



## FOAM STABILITY OF LOCAL SURFACTANT ON THE PRESENCE OF CONTAMINANT CD IONS, COFFEE AND OIL IN SOLUTION

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### ABSTRACT

The foam stability of the local product of surfactant was studied. The effect on the presence of contaminants: cadmium ions, coffee, and oil in surfactant solution were investigated. The foam of local surfactant at different concentrations in the presence of contaminant was generated by using a foam generator. After the foam capacity has reached a constant value, the foam then flows to column stability until a certain height of foam volume. The stability was then measured based on the decreasing height against the increasing time. In the presence of contaminant Cd ions in the solution, it could increase slightly the stabilization of the foam, especially at 0.5x cmc. For coffee particles and oil, it has the ability to decrease the foam stability of all surfactant variation concentrations. The stability of 2.0x cmc was slightly better than 1.0x cmc and 0.5x cmc for all contaminants. The ability of coffee colloidal particles was tending to decrease the foam stability of local surfactant then by oil and Cd ion. Coffee with colloidal particles may have stronger interaction with local surfactant and thus reduce the formation of the foam. Oil also has the ability to decrease foam stability.

**Keywords:** local surfactant, foam stability, coffee, Cd<sup>+2</sup> ions, oil, contaminant.

### INTRODUCTION

Remediating media contaminated by metal ions with surfactant foam applications is reported in many research activities (Mulligan and Gibbs, 2004; B Haryanto, *et al.*, 2014; B Haryanto and CH Chang, 2014; B Haryanto and CH Chang, 2015; B Haryanto, 2018a).

Recoveries of wasted oil on the environment by applying surfactant foam are reported by Urum, *et al.* 2004. Surfactant applications on transporting nanoparticle material to porous media in the remediation process are reported by Raymundo *et al.*, 1998. Paria, 2008 is explaining the ability of surfactant to interact with mercury in liquids which then can be separated from the fractional fraction. Studies on foam capacity and stability were reported by B. Haryanto *et al.*, 2017; B. Haryanto *et al.*, 2018b).

Surfactants are compounds with heterogeneous molecules that have long chains in which the head has water-like and the tail has a water-dislike character. The concentration of surfactant in the aqueous phase over a certain critical value, the monomer molecule forms an organized group of large numbers of molecules called micelles. This concentration worth is called critical micelle concentration (CMC). Physical properties of surfactants such as surface tension, interface tension, adsorption, and detergency provide changes to concentrations below CMC but provide no change if more than CMC (Mulligan, *et al.*, 2001; Mulligan, 2005). The surfactant solution indicates significant changes in other physical properties such as organic solubility, equivalent conductivity, and density below and above the CMC when compared to the previous concentration (Razafindralambo, *et al.*, 1998).

Surfactant foam is a dispersed fluid containing small air bubbles with a large surface area that can be

stabilized by surfactant molecules (Urum and Pekdemir, 2004). Foams serve as a paradigm for a wide range of physical phenomena. The foams may be described as a dispersed system in which the bubbles of gas are encircled and stabilized by surfactant molecules absorbed in the liquid-air interface in a continuous liquid medium (Halling, 1981; Razafindralambo, *et al.*, 1998; Durand, 2010; B Haryanto. 2014)

One of the most important interfacial properties possessed by surfactants is foam capacity. The quantity of foam capacity will influence the surfactant's ability to spread and press down to the pores of contaminated material (Mulligan and Gibbs, 2004). Foaming capacity can be seen from the increase in volume, during which the gas is fed into the surfactant solution. Foam stability is related to a decrease in the height of the foam with time (Zhang and Miller, 1992).

The capacity and stability of the surfactant foam is the main important aspect in applying it to the remediation process. The foam capacity is the surfactant's ability to produce foam and foam stability is the ability of the surfactant in the form of foam ability not to break (B. Haryanto *et al.*, 2018b; B. Haryanto *et al.*, 2018c)

The purpose of this research is to investigate the foam capacity and stability of local surfactants on the effect of the presence of contaminants in the liquid phase. The contaminants are Cd metal ions, coffee powder, and cooking oil.

