Review on Natural And Synthetic Surfactant for Pool Boiling

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Abstract—

Boiling is an efficient mode of heat transfer and having numerous applications in distillation, desalination, chemical process, refrigeration system. Due to energy problem, boiling heat transfer may be enhanced by active and passive techniques. Passive methods of heat transfer enhancement need no external power for heat transfer enhancement. One of the passive techniques is use of additives in order to enhance the heat transfer. The use of surfactant is simple and cost effective.

Keywords— Surfactant, Natural Surfactant, Surface Tension, Boiling

I. Introduction

The name "Natural Surfactant" indicates that the Surfactant which are obtained from the natural resources. The natural surfactant can be obtained either by the separation procedure such as extraction, precipitation or distillation or from the origin of the animals and plants such as Shikekai and Reetha. No chemical procedure is involved for the preparation of the Natural surfactant. There are so many natural and synthetic surfactants available in the market for the use of practical applications. Surfactant are the chemicals that have the ability to dissolve in water or other solvent. As a result, properties will be changed after dissolution. By adding the small number of surfactant, the surface tension of the liquid will be changed. The surface tension decreases significantly with the concentration of the surfactant until reaching to the critical micelle.

Nihar Biswal [1] studied adsorption and wetting phenomenon on solid surfaces in Natural surfactant solutions using Reetha, Shikakai. The CMC value of Reetha and Shikakai was found to be 0.5 mM and 0.513 mM respectively at 25'C measured by surface tension method. The surface tension value decreases from 71.5mN/m (pure water) to a minimum value near to CMC of surfactant. Minimum surface tension values achieved are 38.29 mN/m and 38.71 mN/m for Reetha and Shikakai respectively.

Birce Dikici et al. [2] demonstrated the water pool boiling phenomena under the influence of environmentally friendly surfactant additives. The effect of addition of the surfactant in the boiling, the volume percentage is directly proportional to the nucleation site and inversely proportional to wall superheat. For determining surfactant effects, different concentrations of sodium lauryl sulfate (SLS), ECOSURF TM EH-14, and ECOSURF TM SA-9 are added to pure water and enhancement through surfactants is quantified. When times until boiling (liquid temperature reaches the boiling point) are measured, 17, 10.3, and 19.6 % lower times found (for SLS, EH-14, and SA-9, respectively) compared to pure water. Wall temperature reduction is measured for 50 ppm SLS 9.48 %, for 300 ppm EH-14 11.3 %, and for 200 ppm SA-9 10.43 %. It can be concluded from this study that a reduction in surface tension leads to a higher nucleation site density and more small bubbles on the boiling surface.

G. Hetsroniet al. [3] experimentally investigated saturated pool boiling of environmentally acceptable surfactant solutions on a horizontal tube. Boiling curves for various concentrations from 25 ppm to 7000 ppm were obtained and compared. Surfactant used in experiment was Alkyl Glycoside. The addition of small amount of Alkyl Glycoside makes the boiling behavior quite different from that of pure water. Bubbles formed in surfactant solutions were much smaller than those in water.

S.S. Gajghate et al. [4] experimentally studied heat transfer enhancement in pool boiling using 2-Ethyl 1-Hexanol additive with varying concentrations in the range of 10 – 10000 ppm. Boiling heat transfer coefficients are measured for Nichrome wire, immersed in saturated water with & without additive. Results showed that there is an optimum additive concentration for higher heat fluxes which is observed up to a certain tested range of 150-500 ppm. A 30% increase in the average heat transfer coefficient was obtained. Up to concentration of 500 ppm excess temperature becomes smaller and vapor bubbles are formed more easily.

Yong Hoon Jeong et al. [5] investigated the wettability of the heated surface under pool boiling of surfactant solutions and Nano-fluids using Tri-sodium phosphate (TSP, Na3PO4) solutions (0.01, 0.05, 0.1, 0.3, 0.5, 0.8 wt. %) and Aluminum oxide (Al2O3) Nano-fluids (NF) (0.5, 1, 2, 4 vol. %) Stainless steel (SUS 304) strips (30 _ 30 _ 3 mm) were heated by an alcohol lamp and quenched in the prepared solutions. The solutions (TSP, NF) on the quenched surface show the smallest contact angle (50–150). It is concluded that the surface deposited TSP and Nano-particles enhanced wettability of the surface.

A.R. Acharya et al. [6] carried out experiments on pool boiling in presence of the surfactant in pure water to enhance heat transfer. Ammonium Chloride (NH4Cl) is taken as test surfactant and added separately in water with varying concentration. The results of surfactant in pure water showed the heat transfer enhancement due to slight reduction in surface tension up to 800ppm.The trend of boiling curves shifted towards the lower excess temperature side (Left side). Kinetics of vapor bubble was observed in terms of bubble nucleation, growth, and its departure.

