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Analytical Investigation of Foam Formation and Emulsifying Power of Sanya (*Securidaca Longepedunculata*) Roots and Comparison with Some Commercial / Synthetic Surfactants

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--ABSTRACT--

The study investigated foam production and stability of Sanya Roots (SR) with two synthetic surfactants (SS1 and SS11) as well as their emulsion capacity. The data showed that enormous foam was produced in all the investigated materials by the use of Ross-Mile method with foam accumulate measuring systems. The disappearance of the foam from Sanya Roots (SR) and commercial/synthetic surfactants (SS1 and SS11) was observed at 3 h, 8 h and 7.2 h respectively. This could be attributed to their physical nature and bubble formation. Foam production and stability was studied by measuring the height after 5 minutes, and by varying the concentration it was observed that SR, SS1 and SS11 fell at the range of 3.2- 5.4 cm. As foam deposit in water bodies is a contributory factor for low biodegradability, therefore the fast disappearance of Sanya Roots (SR) foam at equal concentration with SS1 and SS11 shows that the plant root may be better than the synthetic surfactants in biodegradability and eco-friendly properties. Foam production for Sanya Roots (SR) between 0.1 to 3.0 g concentrations yielded a foam height between 3.5 to 6.0 cm while SS1 and SS11 were between 4.5 to 5.6 cm and 4.2 to 5.7 cm respectively at the same concentration range. The investigation equally showed that Sanya Roots (SR) is good emulsifier as it promotes emulsion formation at both low and high concentration. The comparative similarity of Emulsion formation for 1 g at 1 h and 48 h was obtained as 98.3 % and 70.0 % for Sanya Roots; 95.0 % and 64.2 % for SS1 and 96.7 % and 65.0 % for SS11.On varying the concentration of SR, SS1 and SS11 at the same time range of 1 h to 48 h it was observed that emulsion capacity of SR, SS1 and SS11 decreases with increase in storage time. Therefore Sanya Roots are surface active, that is, it must have the capacity to lower the surface tension at the oil-water interface, both substantially and rapidly at a concentration typically used during emulsification. The study showed that Sanya (Securidaca longepedunculata) Roots can be regarded as a natural surfactant for its highly remarkable surface properties on comparison with commercial/synthetic surfactants like SS1 and SS11. Hence Sanya Roots could be used as a foaming, emulsifying, wetting and cleansing agent. This will therefore go a long way to erase the fear of depletion of the main source of synthetic detergent which is petroleum.

***KEYWORDS**: Sanya, Foam, Biodegradability, Concentration, Emulsion, Synthetic Surfactant*

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I. INTRODUCTION

In order to improve on the biodegradability, the toxicity and environmental friendliness of domestic and industrial effluents of synthetic detergent which destroys aquatic flora and fauna, and pose a hazard to the environment the thought and search for a natural surfactant that can limit the environmental hazard of soap and synthetic detergents on one hand and reduce drastically their toxic effects to plants and animals on the other hand. Based on this Sharma (2006) emphasized on the use of eco-friendly detergents and products for various domestic purposes so as to limit the effects of syndets (synthetic detergents) on aquatic invertebrates for example crayfish which are reduced in number by 15 days exposure to 10 ppm of toxic effluents. Based on this background, Myers (1992) reported that natural surfactants which is based on plant-derived chemicals use renewable resources, are readily biodegradable, non toxic and do not add to the Earth's CO_2 burden. More so, many plants produce significant qualities of Saponins (Steroid or triterpenoid glycosides) which have surfactant properties. Sanya Roots is one such plant like Soapwort Saponaria Officianalis whose foliage yields glycosides capable of wetting, foaming and grease dispersion-the very qualities that we recognize in a modern detergent. These natural glycosides are still in use today for specialized processes such as washing delicate fabrics. It is likely that the Saponins provided our ancestors with the first useful surfactants. According to (Azab 2001) a surfactant is a substance that has a characteristic molecular structure consisting of a hydrophobic portion and hydrophilic end but if present in a small amount, it exerts a marked effect on the surface behavior of a system. Garrett (1997) reported that the most widely appreciated property of surface active substances in aqueous solution is their ability to promote the formation of foams and bubbles. Also the presence of foam on the surface of a washing solution has long been regarded as an indication that the solution contains an adequate amount of washing agent. For modern surfactants Karsa (1999) puts it that they are of many different chemical types and do far more than produce foams and disperse grease.