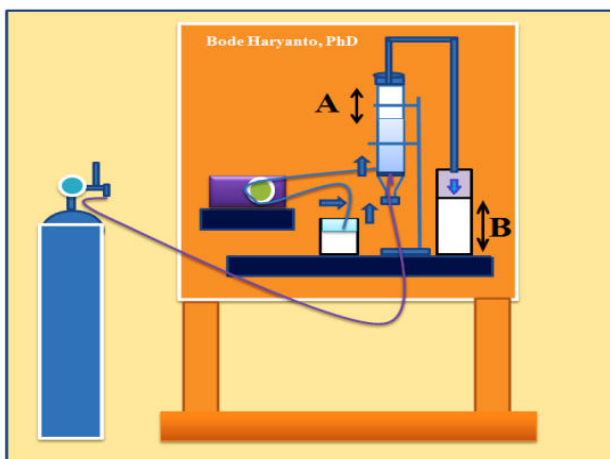
### MATERIALS AND METHODS

Local surfactant was produced and purchased from a product of Pengabdian Masyarakat LPPM USU 2017. Cadmium acetate (Cd (CH<sub>3</sub>COO)<sub>2</sub> · 2H<sub>2</sub>O) was used as the model inorganic contaminant and purchased from Merck KgaA, Darmstadt, Germany. The black coffee as

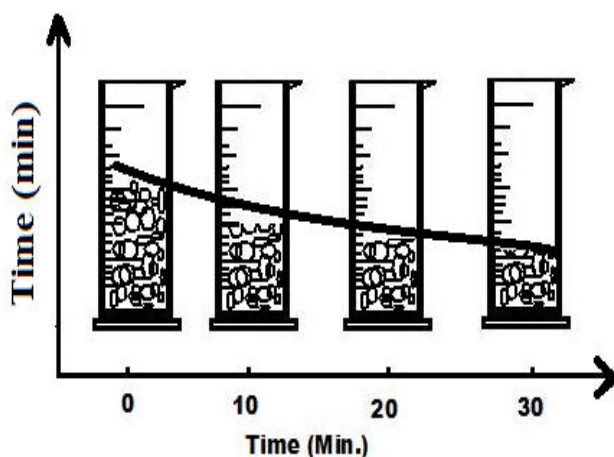


the model organic contaminant was purchased from PT Santos Jaya Abadi Indonesia. Another organic contaminant, cooking oil was purchased from Salim Ivomas Pratama Tbk PT (SIMP), Indonesia. The sodium hydroxide (NaOH) was purchased from Merck Kga A. Darmstadt, Germany. The hydrochloric acid (HCl) was purchased from Mallinckrodt Baker, Inc, Paris, and both chemicals were used to control the pH variation of the deionized water. They were used to dissolve local surfactants and contaminants.

Foam-generator was applied to produce the foam of local surfactant. It was a research instrument at the laboratory of surfactant and application, Chemical Engineering Department University of Sumatera Utara (USU). Figure-1A shows the size dimension of the foam generator (A) with  $L=20$  cm and  $OD=3.5$  cm. It is equipped with circular porous ceramic, which enabled the foam generated dynamically in the presence of surfactant solution and  $N_2$  gas. To deliver the surfactant solution to the foam generator, used a peristaltic pump. The foam product was flowed with progressed cylinder column (B) to measure foam stability (Figure-1 B).



(a)



(b)

**Figure-1.** Generator dynamic foam capacity, foam generator (a) and column foam stability (b) (B Haryanto, *et al.*, 2017; B Haryanto, *et al.*, 2018b).

In this study, by measurement activities for each run, the variables determined the foam stability at progressed cylinder column. Measurement of the stability of the foam is carried out by flowing the foam generated from the generator at a constant foam height to the foam stability measurement column (B Haryanto, *et al.*, 2018C). At the cylinder column, it was controlled until achieving the same height for all variations of the experiment. The beginning measurement of decreasing foam stability was started until achieving constant foam capacity for the time needed (T) as shown in Figure 1B. For the foam stability, the measurement was started after the initial foam height of 9 cm in the cylinder column then begins to measure the foam height for a certain time. The analysis tools used are an Atomic Absorption Spectrometer (AAS) for metal ion concentration and a manual scale measuring the height of foam stability. Measuring the time of foam stability to reach constant height using the timer (B Haryanto, *et al.*, 2018c).

