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NIGERIAN SOCIETY OF PHYSICAL SCIENCES
Available online @ https://asr.nsps.org.ng/index.php/asr

African Scientific Reports 3 (2024) 164

African Scientific Reports

Physical quality assessment of selected made in Nigeria synthetic surfactants for surface activity in Bali, Taraba State, Nigeria

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Abstract

The properties of high-quality soap is determined by its cleansing, foam formation, surface tension, emulsion capacity, pH, etc. To produce a generally better product, soap manufacturing companies take these properties into account during production which necessitated the physical assessment properties of some selected made-in-Nigeria synthetic surfactant for surface activity. The samples were evaluated based on tests for saponins, foam formation and stability, emulsion formation/capacity, surface tension, and pH at different concentrations. The percentage of each of the synthetic surfactants (Ariel=DA, Bonus=DB, Good mama=DG, Sunlight=DS and Zip=DZ) concerning foam formation at five minutes and stability after 30 minutes were as follows; DZ(6.7) > DS(6.3) > DG(5.3) > DA(4.2) > DB(4.1) and DZ(2.6) > DG(1.9) > DA(1.1)/DS(1.1) > DB(1.0) in cm, respectively. The study of the emulsion formation/capacity of the different samples at different concentrations in terms of creamy behaviour was observed as DS > DZ > DA > DG > DB. All the samples studied showed a good reduction in surface tension. At 2g and 10g of the different samples, the following results were obtained: DS(2.87), DZ(20.25), DB(21.55), DA(21.65), DG(21.85) Nm-1 and DS(22.45), DZ(22.25), DB(22.45), DA(26.65), DG(22.65) N/m, respectively. The result of the pH values of the different samples varied within the range of 10.80 to 10.91 as moderately weak base with an increase in concentration. Detergents studied conform to the minimum quality examinations but regular assessment check should be carried out by enforcement/regulatory agencies to ensure quality of detergents produced in the country meets the minimum required standard.

DOI:10.46481/asr.2024.3.1.164

Keywords: Emulsion, Stability, Surface activity, Surfactant, Tension

Article History :
Received: 14 October 2023
Received in revised form: 31 March 2024
Accepted for publication: 01 April 2024
Published: 28 April 2024

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1. Introduction

From time immemorial, the importance of both household and industrial soaps and detergents cannot be overemphasized. Soap is defined as any cleansing agent, manufactured in granules, bars, flakes, or liquid form obtained from salt of sodium or potassium of various fatty acids that are of natural origin (Salt of non-volatile fatty acids). It's a common cleansing agent known to everyone according to Warra [1].

Chemically, soaps are the product of the reaction between a fat and sodium hydroxide which has been in existence since 2,500 years ago. There are four different basic steps in soap production though these different steps undergo several process steps in industries. Detergents are similar in structure and function to soap, and for most uses, they are more efficient than soap and their use is enormous. In addition, detergents usually incorporate a variety of other ingredients that act as water softeners, free-flowing agents, etc. to that of soap.

Soaps are produced for a variety of purposes ranging from washing, bathing, medication, etc. The report of the study of Ref. [2] on some properties of natural surfactants clearly described the similarities of both synthetic and natural surfactants in terms of detergency, wetting, and foam production. The hydrocarbon action of soap is due to the negative ion on the hydrocarbon chain attached to the carboxylic group of the fatty acids [3]. The affinity of the hydrocarbon chain to oil and grease, while the carboxylic group to water is the main reason soap is being used mostly with water for cleansing purposes [4].

Generally, surfactants are classified as anionic, cationic, or non-ionic surfactants based on the nature and the type of the surface active moiety group present in the molecule, and in a case where both cationic and anionic centres are present in the same molecules, they are termed as zwitterionic (amphoteric) surfactants [5].