An emulsion is a heterogeneous system containing two immiscible liquid phases in which one is dispersed in the other as droplets which varies between 0.1 -50µm in diameter (Walstra 1993). Also according to Mill (1997) Emulsion is a dispersion of one liquid in a second immiscible liquid. As the majority of emulsions contains water as one of the phase, it is customary to classify emulsion into two types, the oil-in-water (o/w) type consisting of droplet of oil dispersed in water and water – in- oil (w/o) consisting of droplet of water dispersed in oil. A stable emulsion consisting of two pure liquids that cannot be separated; to achieve stability a third component, an emulsifying agent must be present generally. The difference between the concept of an emulsion stabilizer and emulsifier was pointed out as maintaining the stability of the emulsion over a long period and promoting the formation of an emulsion respectively (Darling and Birketti 1987).

The introduction of an emulsifying agent lowers the interfacial tension of two phases. Based on this, Sharma et.al, (1999) puts it that emulsifying agent reduces the interfacial tension and the most commonly used emulsifying agent is Soap. Therefore, as Sanya Roots (SR) has the properties of Soap, the investigation of its emulsifying power is necessary. Hence, the cleansing action of Soap can be ascribed to the formation of an emulsion with oil, grease and water.

Above all, emulsions are usually opaque owing to the differences in refractive index between the two liquids and the droplets in emulsion are often negatively charged. An emulsifying agent or emulsifier may be involved as a third component in such mixtures. It has two principal functions such as to stabilize the dispersed phase against coalescence once it is formed and to decrease interfacial tension between oil and water to enable easy formation of the emulsion.

For a formation of a spontaneous emulsification Chin and Han (1980) agreed that if surfactant concentration is high and the resulting interfacial tension very low, it may under some conditions cause 'spontaneous emulsification' due to the strong interfacial tension gradients induced. The liquids present in emulsions are usually in the form of a droplet which is referred to as the internal phase, while the liquid in which the droplets are dispersed is called the continuous or external phase. If water is fairly dispersed in a non-aqueous liquid, water-in-oil (w/o) emulsion is produced. On the other hand, if water consists of the external phase and organic liquid is the internal phase, the term oil-in-water (o/w) emulsion is used (Reuben, 2005). Emulsifiers like Soap are used to decrease interfacial tension and to slow or prevent the separation of emulsions after they are formed (Michael, 2001). Practically, Adebayo, (2001) classified emulsifiers into four groups namely; Anionic, Cationic, Non ionic and Amphoteric.

Sanya as it is called in Hausa is scientifically identified as *Securidaca longepedunculata* from the family polygalaceae. It is generally called Uwar Magunguna (literally called in English Mother of Medicine). It is a shrub mostly found in both North Eastern Nigeria and Southern Nigeria. The Yoruba call it Epeta while it is called Alali in Fulfulde. Other parts of West African countries like Ashanti people in Ghana calls it Ofodo or Rattray. Gambians call it Juto while Sierra Leonians call it Yodo or Jodo It is commonly called Rhodes Violet or Wild Wistaria in South Africa (Dalziel, 1937). A common small tree or shrub in savanna country, readily recognized by its brilliant purple (occasionally white) flowers and by the dry wrinkled fruits ending in a broad flat wing about 5 cm long (Keay, 1989). The tree produces seeds that are irregularly wrinkled, more or less flat but flowers between (February-May) that are distinctly ornamental (Arbonnier, 2004). The plant generally has manifold of traditional uses and pharmaceutical applications but its usage varies in different areas.

