Interfacial Properties and Foamability of Amphiphilic Molecules

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***Abstract* – Surface-active molecules are widely used in industry. Triton X-100, sodium lauryl ether sulfate, sodium dodecyl sulfate and bovine serum albumin are commonly used in daily products. They can form foams because of adsorption phenomena at the surface. Each molecule has its own characteristic and foaming ability. This research deals with relation between interfacial properties and foamability by using three different methods: the Wilhelmy plate method to verify the CMC value, the maximum bubble pressure to determine dynamic surface tension, and the Bikerman method to assess the foamability. Interfacial properties and foamability will be studied and the difference observed between surfactant and protein will be discussed.**

***Index Terms* – Foamability, Interfacial Properties, Protein, and Surfactant.**

INTRODUCTION

Surfactant is an amphiphilic molecule which has hydrophobic and hydrophilic parts. These different structures make surfactants as emulsifier, foaming, and wetting agent. When it is used in dispersed solution, it will minimize contact between the hydrophobic part and water which leads to adsorption at interfaces and causes a decrease in interfacial tension between air/water. At one point, the system interface is saturated with surfactants; the molecules have ability to auto-associate in aggregate called "micelles". The concentration at which the monomers begin to form micelles is defined as the Critical Micelle Concentration (CMC) [1].

The main phenomenon in surfactant solution foaming properties originates from adsorption of the surfactant at air/liquid interface [2]. First of all, the decrease in surface tension allows the fragmentation of gas as small bubbles. Foam can be defined as dispersion of a gas in a liquid. It is thermodynamically unstable. Different types of surfactant can be used to control the foamability and foam stability. The amount of foam produced depends on the surfactant concentration, and it is preferred to operate at a value near or slightly superior than the CMC [3].

Proteins have complex structure and high molecular mass. Otherwise, their easy biodegradation makes their use in various industrial applications. Bovine Serum Albumin is a water-soluble protein and has ability to form hydrogen bonds both within its own structure and with polar solvents [4]. They are characterized by their Critical Aggregation Concentration (CAC).

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In industry, surfactants are used based on their function, properties, and foaming ability. In this study, we compare the behavior of surfactants and protein that are used in our daily products.

MATERIAL AND METHOD

A. Materials

Pure components samples of Triton X100, Sodium Lauryl Ether Sulfate (SLES), Sodium Dodecyl Sulfate (SDS), and Bovine Serum Albumine (BSA) are used in this study. The details of each material will be explained below.

Triton X-100 was purchased from Alfa Aesar Company (Germany). It is a non-ionic surfactant with molar mass 420 g/mol and the value of CMC is 0.25 mM [5].

SLES was purchased from Thor Company. It is an anionic surfactant which mostly used in industry, with a high foaming power and easy to rinse. Molar mass of SLES is 420 g/mol and its CMC value is 0.5 mM [6].

SDS was purchased from Merck (Germany). It has similar molecular structure than SLES and they are both anionic surfactants. The only difference is SLES has ethylene oxide units spacing the hydrophilic and hydrophobic parts. The molar mass of SDS is 288.4 g/mol and its CMC value is 8.5 mM [7].

BSA, which was purchased from Amresco, is sensitive to temperature. The molar mass of BSA is 66400 g/mol and its CAC value is 0.0004 mM [8].

B. Methods

Bubble Pressure Dynamic Method. This method consists in determining the maximum pressure which could be obtained during the formation of inert gas bubbles (nitrogen) at the end of a capillary of radius 0.377 mm immersed to a depth 10 mm in the liquid studied. By using a maximum bubble pressure tensiometry (Kruss BP2), the surface tension dynamic can be obtained and it is used for measuring the decreased of surface tension for very short times (20 ms – 10000 ms)[9].

Bikerman Method. This method consists in generating foam in a column already containing the solution (20 mL), by injecting a constant flow of nitrogen through a sintered-glass filter producing small bubbles for 30 s and the height of foam was noted for 5 minutes. The foam formed accumulates in the column and its volume increases for 30 s. After some time, the foam of the top begins to break. The height of foam and solution obtained gives an index that combines stability and foamability [10]

RESULT AND DISCUSSION

The value of CMC for each surfactant has been verified and they have similar CMC value than the

ones published in the literature. BSA needs more time to reach equilibrium conditions because of its complex structure, about 1800s compared to 300s for small surfactant molecules.

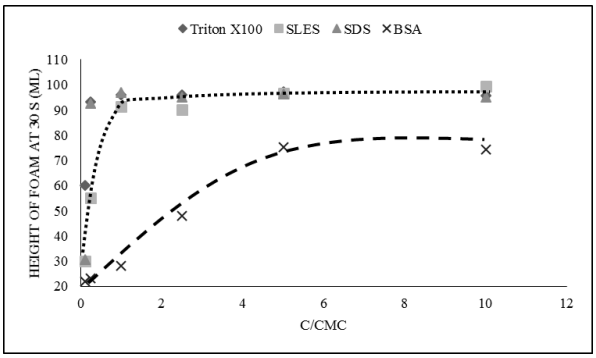

Figure 1. Foamability of surfactants and BSA.

From Figure 1, we observe that the foam height obtained after 30s reaches its maximum value slightly before the CMC and remains constant for higher concentrations. Contrarily, BSA shows a different result, as a concentration of about 5 times the CMC is needed in order to reach maximum foam formation.

Figure 2 shows a diminution of dynamic surface tension with increasing of surfactant concentration, which reaches a constant surface tension at the CMC. In contrary, protein shows only a very little decrease of surface tension while the foam formation increases. However, the foam of BSA is not stable and breaks easily. Further work will involve the study of mixtures to better control the foamability of industrial products.

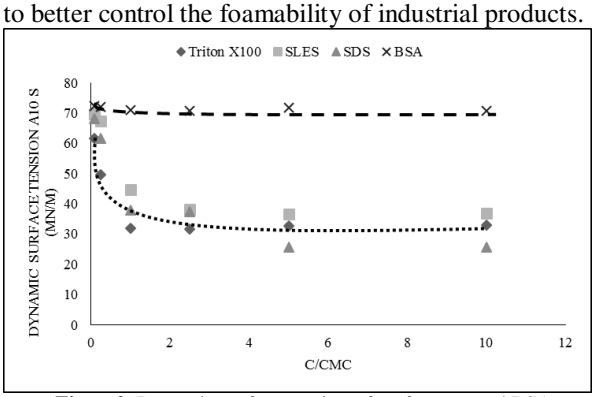

Figure2. Dynamic surface tension of surfactants and BSA.

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