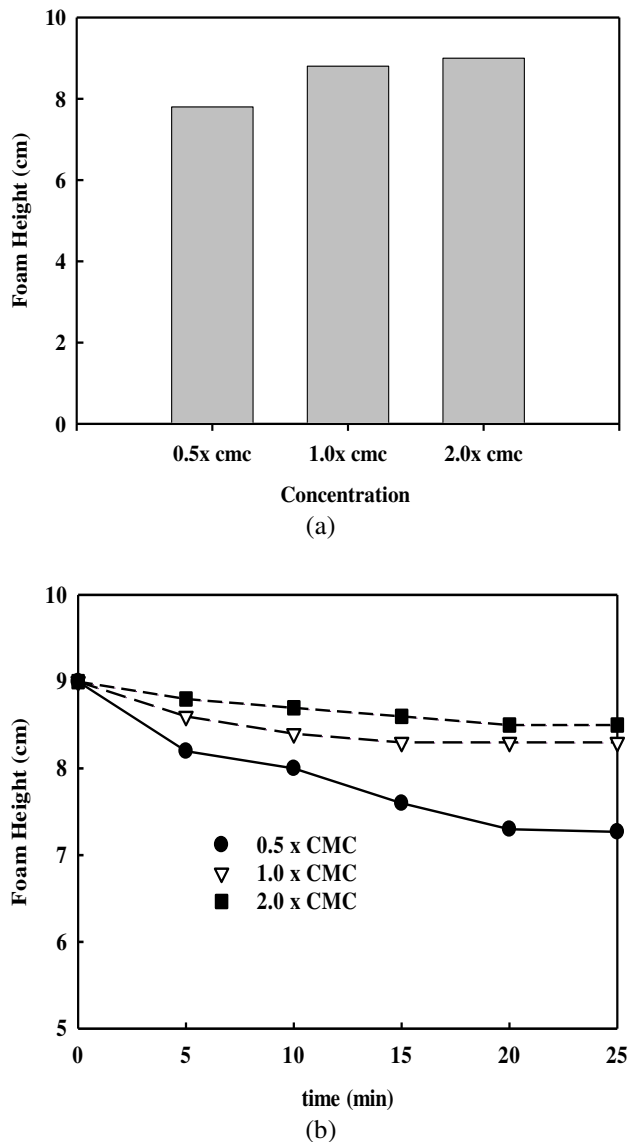
In this study, the concentration variations used for  $Cd^{2+}$  and coffee concentration were 50 ppm, and oil was 50 ml/liter. Local surfactant concentration variations were applied 0,5x CMC, 1x CMC, and 2x CMC at the same pH (B Haryanto, *et al.*, 2018b). The local surfactant is shown in Figure-2.



**Figure-2.** Local surfactant product.

## RESULT AND DISCUSSIONS

Measurement of the stability of the foam is carried out by flowing foam generated from the foam generator at a constant foam height to the progress cylinder column as the foam stability measurement column. Measurement of foam stability on the cylinder column began to be done at the height of foam 9 cm. Figure-3 A and B show the foam stability measurement. It is done to find the time needed to return the foam to the liquid phase. The result of the measurement of the height of the local surfactant foam stability base on the varying concentration of the surfactant is shown in Figure-3.