Sanya Roots appear as woody pieces but yellowish on section and covered with rather smooth thick bark. When fresh it has a rank odor like Wintergreen with a peculiar sweetish taste (Delziel, 1937). The roots have the following uses as they are purgative, violent sneezing if powdered, treatment of syphilis infection, rheumatic pain reliever and stiffness, treatment of tooth decay, cough, bronchitis, tuberculosis and jaundice, stimulant - can keep one awake at night, natural surfactant etc.

Some of the native uses can be correlated with the pharmacological findings, the root having been shown to contain, besides mucilage and tannin, a substance of the class of saponin and also small quantity of methyl salicylate.

II. MATERIAL AND METHODS

Materials

Collection and preparation of plant material, Sanya Roots (SR) and the synthetic /commercial surfactants (SS1 and SS11)

The Sanya Roots was provided from Hong Local Government Area of Adamawa State, Nigeria. The Roots was collected, washed, peeled, cut into smaller pieces and dried in the laboratory at room temperature of (29^oC) for two weeks. It was later pulverized (grounded) to a reasonable size with pestle and mortar, followed by sieving from where surfactant solution was prepared.

On the other hand, the synthetic/commercial surfactants (Samples SS1 and SS11) were purchased from the Market in Jalingo, Taraba State, Nigeria.
The following materials were used for this study. They are:-50 ml burette, measuring cylinder (100 ml), 30 cm length meter ruler, glass beaker (250 ml), distilled water, surfactants solutions, glass syringe (60 ml) and paraffin oil,

III. METHODS

Foam formation

The foam formation was determined by the Ross-Mill method with foam accumulate measuring systems, whereas the foaming production was measured by the height of the foam initially produced.

The Surfactant solutions-SR, SS1 and SS11 were prepared at different concentrations of 1 g/100 ml, 2 g/100 ml and 3 g/100 ml. Then 50 ml surfactant solution in the burette was allowed to run out into the receiver from a height of 10 to 12cm. For each surfactant at different concentrations, the height of foam formed in the receiver was measured immediately and at interval of 5 minutes. This study was carried out in duplicate, and the average result was reported.

Emulsion Formation

Emulsion of the Surfactant Solutions (SR, SS1 and SS11) was prepared by mixing 30 ml paraffin oil and 30 ml sample solutions in a beaker. The mixture was homogenized by the use of an improvised method of 60 ml glass syringe. This improvised homogenized process involved repeated cycles of sucking and rapid expulsion of emulsion from the syringe.

The emulsion capacity which represents the emulsifying power was expressed as the amount of oil emulsified and held per gram of sample (Padmashree et. al, 1987). It is mathematically calculated as:-

Emulsion Capacity = (X÷Y) x 100

Where **X**= height of emulsified layer
Y= height of whole solution

IV. RESULTS AND DISCUSSION

Foam production and stability

Being that the most widely appreciated property of surface active substances in aqueous solution is their ability to promote the formation of foams and bubbles, therefore the foam result obtained for SR study shows a high quality foam production which favorably competes with the commercial/synthetic surfactants (SS1 and SS11) studied. This is illustrated in figure 1a. At 2 g of surfactant solutions in 100 ml for SR, SS1 and SS11 it was observed that SR foam disappeared at 3 h leaving behind Samples SS1 and SS11 that disappeared at 8 h and 7.2 h respectively. This behavior could be attributed to their physical nature and bubble formation. From the study, the nature of foams produced from SR has thicker nature with small bubbles throughout the experimental period. On the other hand, Sample SS1 had light foam with variable large bubbles whereas Sample SS11 had also lighter tiny foams with variable larger bubbles throughout the experimental time. Hence the foam stability of SR, SS1 and SS11 shows a gradual decrease in the first one hour of the experiment followed by a sharp decrease till the 8^{th} hour. This is shown on figure 1 a

