl Sulphate, Sodium laurylbenzenesulphonate, Separation purity**

I. INTRODUCTION

The production of fuel grade bioethanol has gained attention recently due to two main reasons. First, it is used gradually / frequently as an oxygenated fuel instead of methyl t-butyl ether (MTBE). The second reason is related to its potential to be used as an alternative fuel. The bioethanol fuel is produced mainly by the sugar fermentation process; although it can also be manufactured by the chemical process or as a byproduct of some chemical processes. The main sources of ethanol are sugar and crops. The crops are grown specifically for energy use and include corn and wheat crops, waste straw, willows and popular trees, sawdust, cane grass, string grass, Jerusalem artichoke, myscanthus plants and sorghum. There is also ongoing research on the use of municipal solid waste to produce ethanol fuel. Ethanol or ethyl alcohol (C_2H_5OH) is a clear and colorless liquid, which is biodegradable, of low toxicity and causes little environmental contamination if it is spilled. Ethanol is burned to produce carbon dioxide and water. It reduces pollution associated with petroleum products such as SO_x and NO_x.

Alternative fuel production is due to the fact that stocks of crude oil are limited, hence the shift towards more renewable sources of energy. Bioethanol have received growing attention as excellent alternative fuel and have virtually unlimited growth potential. However, the main challenge facing bioethanol production is the separation of high purity bioethanol, because bioethanol contains water. The separation of ethanol from water is difficult due to the existence of an azeotrope in the mixture. Therefore, for these purposes of removing the ethanol from the ethanol and water mixture, I am going to study the effect of addition of surfactants such as SDS and SLBS into the mixture to improve the process, that is, to reduce the time required and energy consumption for the separation process.

II. LITERATURE REVIEW

Yang et al. [1] studied the effect of surface tension on the surfactant solution. They discovered that surface tension had a significant influence on heat transfer. Hetsroni et al. [2] investigated the nucleate pool boiling of pure water and water with cationic surfactant. They discovered that surface tension and kinematic viscosity have a large impact on the heat transfer coefficient. At a low concentration below 530 ppm, the heat transfer coefficient increases due to the decrease in surface tension. However, for high concentration (1060 ppm), the heat transfer coefficient decreased due to the increase in kinematic viscosity. Inoue et al. [3] observed in his experiment that the coefficients were improved in a fraction of lower ethanol and in low heat flow that is slightly higher than the heat flow in the start of boiling. It was also found that the improvement due to the surfactant disappears at more than 1000 ppm. Zhang [4] confirmed the hypothesis by measuring many interfacial properties such as dynamic and equilibrium surface tensions, wettability for different surfactants solutions. It was shown that a dynamic surface tension, which decreases to an equilibrium value after a long duration, is the most critical factor of the phase change phenomenon because it has a great impact on the adsorption-desorption process of the surfactant, which is the dependent on time. Nafey et al. [5] studied the effect of surfactant additives on the solar water distillation process. Different concentrations of sodium lauryl sulfate (SLS) including 50, 100, 200 and 300ppm were used in this work. The results showed that the daily productivity of the system (DP) was not affected when the concentration of surfactant reached more than 300 ppm. On the contrary, it was observed that the DP was reduced by 6% at a surfactant concentration of more than 400 ppm. The authors attributed the increase in DP to depression of surface tension. Ngema [6] studied the methods of extraction and pervaporation of the separation of pure ethanol from the mixture of ethanol and water. The extraction process requires salt for separation and the pervaporation process did not require salt for it. It also reviews different types of separation agents used in the extraction process. Elghanam et al. [7] carried out an experimental study to enhance saturated nucleate pool boiling by means of surfactant additives. Sodium dodecylsulfate (SDS) and sodium lauryl ether sulfate (SLES) as anionic and Triton X-100 as non-ionic were used as surfactants, and the working fluid was distilled water. The percentages of heat transfer improvement reached 133% for Triton X-100, 185% for SLES and 241% for SDS. They concluded that the depression of surface tension is the main reason. Peng et al. [8] experimentally studied effect of surfactant additives on nucleate pool boiling heat transfer of refrigerant-based Nano fluid. In these experiments three types of surfactants were used namely sodium dodecylsulfate (SDS), cetyltrimethyl ammonium bromide (CTAB) and sorbitan monooleate (Span-80). The refrigerant-based Nano fluid was formed from Cu nanoparticles and R113 refrigerant. They observed an improvement in boiling performance under most conditions, except at high concentrations of surfactant. Zicheng et al. [9] investigated the performance of surfactant additives (99% sodium dodecyl sulfate (SDS) and Triton X-114) in the nucleate pool boiling heat transfer. The experimental results showed that an optimal heat transfer augmentation was achieved near the critical micelle concentration (CMC) of the surfactants. The authors attributed the increase in heat transfer to many characteristics, such as the influence of surfactant species, the decrease in surface tension and the effect of the contact angle. In addition, efforts have been made to understand the effect of bubble diameter and bubble dynamics on boiling performance. Acharya et al. [10] have presented the literature review on augmentation of heat transfer in boiling using surfactants. They presented that the effect of surface roughness on heat transfer decreases with increasing pressure and with increasing heat flow. Also the reduction of the surface tension due to the surfactant greatly improves the heat transfer coefficients in the nucleate pool boiling. The objective of the study was to conduct studies of heat and mass transfer in the pool boiling phenomenon (for water and LiBr-H_2O) with and without surfactants and identify their optimum quantity for commonly used additives.