Synthetic detergents came into wide use in the late 1940s and early 1950s as they proved to be effective in hard water and cool or cold water. Sharma [6] reported that alklyl benzene sulphonate considered a surfactant has one serious disadvantage from the ecological point of view by breaking down the non-organic anion into smaller species. Synthetic detergents, according to Lee [7], are categorized into soft and hard detergents with biodegradability percentage of 50% for hard detergents and 90% biodegradability for soft detergents. The aim of the study was to evaluate some physical properties of "Made in Nigeria surface active agent" sold in Bali, Taraba State, for better assessment of their effects to human and materials. The objectives of the study covers determination of pH value, foaming properties and foam stability, emulsifying power/capacity, and comparing the physical properties of the different detergents studied.

2. Materials and methods

2.1. Collection of sample materials

The made in Nigeria detergent' were randomly purchased from different shops and supermarkets located around the Friday weekly market in Bali, Bali Local Government Area of Taraba State. The Commercial/Synthetic detergents bought for study were Sunlight, Zip, Bonus, Good Mama, and Ariel and in this context were coded as DS, DZ, DB, DG, and DA. A 500 g pack of each of the synthetic detergents were purchased as sample material.

2.2. Preparation of sample materials

The samples were brought to the laboratory where each pack was opened and transferred to a plastic bowl with cover. Before the transfer of the sample, the content was further pulverised using a mortar and pistil to maintain homogeneity so as to achieve total and fast dilution when dissolved. During experimentation 30 g of the required dissolved quantity was kept for 24 hr and at normal room temperature between 25 to 30°C to achieve complete dilution. The unused materials were stored in a container and kept in a refrigerator for further studies.

2.3. Tests for saponins

2.3.1. Frothing test

The method described by Refs. [8, 9] was employed for this test. Approximately, 0.5 g of the sample powder was vigorously shaken with 10 ml of water in the test tube for 30 seconds. It was then allowed to stand for 30 minutes and observed. A formation of honey comb froth was observed which indicates the presence of saponins.

2.3.2. Haemolysis test

An amount of 1 g of the sample was dissolved in water and later filtered. To the filtrate in a test tube, 2 mL of NaCl solution was added. Later, three drops of an animal blood was added to the test tube by means of a syringe and mixed gently by inverting the tube (no shaking) and allowed to stand for 15 minutes. The scattering of the red blood cell indicates the presence of saponins [10].

2.4. Foam formation and stability

It was determined by the Ross–mile method with foam accumulate measuring systems, the foaming production was measured by the height of the foam initially produced. The foaming properties were measured using the method described by Ref. [11]. The surfactant solutions were prepared at different concentrations. The 50 cm^3 surfactant solutions in the burette was allowed to run out into the receiver from a height of 10 to 12 cm for each surfactant solution 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 average result was reported.

2.5. Emulsion formation and capacity

Emulsion as reported by Barminas and Agu [12] was prepared by mixing 30 ml paraffin oil and 30 ml sample solution in a 250 ml glass beaker. The mixture was homogenized using an improvised method of 60 ml glass syringe. This improvised homogenization process involved repeated cycles of sucking and rapid expulsion of emulsion from the syringe. This was done to ensure proper droplet break–up until a creamy homogeneous emulsion was obtained.

Emulsion capacity was expressed as the amount of oil emulsified and held per gram of the sample [13]. The emulsion capacity was calculated using the established mathematical formula:

$$\text{Emulsion capacity} = X \times Y \times 100\%, \tag{1}$$

where X is the height of emulsified layer and Y is the height of whole solution.

2.6. Determination of surface tension

The surface tension measurement was carried out using modified drop weight method by Ref. [14]. This was repeated for all the surfactants at different concentrations. All analysis was carried out at room temperature, and the surface tension was calculated using the formula below:

$$r_2 = r_1 n_1 \rho_2 n_2 \rho_1, \tag{2}$$

where r_2 is surface tension of the sample, r_1 is surface tension of the distilled water, n_1 is number of drops of water, n_2 is number of drops of samples, ρ_1 is density of water, ρ_2 is density of sample. The Surface tension of 72.13 Nm^{-1} was adopted for distilled water, taken as standard at 25°C [15].