From the result of the study, SR has a foam production capacity comparable to the commercial/synthetic surfactants like Samples SS1 and SS11. This is illustrated in figure 1b. It could be observed from figure 1b that the higher the concentration of the surfactant solutions the higher the foam production and stability over time. The foam production and stability at 5 minutes for the natural surfactant SR, SS1 and SS11 is shown on Table 1(a-c) with the drop from 3.5 cm to 3.2 cm, 4.5 cm to 4.2 cm and 4.2 cm to 3.7 cm for SR, SS1 and SS11 respectively at concentration of 0.1 g/ 100 ml of the surfactant solutions. According to Garrett (1997) gas pressure is greater in smaller bubbles in non-uniform foams and the intervening walls are no longer flat but curved. The gas will therefore tend to diffuse through the walls from the smaller to the larger bubbles; a clearly autocatalytic process. Hence, small bubbles will disappear with time, and the foam will tend towards a structure of nearly large bubbles. These therefore, are one of the major reasons of SR disappearing earlier than SS1 and SS11. Also, the production of thicker foam observed in SR may be attributed to its crude nature i.e. absence of formulation ingredients like builders, stabilizers etc.

Table 1(a-c):- Presents the foam production and stability of SR, Samples SS1 and SS11 at different concentrations

Table 1a: shows the foam production and stability of Sanya Roots (SR) in 100 ml dilution.

Concentration of SR (g)	**Initial foam height (cm)**	**Foam stability at 5 minutes (cm)**
0.1	3.5	3.2
1.5	5.5	4.6
2.0	5.8	5.2
3.0	6.0	5.2

Table 1b: shows the Foam production and stability of commercial surfactant (SS1) in 100 ml dilution

Concentration of SS1 (g)	**Initial Foam height (cm)**	**Foam stability at 5 minutes (cm)**
0.1	4.5	4.2
1.5	5.0	4.7
2.0	5.5	5.0
3.0	5.6	5.2

Table 1c: shows the Foam production and stability of commercial surfactant (SS11) in 100 ml dilution.

Concentration of SS11(g)	**Initial foam height (cm)**	**Foam stability at 5 minutes (cm)**
0.1	4.2	3.7
1.5	5.3	4.8
2.0	5.5	5.0
3.0	5.7	5.4

Generally, the result obtained from the foam production and stability shows that Sanya Roots (SR) and the other synthetic surfactants (SS1 and SS11) are similar in terms of their correlation as shown in figure 1 (a-b). This however may mean similarity in detergency, wetting and foam production.

Emulsifying Power

Stable emulsion was formed using surfactant solution to oil in a ratio of 1:1 (volume: volume). At different concentrations of the Sanya Roots (SR) a creamy substance of oil-in- water emulsion was observed. All the surfactant solutions exhibited high emulsifying activities or capacity (EC) at different concentrations. Figure 2 (a-d) is a bar chart of emulsifying power of SR, SS1 and SS11 at different concentrations and time intervals. The emulsifying power of SR at 1 g/100 ml concentration was higher than Sample SS1 and SS11. From 1 h to 48 h determination time, SR was in the range of 98.4 % to 70 % while Samples SS1 and SS11 were at 96.7 % to 64.17 % and 98.3 % to 65 % emulsifying capacity respectively. In fact, the SR at different concentrations showed better creamy behavior than SS1 and SS11. On storage, during the study it was observed that the creamy stability gradually decreases in SR but faster in the commercial surfactants (SS1 and SS11). This may be as a result of droplet size distribution which depends on droplet break-up and not droplet formation (Dickinson 1988).

The result obtained in 1 g concentration is similar to that of 2 g concentration with SR exhibiting a higher emulsifying power than SS1 and SS11 at a time frame of 1 h to 48 h. The range of emulsifying power of SR, SS1 and SS11 was 97.5 % to 63.3 %; 96.7 % to 60 % and 95 % to 56.6 % respectively.Using 4 g/ 100 ml concentration, of the emulsion capacity study it was observed that SR has also a higher emulsifying power than SS1 and SS11 at a determination time range between 1 h to 48 h. The results were 93.3 % to 61.6 %; 91.6 % to 48.3 % and 95 % to 50 % for SR, SS1 and SS11 respectively.

