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Static Foam Properties of Tween-20 - Water– Caprylic Acid Systems

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ABSTRACT

In this research paper, the static foam properties of Tween-20 + Water + Caprylic Acid (co-surfactant) system and Tween-20 + Water + Caprylic Acid + Nanoparticles (NPs) system were investigated. Initial mean static foam height at temperature 30 ±1 ^{0}C for Tween-20 + Caprylic Acid system was better (*i.e.*55.00 cm) than that of individual Tween-20 + water system(*i.e.* 45.66 cm). It was observed that the percentage foamability of Tween-20 surfactant decreased by an addition of caprylic acid. The system of surfactant solution + co-surfactant was compared with the system of surfactant solution + cosurfactant + NPs. Static foam behavior was also studied for high temperatures. It was found that initial foam height decreased drastically at 55 ^{0}C, 65^{0}C & 75^{0}C.

Keywords - Foamability, Foam stability, Nanoparticles, Static foam, Surfactants, Co-surfactant

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I. INTRODUCTION

Work on boosting the foaming properties of static foam was done by many researchers. Co-surfactants plays vital role in increasing the foaming properties of static foam. NPs + co-surfactants can be used to improve the properties of static foam. Foam is a gas-liquid system where gas is separated by water channels [1-2]. In dynamic method, foams are formed when the gas is continuously passed through a relatively small amount of liquid usually containing surface active agents. In dynamic method, foams are continuously formed while in static method, foams generated in the initial step only. Improved foam properties are beneficial in many industrial applications like to enhance oil recovery, for food processing, fire control, to pretreat lignocellulosic materials *etc.* [3-6]. Tween-20 is a non-ionic surfactant. This surfactant is non-toxic, and applicability of this surfactant increases due to other additional advantages like easy accessibility, solubilization *etc*. [7-9]. Co-surfactants are used with surfactants to improve properties of foam, to increase the solubility of drugs, improving thermodynamic stability *etc*. In the present research work, foaming power and percentage foamability were investigated for Tween-20 + water system; Tween-20 + water + co-surfactant system and Tween- 20 + water + cosurfactant + NPs system.

II. MATERIALS AND METHODS

2.1. Materials

Tween-20 (density is 1.100-1.110 g/cm3 and hydroxyl number is 96-108 and saponification number is 40-50) was purchased from LOBA Chemie Laboratory Reagents and fine chemicals, Mumbai, Caprylic acid as co-surfactant purchased from SRL, Sisco Research Laboratories Pvt. Ltd. Mumbai, Titanium oxide mixture of rutile nano-powder (<100nm particle size (BET)) was purchased from Sigma-Aldrich and double distilled water.

2.2. Methodology

Static foam was generated by using Bartsch shaking method (*See* figure1(A)), where a 20 ml of surfactant solution (5 ml Tween-20/100 ml of water) was mixed with 0.058g caprylic acid and then vigorously shaken for 30 seconds, 30 times in a 100 ml graduated measuring cylinder by hand and foam volume was measured instantaneously and later up-to 30 minutes with 5 min of interval [10-11]. Sometime uneven foam height was formed. In such case to minimize the error, mean value of minimum (X_1) and maximum height (X_2) of the foam was calculated as shown in figure 1(B). Sometimes the big bubble was generated in static foam just after shaking the glass cylinder. In such case to minimize the error its volume was excluded, because such single bubble was not the part of foam. NPs surfactant solution was prepared by adding defined amount (0.05 g/ 20ml of surfactant solution) of NPs in surfactant solution and then sonication it for 20 minutes. Percentage foamability (*See* equation 1) was calculated as follows:

% foamability = (FH at 30 min / FH at 0 min) X 100…(1)

Where, FH is foam height.

Foam stability was studied by monitoring foam height (in cm) as a function of time. All experiments were carried out in triplicate and calculate the mean foam height.

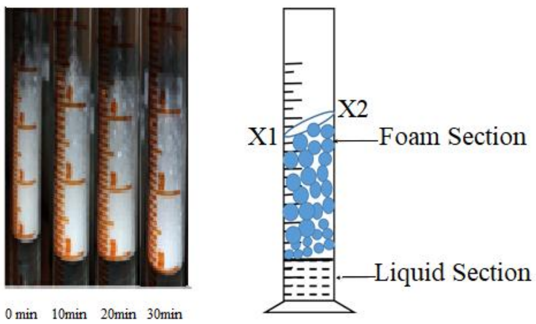

Fig.1(A) Static Foam (B) Minimizing foam majoring error. (Where, X_1 - minimum foam height and X2- maximum foam height)

III. RESULTS AND DISCUSSION

3.1. Foamability

3.1.1. Effect of temperature on foamability

The foamability and foaming power of Tween-20 + water system, Tween-20 + water +cosurfactant system and Tween-20 + water+ cosurfactant + NPs system were investigated (*See* table 1) at temperature 30 ±1 ^{0}C. Initial foam height increased when Tween-20 surfactant solution used with cosurfactant. Small amount of cosurfactant 0.058g (Caprylic acid) in Tween-20 solution increases the initial foam height from 45.66 cm to 55.00 cm.