2.7. pH determination

The method described by Ref. [16] was adopted. The sample solutions were poured into a beaker and a standardized pH meter was used to determine the level of acidity or alkalinity in the sample solution.

3. Results

3.1. The result of test for saponin

From Table 1, the two different methods (Frothing and Haemolysis test) used to test for the presence of saponins for the different synthetic surfactant was found positive with its distinct foaming properties. Being that saponin is present in all the different synthetic surfactant shows that they are effective cleaning agents capable of lifting grease, dirt and grime from clothing.

Table 1. The result of the test for Saponin of different synthetic surfactant studied.

Test	DS DZ DB DA DG Observation	DS DZ DB DA DG Result
Frothing test	Honey comb foam	Present
Haemolysis test	Scattering of Red Blood Cell	Present

Table 2. Result of the foam formation and stability of different synthetic surfactant at 5 minutes in 100 ml dilution.

Surfactant concentration (g)	Synthetic surfactants indicating foam heights (cm)				
	DS	DZ	DB	DA	DG
2	6.2	6.7	4.1	4.7	5.3
4	4.9	5.8	6.4	5.9	4.6
6	5.9	4.7	3.4	5.7	5.5
8	4.8	7.6	3.3	4.1	3.5
10	3.7	5.6	3.4	3.0	3.4

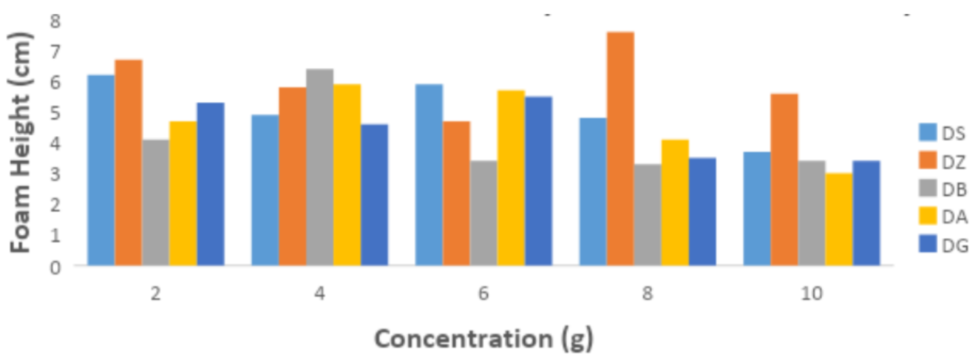

Figure 1. Result of the foam height and stability of the different detergents at different concentrations in 5 minutes.

Table 3. Result of the foam formation and stability of different synthetic surfactant at 15 minutes in 100 ml dilution.

Surfactant concentration (g)	Synthetic surfactants indicating foam heights (cm)				
	DS	DZ	DB	DA	DG
2	5.1	5.0	2.3	3.7	3.6
4	3.0	3.6	2.7	5.0	3.7
6	3.9	3.9	2.1	3.7	5.3
8	3.0	3.7	1.5	2.9	3.1
10	2.2	4.3	2.1	2.1	3.0

3.2. Results for foam formation and stability at 5 minutes for the different synthetic surfactant

From Table 2, the result of the foam formation and stability of different synthetic surfactant indicates that the foam heights decreases with increase in concentration over time. In all, at a low concentration of 2 g the foam formation and stability at 5 minutes increases from DB > DA > DG > DS > DZ which almost persisted to a higher concentration of 10 g except DB > DA. It also indicates that the different synthetic detergents studied produced an excellent foam heights. Usually the efficiency of a detergent is assessed through the amount of foam it is capable of producing. The presence of persistent foam exemplifies a good detergent [17]. From foam stability at 5 minutes to 30 minutes DZ and DS maintained high foam formation and stability while DB and DA were significantly lower over time.