At 6 g/100 ml emulsion capacity/formation it was still observed that SR had a higher emulsifying power than SS1 and SS11. The results of the study at a determination time of 1 h to 48 h were 95.8 % to 66.7 % for SR, 98.3 % to 63.3 % for SS1 and 85.8 % to 62.5 % for SS11. It is worthy to note that the stability achieved at different concentrations was as a result that the surfactant solutions (SR, SS1 and SS11) thus acted as an emulsifying agent. Base on this, Mill (1997) states that to achieve stability in emulsion a third component, an emulsifying agent must be present. The work of surfactants as emulsifiers are characterized by the fact that they possess both a hydrophilic and a hydrophobic moiety and as a result of this structure they do orient themselves at oil-water or gas-water interface thereby reducing surface energy (Adebayo, 2001). A good emulsifying agent therefore must be surface active, that is, it must have the capacity to lower the surface tension at the oil-water interface, both substantially and rapidly when present at the concentrations typically used during emulsification. Dickson (2003) indicated that the lower the interfacial tension the greater the extent to which droplets can be broken up during intense shearing or turbulent flow.

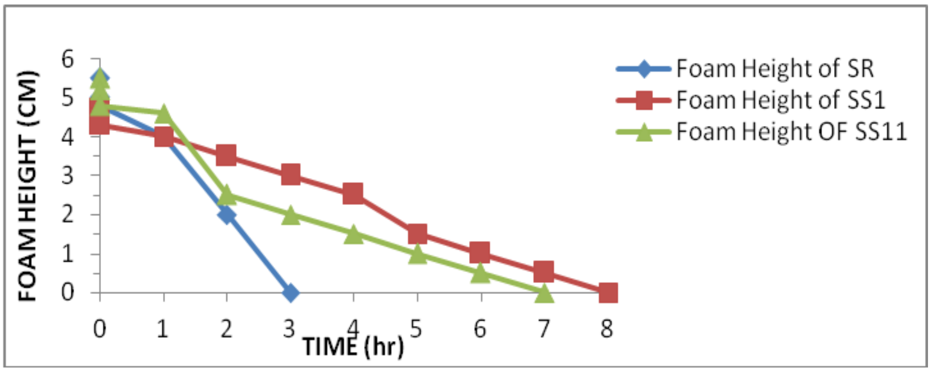

Figure 1a show a plot of foam production and stability for 2 g of surfactants at room temperature (29°C) with Time

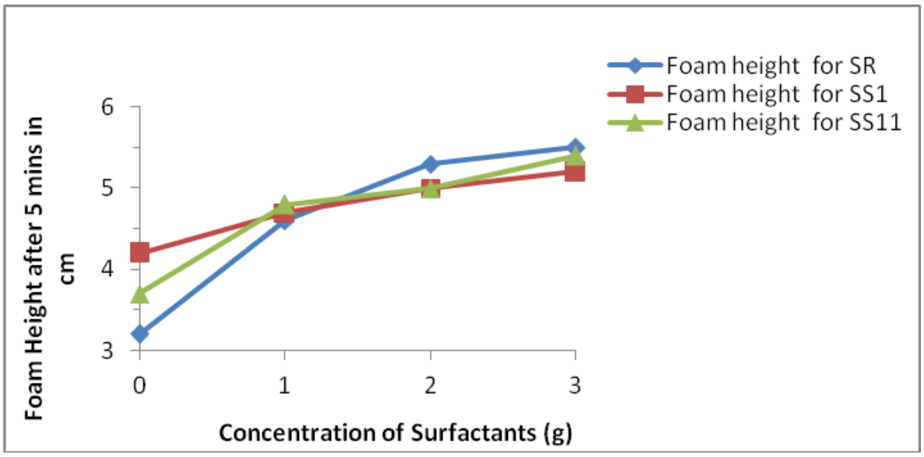

Figure 1b shows a plot of foam production and stability using different concentrations of the surfactant solutions at 5 minutes.