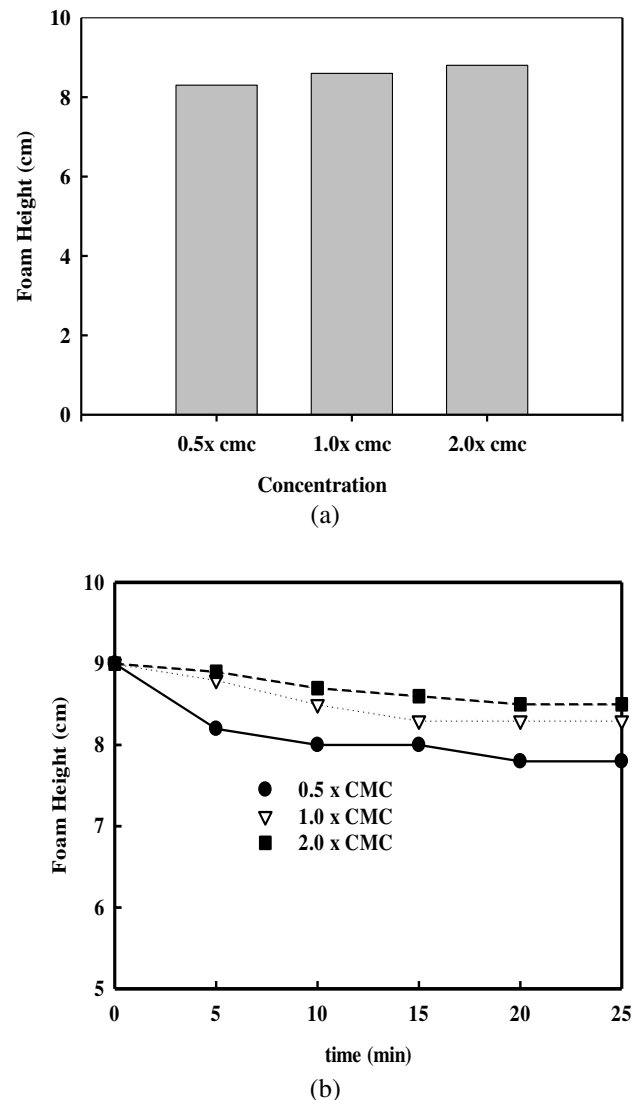


**Figure-3.** Foam stability free of contaminant.

The greater local surfactant concentration will cause increasing the foam stability obtained. The greater concentration was tending to increase the foam stability. The local surfactant's higher concentration will increase the micelle number in the solution. It will increase the interaction of foam lamella on the formation of micelles. The bubble interface stabilization mechanism of the surfactant is concerned with the ability of micelles to stand with a surface tension gradient. Resistance to changes in surface concentrations or surface area is described by interface resistance (Fameau, and Salonen, 2014). Figure-3.B shows the graphic kinetics of foam stability by adding the time against variation of concentration of local surfactant. The higher concentration has higher foam stability (B Haryanto 2017).

Figure 4A shows the result of the various concentration of local surfactant in the presence of contaminant  $\text{Cd}^{2+}$  50 ppm. The result obtained was that the contaminant has the ability to decrease slightly the foam stability of local surfactant and tends to be more stable in

comparison to the surfactant with a free contaminant, especially at 0.5x CMC. The presences of the contaminant tend to increase the stability of the foam of local surfactant. Figure-4B shows the graphic kinetics of foam stability by adding the time against variation of concentration of local surfactant in the presence of contaminant  $\text{Cd}^{2+}$  50 ppm.



**Figure-4.** Foam stability with 50 ppm Cd.

Figure-5A shows the result of the various concentration of coffee on the effect of the foam stability of local surfactant. The result obtained is that coffee colloidal particle has the ability to decrease the foam stability of local surfactant. The presence of the contaminant decreased the foam stability of the local surfactant significantly. The foam stability of the local surfactant was decreased by decreasing the concentration of the surfactant.

Black coffee has a pH of 4.5 to 5 as reported by Petkova, *et al.*, 2013 and Wayan, 2015. It has a negative charge on its surface particle (Hinde, 2000). The kinetics of dynamic foam stability of the local surfactant in the



presence of the coffee particle 50 ppm is shown in Figure 5B. The presence of a coffee colloidal particle in the solution may create complexity on the local surfactant micelles in the solution. The coffee particles with negative charge interact with micelles, the foam stability starts to reduce by adding time. The wet foam lamellae from the micelle are where the both layers as fairly thick water slabs become more complex by the presence of coffee colloidal particles of coffee. Then it impacted the dynamic foam stability of variation local surfactant concentration even though the higher local surfactant concentration has higher foam stability (B Haryanto, 2018c). One can see from the results of this study that the coffee particles have the ability to decrease the foam capacity in comparison with Cd<sup>2+</sup> ions.