Figure 1 which depicts the foam height and stability of the different detergents at different concentrations in 5 minutes is a graphical presentation of Table 2 in 100 ml dilution of the different detergents.

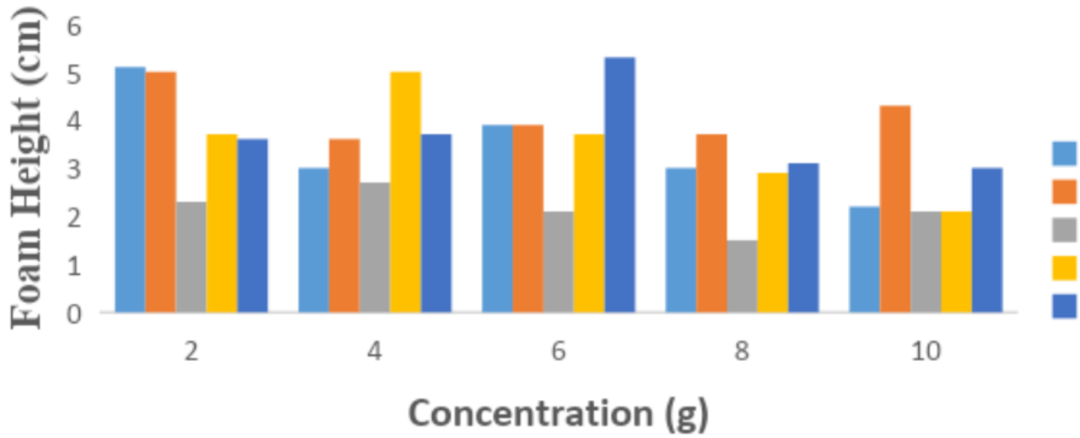

Figure 2. Result of the foam height and stability of the different detergents at different concentrations in 15 minutes.

Table 4. Result the foam formation and stability of different synthetic surfactant at 20 minutes in 100 ml dilution.

Surfactant concentration (g)	Synthetic surfactants indicating foam heights (cm)				
	DS	DZ	DB	DA	DG
2	4.7	4.5	2.1	3.3	3.1
4	2.7	3.0	2.3	4.6	3.2
6	3.1	2.8	1.7	2.8	3.0
8	2.7	3.1	1.1	2.0	2.6
10	1.8	3.7	1.7	1.7	2.9

Table 5. Result of the foam formation and stability of different synthetic surfactant at 30 minutes in 100 ml dilution.

Surfactant concentration (g)	Synthetic surfactants indicating foam heights (cm)				
	DS	DZ	DB	DA	DG
2	3.7	2.6	1.5	1.4	2.3
4	2.0	1.9	1.6	2.1	1.7
6	2.1	2.0	1.0	1.1	2.0
8	2.0	1.4	0.5	1.3	2.1
10	1.1	1.6	1.0	1.1	1.9

From Tables 3 and 4, it was observed that the foam heights of the different synthetic surfactants degraded or lowered across the concentrations and over time (15 min and 20 min). At 15 min the foam heights degraded as the concentration increases for the different synthetic surfactants from 5.1 cm to 2.2 cm, 5.0 cm to 4.3 cm, 2.3 cm to 2.1 cm, 3.7 cm to 2.1 cm, 3.6 cm to 3.0 cm for DS, DZ, DB, DA, DG, respectively.

At 20 min, the foam height continued to degrade for the different synthetic surfactant at different concentrations. DS and DZ maintained high foam formation and stability than the others that still maintained a reasonable level of foam height.

At 30 min, the synthetic surfactants continue to maintain reduction in foam heights which describes the nature of foam formation over time [2]. The reduction in foam height of the different synthetic surfactant is in the form DS>DZ>DG>DB>DA.

Figures 2, 3 and 4 were used to graphically represent foam height and stability of the different detergents at different concentrations in 15 min, 20 min and 30 min respectively and as shown in Table 3, 4 and 5.