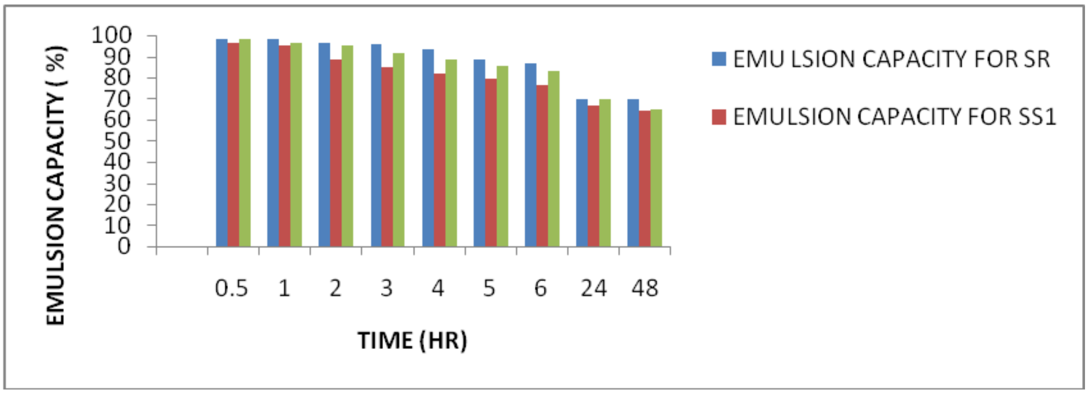

Figure 2 a shows the plot of emulsion capacity (%) against Time (h) for 1 g of the surfactant solutions

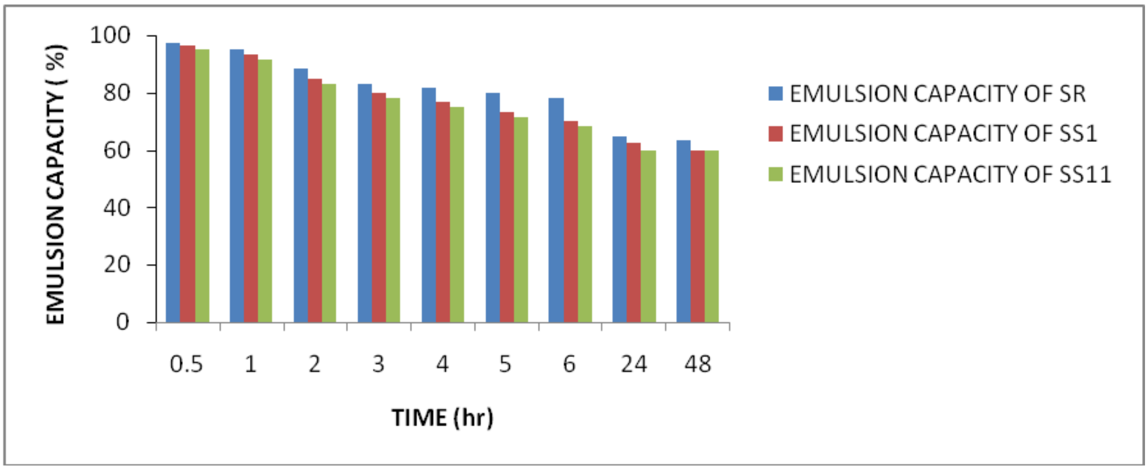

Figure 2 b shows the plot of emulsion capacity (%) against Time (h) for 2 g of the surfactant solutions