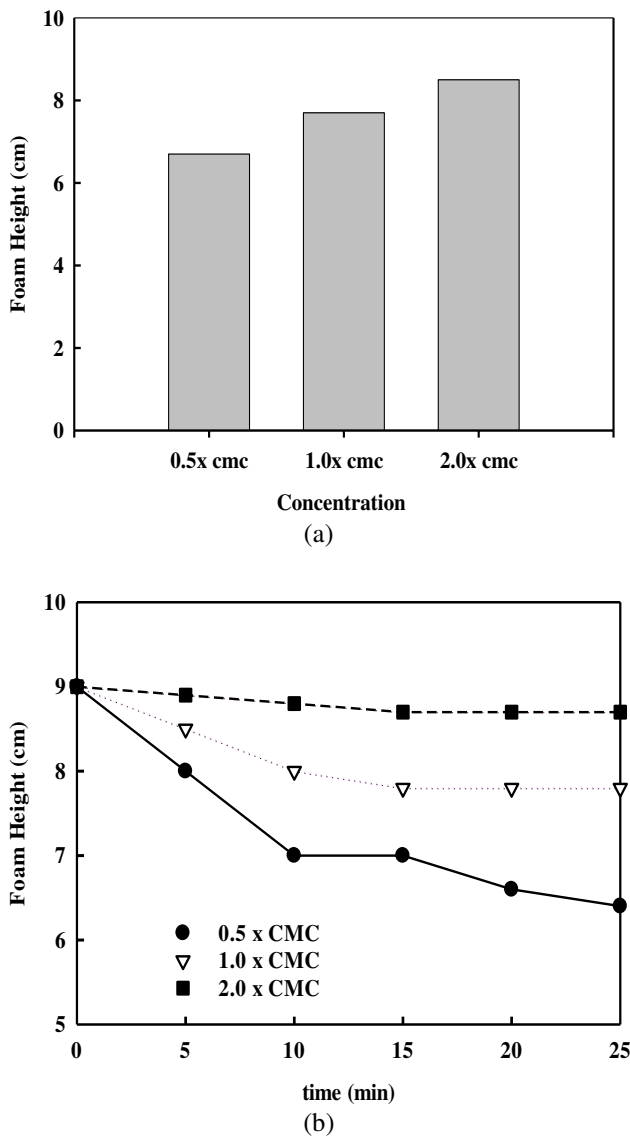


Figure-5. Foam stability with 50 ppm coffee

Figure-6 A and B show the foam stability measurement in the presence of 50 mg cooking oil in the solution. The study has done to find the time that the foam needed to return to the liquid phase by the impact of the

oil. The result obtained is that cooking oil can decrease foam stability. The presence of the cooking oil decreased the foam stability of the local surfactant significantly. Decreasing the concentration of the surfactant increased the foam stability of the local surfactant as shown in Figure-6 B as the kinetics of dynamic foam stability.

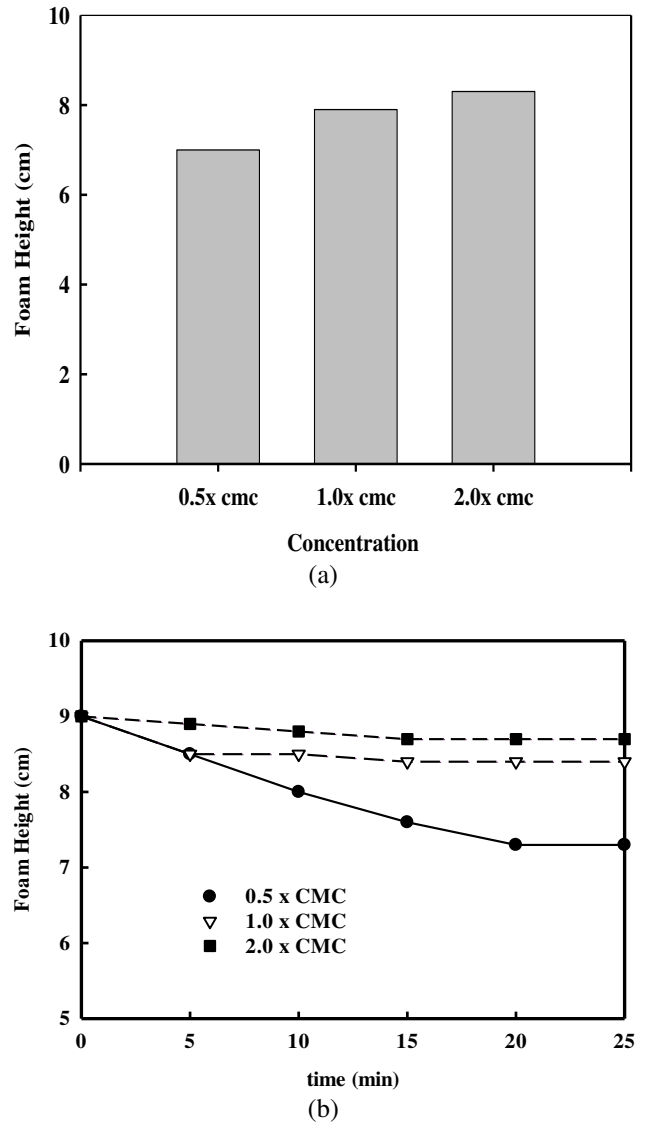


Figure-6. Foam stability with 50 mg/L oil.