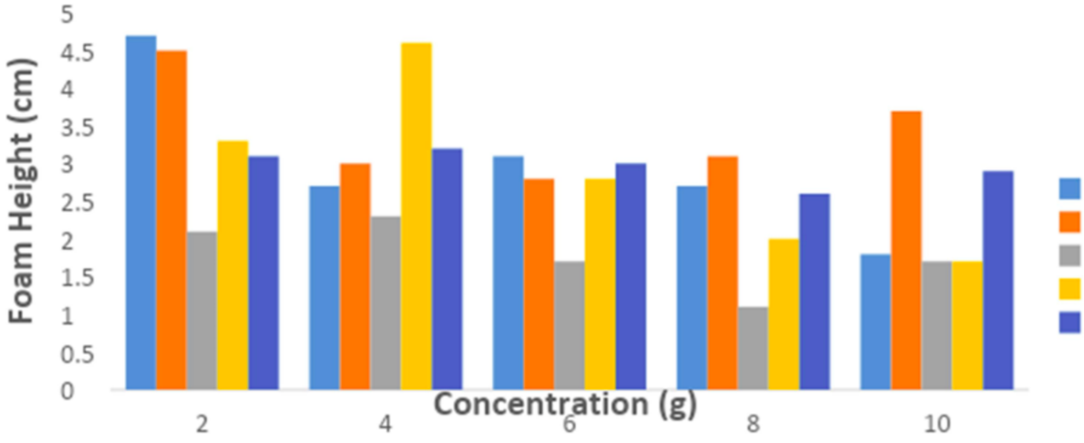

Figure 3. Result of the foam height and stability of the different detergents at different concentrations in 20 minutes.

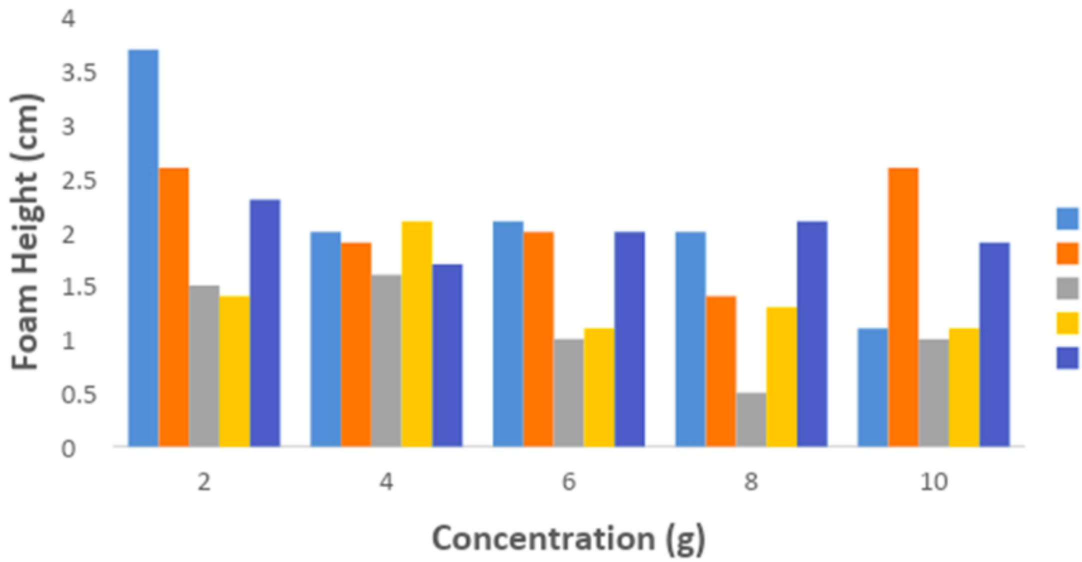

Figure 4. Result of the foam height and stability of the different detergents at different concentrations in 30 minutes.