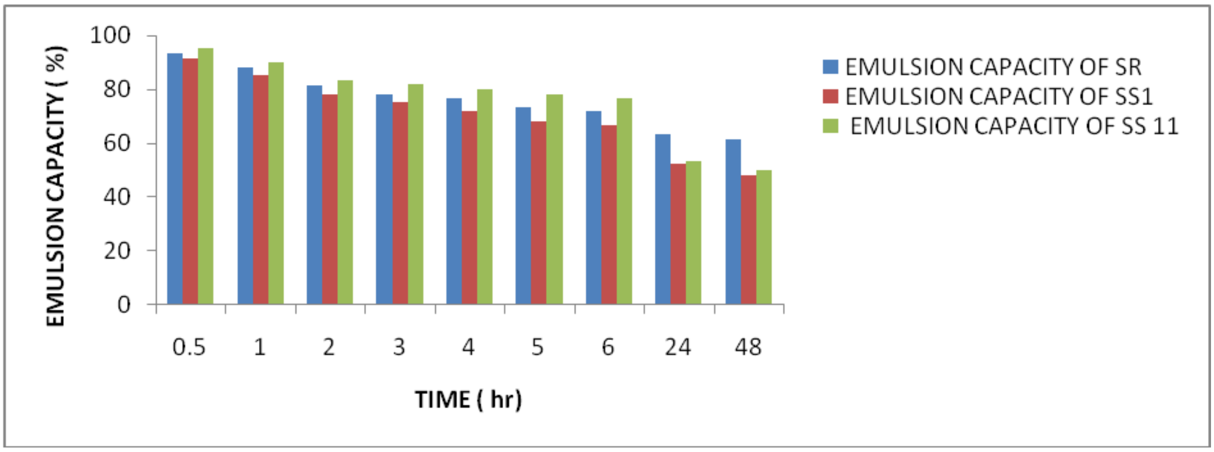

Figure 2 c shows the plot of emulsion capacity (%) against Time (h) for 4 g of the surfactant solutions

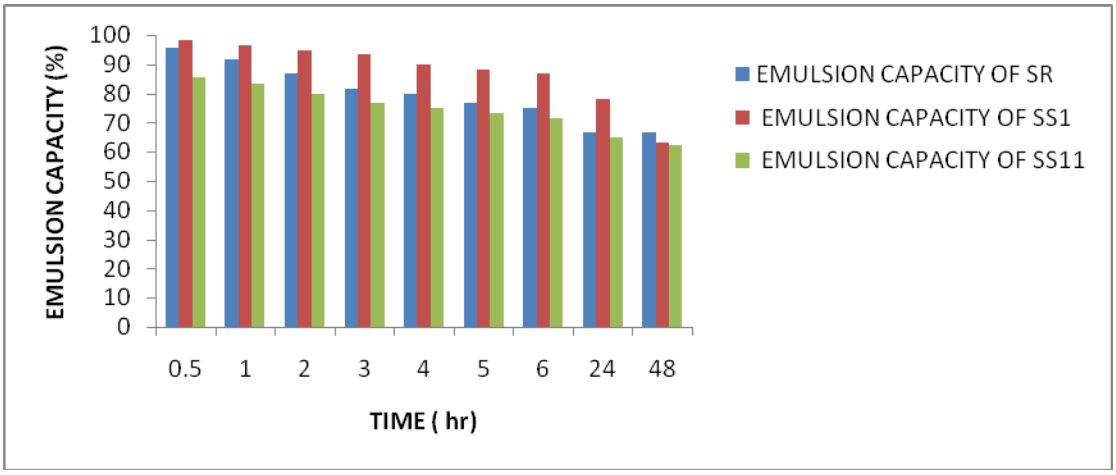

Figure 2 d shows the plot of emulsion capacity (%) against Time (h) for 6 g of the surfactant solutions

V. CONCLUSION

The analytical investigation of the foam formation and emulsifying power of Sanya Root (SR) with some Synthetic Surfactants (SS1 and SS11) proves that Sanya Root (SR) at all concentrations can compete with the synthetic surfactants in most of its detergency, wetting, emulsifying and foaming properties. The consideration of SR as a better emulsifier is as a result of its high stabilization of oil-in-water (o/w) emulsion. From this study, the fast disappearance of SR foam is an indication that it has an advantageous property from the ecological point of view. That is, showing high level of biodegradability for the plant material which will therefore eliminate the problems of synthetic detergent such as non-biodegradable, toxicity and eutrophication problems with pollutants which severely affect the water bodies. Hence the study of this plant for foam formation and emulsifying agent will offer some outlets for utilizing SR in many industrial applications. This will also be based on their availability, inexpensiveness, non-toxic nature and yield expectation (Tanaka 1996). Looking at these advantages of SR and being that it can be propagated easily and hopefully may be hybridized for better yield and growth; there is therefore the need to commercially produce detergent out of Sanya Roots. It therefore stands as a reliable alternative if the source of synthetic surfactants depletes due to over usage.

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