From above discussion it is clear that by addition of surfactants like SDS heat transfer in nucleate pool boiling increases significantly except at high surfactant concentrations that is above the CMC value.

III. EXPERIMENTAL

A. Apparatus

The apparatus for the separation process is fractional distillation because of azeotropic nature of the ethanol-water mixture. It consists of heating mantle having 1 litre capacity, round bottom flask, fractionating column, water condenser and receiving flask.

Fig. 1 Fractional distillation set-up

B. Experimental procedure

Ethanol concentration considered here is 10% and 20% (v/v). First ethanol-water mixture separated using fractional distillation apparatus and then the effect of addition of surfactant at concentration from 1600 ppm to 2800 ppm is studied. The flow rate of water in condenser is kept constant for all the readings. Heat input given is also kept constant.

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IV. RESULTS AND DISCUSSIONS

Fractional distillation of ethanol-water mixture of 500ml solution was carried out to determine time required to distillate and energy consumption for the process. The following table shows the data calculate without addition of the surfactant.

TABLE I Details of Distillation Readings Without Surfactant

Ethanol % in Mixture	Time Required to Distillate (minutes)	Specific Gravity After Distillation	% Ethanol by Volume in Distillate Mixture	Surface Tension of Mixture Before Distillation(Dyne/cm)	Energy Consumption (Kwh)
10	30.56	0.9038	64.1810	46.51	0.10672
20	30.20	0.87606	75.41221	36.48	0.10465

A. *Effect of SLBS and SDS at Different Concentration on Distillation of 10% Ethanol and Water Mixture*

Surfactant is well known to increase the heat transfer rate in boiling up to CMC (Critical Micelle Concentration) values. SLBS (sodium lauryl benzene sulphonate) and SDS (Sodium Dodecyl Sulphate) were used with 1600,1800,2000,2400 and 2800 ppm in ethanol-water mixture.

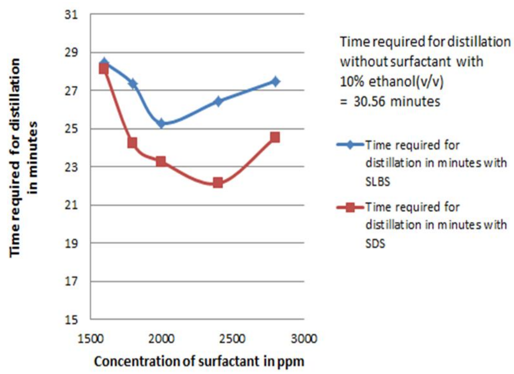

Fig. 2 Variation of Time required for distillation with concentration of surfactant for 10% ethanol (v/v) mixture

Fig. 2 shows the comparison between SLBS and SDS for 10% ethanol-water mixture. The graphs shows that SDS decreases the time required for distillation up to 2400 ppm and then it again starts to increase. For SLBS the case is same but SDS provides better result that is it increases the heat transfer rate more than the SLBS. The percentage decrease in distillate time for SLBS is 17.21% at 2000ppm and for SDS it is 27.59% at 2400ppm.

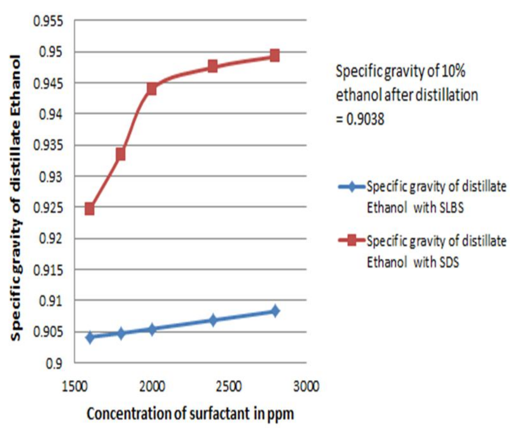

Fig. 3 Variation of Specific gravity after distillation with concentration of surfactant for 10% ethanol (v/v) mixture

Fig. 3 gives the variation of specific gravity with different concentration of surfactant. In this case SLBS provides better specific gravity variations than the SDS. The percentage variation in specific gravity for SLBS is (0.04% to 0.5%) and for SDS it varies from (2.31% to 5.02%).

B. Effect of SLBS and SDS at Different Concentration on Distillation of 20% Ethanol and Water Mixture

Ethanol is added in 20% with 80% distilled water and effect of surfactant addition at different concentration is studied.