Table 6. Results of Emulsion formation/Capacity of different Synthetic Surfactant at different concentrations.

Concentration (g/100mL)	Emulsion Capacity (%)				
	DS	DZ	DB	DA	DG
2	77.29	61.25	54.87	57.69	70.42
6	86.66	64.93	49.33	60.00	65.21
10	97.69	79.30	51.68	78.00	56.75

3.3. The results of the emulsion formation/capacity of different synthetic surfactant at different concentrations.

From Table 6, the emulsion formation/capacity of different synthetic surfactant at different concentration with a proper droplet break–up which gave rise to a creamy homogenous emulsion was obtained in all the synthetic surfactant at different concentration (2, 6, 10 g/100 ml) studied. At 2 g/100 ml, the breaking of a large oily droplet into smaller particles followed by formation of a suspension in the aqueous cleansing solution was obtained in the order of

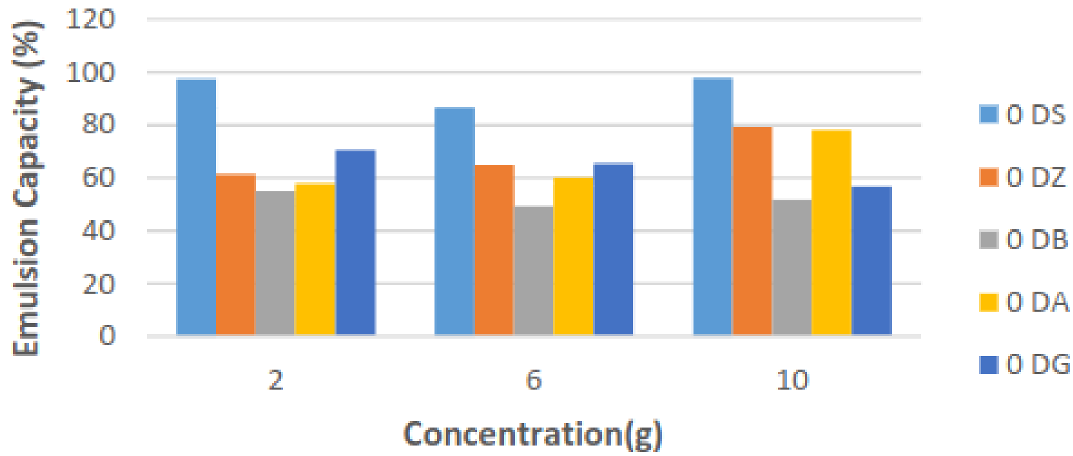

Figure 5. Emulsion formation/Capacity of different Synthetic Surfactant at different concentrations.

Table 7. Result of the surface tension of different synthetic surfactant at different concentration.

Concentration (g/100mL)	Surface Tension (N/m)				
	DS	DZ	DB	DA	DG
2	21.87	20.25	21.55	21.65	21.85
4	22.25	21.65	22.05	21.35	22.05
6	22.45	21.85	21.95	21.75	22.25
8	21.95	21.95	22.25	21.95	22.45
10	22.45	22.25	22.45	21.65	22.65

DS>DG>DZ>DA>DB. At the highest concentration, 10 g/100 ml all the synthetic surfactant studied maintained an increase in the emulsion capacity with the exception of DB and DG. Generally, it can be noted that all the synthetic surfactant studied were of a good emulsifier as it promotes formation at both low and high concentrations [12].

Similarly, the same explanation holds for Figure 5, as it is the graphical representation of Table 6, the emulsion formation/capacity of different synthetic surfactant at different concentrations.

3.4. Results indicating the surface tension of different synthetic surfactants at different concentration

From Table 7, all the synthetic surfactants showed a good reduction in surface tension with increase in concentration. This reduction in surface tension determines the efficiency of detergent formulation as high surface tension of water makes it a relatively poor cleansing detergent. At 2 g/100 ml concentration the synthetic surfactants studied had a decreasing surface tension from DS<DG<DA<DB<DZ as also shown in Figure 6. In all, there was little changes for the surface tension between the studied concentrations.