The results on the impact of the presence of contaminants to foam stability and the kinetics are shown in Figure-7A and B. For coffee particles and oil was the ability to decrease the foam stability of all surfactant variation concentrations. The foam stability of 2.0x cmc was slightly better than 1.0 x cmc and 0.5x cmc for all of the contaminants. The lower stability of surfactant 0.5x cmc is because its only impact on the air-water surface of the liquid phase and there is no micelle structure in the solution. The ability of coffee colloidal particles was tending to decrease the foam stability of local surfactant higher than by oil and Cd ion. Coffee with colloidal



particles may have stronger interaction with local surfactant and thus reduce the lamella of the foam.

Oil also has the ability to decrease the foam stability, the dissolving ability in the solution may impact the low interaction that occurs with the foam lamella in comparison with coffee particles. On the other hand still more stable than local surfactants without contaminants.

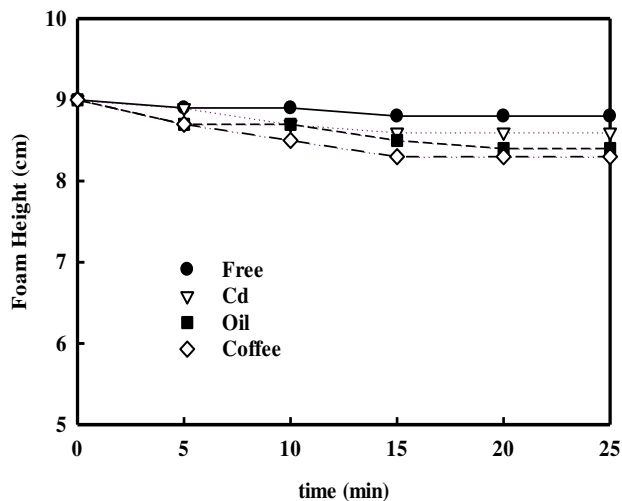
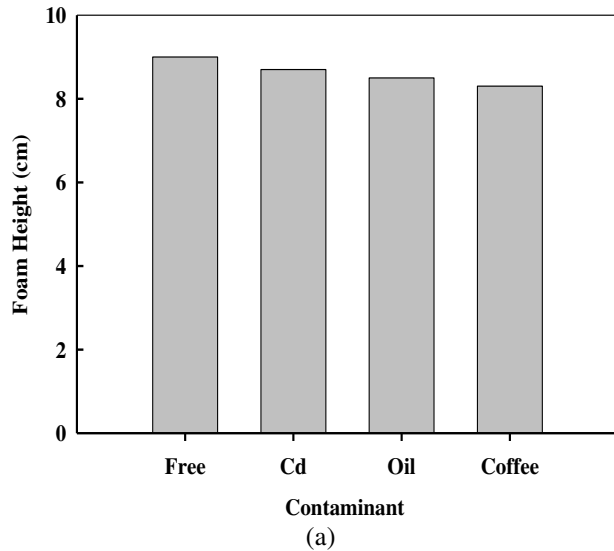


Figure-7. Foam stability the variation of contaminant.

## CONCLUSIONS

The contaminants  $\text{Cd}^{2+}$ , coffee, and cooking oil are important element that affects the stability of the foam. The foam stability of local surfactant at  $2.0\times$  cmc is higher than  $1.0\times$  cmc and  $0.5\times$  cmc with the presence of concentration  $\text{Cd}^{2+}$  50 ppm, coffee 50 ppm, and cooking oil 50 mg/L. Coffee has the ability to decrease the local surfactant foam stability better than  $\text{Cd}^{2+}$  and cooking oil. The dynamics foam stability of local surfactant in the presence of  $\text{Cd}^{2+}$  reaches a constant height faster than coffee and cooking oil. The presence of a coffee particle in the solution may create complexity on the local surfactant micelles in the solution. The presence of coffee colloidal

particles may cause lower stability at lower local surfactant concentrations.

## ACKNOWLEDGMENT

The authors would like to thank to Lembaga Penelitian dan Pengabdian Kepada Masyarakat Universitas Sumatera Utara on the IbMDosenMuda Project BPPTN USU 2017, No: 3224/UN5.2.3.2.1/PPM/2017 for the financial support on this project.

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