NPs also played vital role individually when used with surfactant solution. NPs when used with Tween-20 surfactant solution initial mean foam height increases form 45.66 cm to 60 cm but when NPs used with cosurfactant initial height of the foam decreased from 60 cm to 29 cm. Temperature effect on Tween-20 + water + cosurfactant system was studied (*See* table 2). It was found that foaming power decreased with respect to temperature while percentage foamability increased with increasing temperature.

Table 1:Variation of foaming power and foamability

Time → (min)	0	10	20	30	↓ (%) Foamability
	Mean Foaming Power (cm)				
T-20+water system	45.66	32.66	28.66	23.33	51.09
T-20+water+NPs system	60.33	40.50	31.00	22.00	36.46
T-20 + water+ Caprylic acid system	55.00	25.75	17.75	13.00	23.63
T-20 + water+ Caprylic acid + NPs system	29.00	12.00	09.00	06.00	20.69

(T-20 means Tween-20)

Table 2 Effect of temperature on Tween-20 + water + Caprylic acid system

Temperature → (± 1ºC) Time(min) ↓	30 ^{0}C	45 ^{0}C	55 ^{0}C	65 ^{0}C	75 ^{0}C
	Mean Foaming Power (cm)				
0	55.00	46.00	18.50	15.00	06.00
5	39.00	22.00	11.00	11.00	05.00
10	25.75	15.00	11.00	11.00	05.00
15	22.75	12.50	09.00	10.00	03.00
20	17.75	12.00	09.00	08.00	03.00
25	16.00	10.00	09.00	08.00	03.00
30	13.00	10.00	06.00	06.00	03.00
% Foamability	23.64	21.74	32.43	40.00	50.00

Fig.2 (A) shows the static bubbles image of Tween-20 + water system and fig.2 (B) shows the static bubbles image of Tween-20+water+cosurfactant (to obtained clear images very small amount of methyl blue indicator added on the top of foam). When compared Fig.2 (A) with Fig.2(B) then the bubbles of Tween-20 + water system are smaller than the bubbles of Tween-20 + water +cosurfactant system.

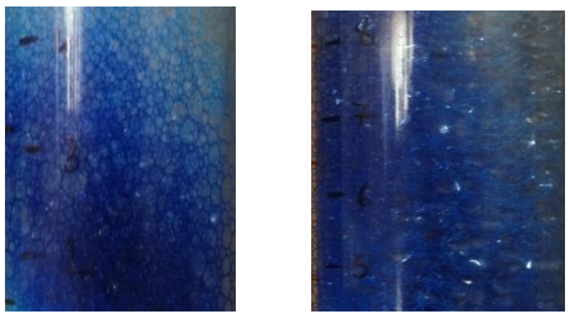

Fig.2(A) Without cosurfactant (B) With cosurfactant

Caprylic acid increased the initial volume of the static foam (at 30±1^{0}C) but at high temperature (*See* table 3 at 55±1ºC) cosurfactant performance was very low.

Table 3. Foam height Vs time at 55±1ºC

Time (min) ↓	Foam height at 55 ±1ºC [With co-surfactant]	Foam height at 55 ±1ºC [Without co-surfactant]
0	18.00	36.00
5	11.00	12.00
10	11.00	10.00
15	09.00	05.00
20	09.00	05.00
25	09.00	03.00
30	06.00	03.00
% Foamability	33.33	08.33

NPs if used without caprylic acid then foaming power and stability decreases. Hence, Tween-20 + water + caprylic acid showed better performance than Tween-20 + water + caprylic acid + NPs. (See fig.3).

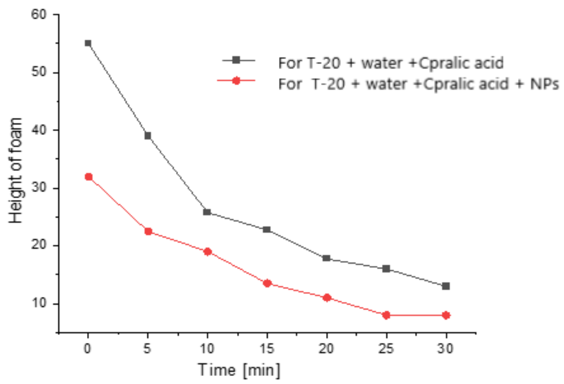

Fig.3 Foam height Vs Time

IV. CONCLUSIONS

The static foam properties reveal that the Tween-20 + water system has good percentage foamability (*i.e.*, 51.09 at 30±1 ^{0}C). Initial foam height was more in Tween-20 + water + caprylic acid system. NPs performance was not good with caprylic acid. Temperature effect for Tween-20 + water + Caprylic acid system was studied. Static foam height was good for temperature 30±1 ^{0}C but foam decreased for high temperature. While percentage foamability increased at high temperature for Tween-20 + water + Caprylic acid system. Caprylic acid increased the size of the bubbles eventually decreasing the film thickness.

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