3.5. The pH gradation of the different synthetic surfactants using different concentrations

For Table 8 which showed the pH values of the different synthetic surfactant at different concentrations to be moderately or weakly alkaline. This is represented graphically in Figure 7. This is possibly because of the presence of alkaline builders in modern detergents to raise the pH above neutral to improve detergency. This result is also within the limit of acceptable standard pH values for powdered detergents.

4. Discussion

The tests for saponins of the different commercial synthetic surfactants were carried out by means of frothing and haemolysis analysis which indicates the presence of saponins which is a special class of glycosides with soapy characteristics [18].

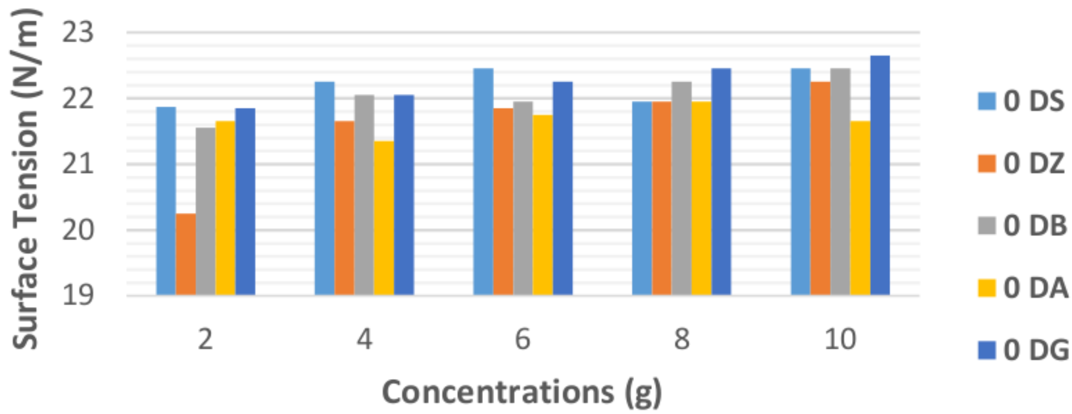

Figure 6. Surface tension of different synthetic surfactant at different concentration.

Table 8. Result of the surface tension of different synthetic surfactant at different concentration.

Concentration (g/mL)	pH of the different synthetic surfactant				
	DS	DZ	DB	DA	DG
2	10.82	10.85	10.82	10.81	10.81
4	10.88	10.89	10.80	10.81	10.81
6	10.88	10.88	10.83	10.92	10.83
8	10.89	10.81	10.84	10.91	10.83
10	10.90	10.91	10.83	10.87	10.83