Rupeshkumar Ghagi et al. [7] investigated functional properties such as critical micelle concentration, emulsification and hemolytic activity of raw Reetha (Sapindus Mukorossi) aqueous solution which is prepared by soaking Reetha fruits overnight. Critical micelle concentration was found to be 0.017 gm. /cc (1.7wt %) at which the surface tension of aqueous solution remains constant to minimum value of 38 mN/m. This study has highlighted the economical use of crude Reetha as a green surfactant similar to the purified Sapindus Saponin.

II. FUNDAMENTALS OF SURFACTANT

Surfactants are chemicals that have the ability to dissolve in water or other solvents. As a result, the properties of the solvent will be changed after dissolution. It was found that adding a small number of surfactants affect the surface tension of the solution. The surface tension decreases significantly with the concentration of the surfactant until reaching the critical micelle concentration (CMC). CMC is defined as the concentration of surfactants above which micelles form and all additional surfactants added to the system go to micelles. After reaching the CMC, the variation in the surface tension becomes quite constant. The value of the CMC for a given medium is affected by many factors such as pressure, temperature, and on the existence and concentration of other surfactants. Surfactants also have a common molecular, which consists of two parts: nonpolar (commonly hydrocarbon, hydrophobic) chain, which is water insoluble component, and a polar (hydrophilic) portion, which is water soluble component. A chain of 8 to 18 carbon atoms can form the hydrophobic part. According to polar head part, surfactants can be categorized into four common groups: non-ionic surfactants, anionic surfactants, cationic surfactants, and amphoteric surfactants. The molecular structure of non-ionic surfactants has no charge parts of its head. However, anionic surfactant has a negative charge, while cationic surfactant has the positive charge. Amphoteric surfactant has a molecular that is able to have both a positive and a negative charge.

III. CLASSIFICATION OF SURFACTANT

Surfactant can be classified based on charged groups present in their head. A nonionic surfactant does not have any charge groups over its head. The head of an ionic surfactant carries a net charge. If the charge is negative, the surfactant is more specifically called anionic and if the charge is positive, it is called cationic. If a surfactant contains a head with two oppositely charged groups,

A. Anionic Surfactant

These surfactants are the most widely used type of surfactant for preparing shampoos because of its excellent cleaning properties and high hair conditioning effects. Anionic surfactants are particularly effective at oily cleaning and oil/clay suspension. Still, they can react in the wash water with the positively charged water hardness ions (calcium and magnesium), which can lead to partial deactivation. The more calcium and magnesium molecules in the water, the more the anionic surfactant system suffers from deactivation. To prevent this, the anionic surfactants need help from other ingredients such as builders (Ca/Mg sequestrants) and more detergent should be dosed in hard water. The most commonly used anionic surfactants are alkyl sulphates, alkyl ethoxylate sulphates and soaps. Most of the anionic surfactants are carboxylate, sulfate and sulfonate ions. The straight chain is a saturated /unsaturated C12-C18 aliphatic group. The water solubility potential of the surfactant is determined by the presence of double bonds.

B. Cationic Surfactant

In solution, the head of the cationic surfactant is positively charged. Cationic surfactants are quaternary ammonium compounds and they are mostly used for their disinfectant and preservative properties as they have good bactericidal properties. They are used on skin for cleansing wounds or burns. Mostly used cationic surfactants are cetrimide which has tetradecyl trimethyl ammonium bromide with minimum amount of dodecyl and hexadecyl compounds. Other cationic surfactants are benzalkonium chloride, cetylpyridinium chloride etc.

C. Non-Ionic surfactant

Those surfactants do not have any electrical charge, which makes them resistant to water hardness deactivation. They are less irritant than other anionic or cationic surfactants. The hydrophilic part contains the polyoxyethylene, polyoxypropylene or polyolderivatives. The hydrophobic part contains saturated or unsaturated fatty acids or fatty alcohols They are excellent grease/oil removers and emulsifiers. Non-ionic surfactants contribute to making the surfactant system less hardness sensitive. The nonionic surfactant can be classified as Polyol esters, polyoxyethylene esters, poloxamers. The polyol esters include glycol and glycerol esters and sorbitan derivatives. Polyoxyethylene esters includes polyethylene glycol (PEG 40,PEG -50,PEG- 55). The most commonly used non-ionic surfactants are ethers of fatty Alcohols.

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Conclusion

From the above data, we can say that the most of the work is done on the synthetic surfactant for various applications like biotechnology, distillation process etc. Again we can conclude that the natural surfactant can reduces the surface tension so that in case of boiling, at the minimum temperature difference can obtain maximum heat transfer rate. The further scope for this work is to addition of natural as well as synthetic surfactant and to study the effects on the boiling curve.

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