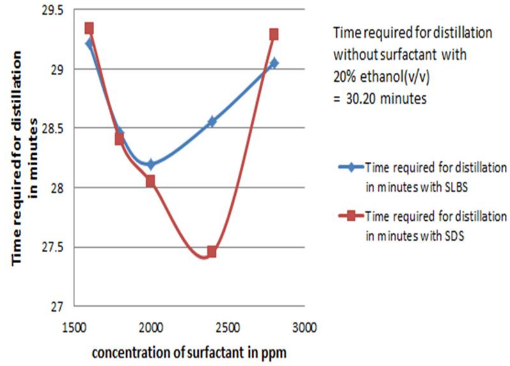

Fig. 4 Variation of time required for distillation with concentration of surfactant for 20% ethanol mixture

Fig. 4 shows time required to distillate the 20% ethanol water mixture is minimum with SDS at 2400 ppm and with SLBS it is at 2000 ppm. SLBS reduces the distillate time from 3.28% at 1600ppm to 6.62% at 2000ppm while SDS reduces it from 2.85% at 1600ppm to 9.11% at 2400ppm.

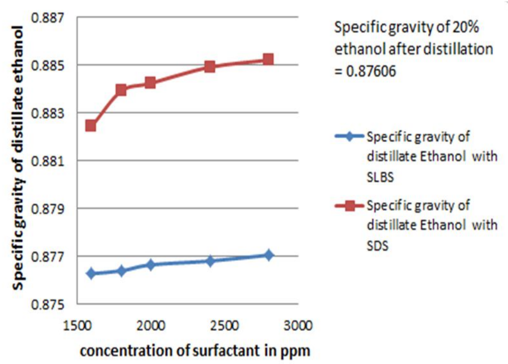

Fig. 5 Variation of specific gravity with concentration of surfactant for 20% ethanol mixture

From the fig. 5 it is clear that SLBS gives the better purity than the SDS. At 1600 ppm SDS gives better purity while for SLBS it is at 2800 ppm. SLBS shows the variation of (0.03% to 0.11%) in specific gravity while SDS shows (0.73 to 1.07%) variation.

V. CONCLUSIONS

A. The Following are the Conclusions Made From the Experimental Results

1) Time required to distillate 10% and 20% ethanol(v/v) is minimum for SDS compared to SLBS and maximum decrease in time occurs at 2400 ppm for SDS and 2000 ppm for SLBS.
2) Specific gravity goes on increasing for both the surfactant as concentration of surfactant increase. SLBS gives better specific gravity variation within 0.5% than the SDS.
3) Energy consumed to distillate ethanol-water mixture is found to be less for SDS as compared to SLBS.

REFERENCES

[1] Yang, Y.M., Maa, J.R., 1983. "Pool boiling of dilute surfactant solutions", Journal of Heat Transfer 105, 190–192
[2] Hetsroni, G., Zakin, J.L., Lin, Z., Mosyak, A., Pancallo, E.A., and Rozenblit, R.,2001, "The Effect of Surfactant on Bobble Growth, Wall Thermal Patterns and Heat Transfer in Pool Boiling," International Journal of Heat and Mass Transfer, 44, pp. 485-497
[3] T. Inoue, Y. Teruya, M. Monde, "Enhancement of pool boiling heat transfer in water and ethanol / water mixture with surface active agent", International Journal of Heat and Mass Transfer, vol. 47 (2004), 5555-5563
[4] Zhang, Juntao. "EXPERIMENTAL AND COMPUTATIONAL STUDY OF NUCLEATE POOL BOILING HEAT TRANSFER IN AQUEOUS SURFACTANT AND POLYMER SOLUTIONS. DOCTOR OF PHILOSOPHY(Ph.D.)" Cincinnati: University of Cincinnati, 2004
[5] Nafey, A.S. , M.A. Mohamad and M.A. Sharafa. "Enhancement of solar water distillation process by surfactants additives." Desalination (2007): 514-523
[6] Ngema P.T., "SEPERATION PROCESS FOR HIGH PURATY ETHANOL PRODUCTION."(M.S.) Department of Chemical Engineering, Durban, 2010

[7] Elghanam R.I., M.M.E.L. Fawal, R.Abdel Aziz, “Experimental study of nucleate boiling heat transfer enhancement by using surfactant.” Ain Shams Engineering Journal(2011): 195-209.
[8] Hao Peng, Guoliang Ding, Haitao Huai, “Effect of surfactant additives on nucleate pool boiling heat transfer of refrigerant-based nanofluid”, Experimental Thermal and Fluid Science 35 (2011) 960–970
[9] Hu Zicheng, Gu Jiaqiang, Song Xinnan, Wang Qian, “ Pool boiling heat transfer of Aqueous surfactant solutions.” Fourth International Conference on Intellegent Computation Technology and Automation. Zhenjiang, Jiangsu, 212013, China : Jiangsu University, 2011. 841-844
[10] A.R.Acharya, A.T.Pise ,“A Review on Augmentation of Heat Transfer in Boiling using Surfactant/additives” Heat Mass Transfer (2017) 53:1457-1477