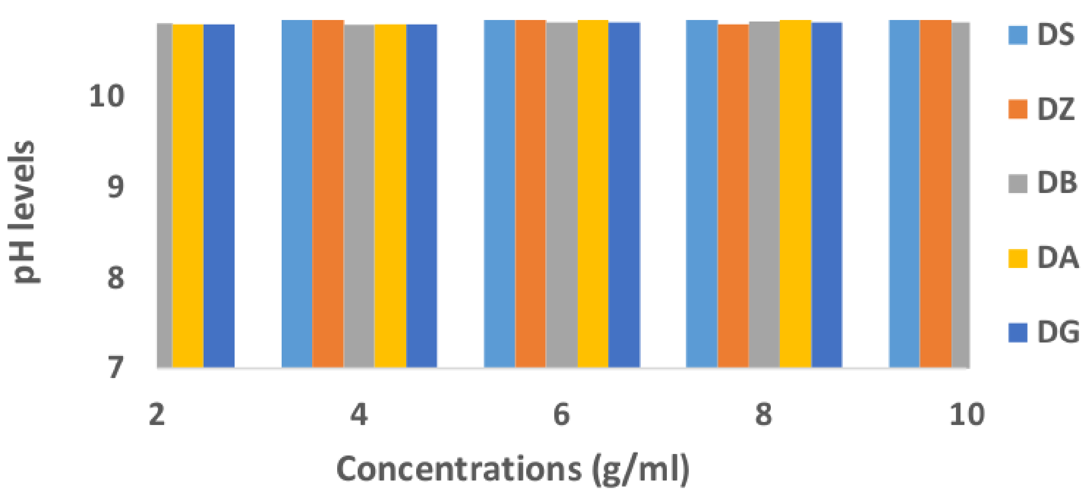

Figure 7. The pH values of the different synthetic surfactant at different concentrations.

From the foam formation and stability characteristics in Table 5 , the study shows that at longer period of 30 minutes the detergent DZ at high concentration retains high level of foam formed than the others. From their initial foam formation in Figure 1, the result of the study had it as DZ > DS > DG > DA > DB from the highest to the least foam formation/capacity. The foam stability retention result for the five detergents at 30 minutes of high concentration are shown as thus: DZ > DG > DA/DS > DB. Generally, there wasn't much difference in range for the foam production and stability which may indicate similarity in detergency, wetting and dirt removal or power against heavy stain. This was recorded in the work of Ref. [2]. For awareness sake, the manufacturers has to regularly upgrade while the users take wise decision in making choice.

In a ratio of 1:1 (volume: volume) of the surfactant solution to oil at a room temperature a creamy stable emulsion was formed at different concentrations. All the surfactant solutions exhibited high emulsifying capacity in percentage at different concentrations. From this study, the emulsion formation (in Table 6) of the different synthetic surfactants at different concentrations in terms of creamy behavior was observed as DS > DZ > DA > DG > DB with respect to high degree of percentage emulsion capacity. It was also observed that the creamy stability of the emulsion capacity decreases from DS to DB at different concentrations and time. This may also be as a result of droplet size distribution which depends on droplet break-up and not droplet distribution as recorded by Ref. [19].

All the commercial synthetic surfactant studied showed a good reduction in surface tension which was not so pronounced with increase in concentration. Generally, the synthetic surfactants decreased the surface activity at room temperature when compared with water which served as a control.

The result of the pH values of the different synthetic surfactants solutions varied but within the range of 10.80 to 10.91 which is moderately weak base with increase in concentration. This result is also within the limit of acceptable standard pH values for powdered detergents which is in the alkaline range.

5. Conclusion

From the study and at all concentrations, the five surfactants studied shows the property of detergency, wetting, emulsifying and foaming capacity. The result of the study will go a long way to guide users and regulation agencies more about the proliferation of industrial and homemade detergents that springs up on daily basis in the country. All the products conform to the physical quality assessment conducted, though regular assessment check should be carried out by enforcement/regulatory agencies to ensure the quality of detergents to meet the minimum required standard. None of the examined synthetic surfactant was characterized by a high acidity or alkalinity which rendered them safe for use. All the analyzed products were lower in surface tension than water. The study reveals that the surfactants are better emulsifiers due to their stabilization of oil-in-water forming a better lasting creaming behavior in most cases.

On the part of the manufacturers it will guide them to embrace the Standard Organisation of Nigeria (SON) Integrated Management System (IMS) Certification, which includes the Quality Management System (ISO 9001: 2015); and Environmental Management System (ISO 1400: 2015) Standards to help their businesses meet legal and regulatory requirements and satisfy industry standards. Users therefore should not base their assessment of product quality through marketing strategies especially the promotional strategies, price, popularity of a product, pleasant odour and packaging of product brands.

Acknowledgment

The authors wish to thank the technologist, Mr. Francis James, and the technician, Mr Elisha Akuki of the Department of Science Laboratory Technology, Federal Polytechnic, Bali, Taraba State, Nigeria for their technical assistance throughout the time of the analysis of this research.

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