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A Novel Method for Preparing a Surface Tension-Reducing Solution Using Vegetable Ghee

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Abstract

This study presents a novel method for preparing a surface tension-reducing solution using locally available vegetable ghee through a sulfonation process. The ghee was sulfonated using concentrated sulfuric acid, followed by neutralization with sodium hydroxide. The surface tension of the resulting solution was measured at different concentrations, both alone and in combination with poly(acrylic acid). Fourier Transform Infrared Spectroscopy (FTIR) was employed to confirm the formation of sulfonic groups. The results showed a significant variation in surface tension with changing concentrations, with a minimum observed at 5 mL and a maximum at 3 mL. When mixed with poly(acrylic acid), the solution exhibited the highest surface tension at a 1 mL concentration and the lowest at a 4 mL concentration. These findings suggest that vegetable ghee can be effectively transformed into a functional anionic surfactant with potential applications in detergents, emulsifiers, and pharmaceutical formulations.

Introduction

Surface tension typically occurs at the interface between a liquid and air, between two immiscible liquids, or between a liquid and a solid surface. A molecule in a liquid is surrounded by neighboring molecules from all sides, resulting in balanced attractive and repulsive forces in all directions. However, molecules at the surface experience only lateral and downward attraction, as illustrated in Figure 1 [1, 2].

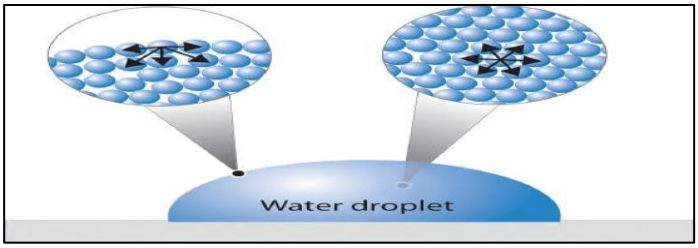

Fig. water molecules.

Among the substances whose surface tension is studied are fatty acids and triglyceride oils, particularly after undergoing sulfonation. This process involves the addition of a sulfonic group to an organic compound, transforming it into a surfactant-like substance that is water-soluble. Such substances are widely used in industries such as detergents and cosmetics. The general reaction for sulfonation is as follows [3, 4]:

$$R\text{-}CH{=}CH\text{-}R' + SO_3 \rightarrow R\text{-}CH(SO_3H)\text{-}CH_2\text{-}R'$$

There are several industrial methods for sulfonating fats. The most common involves using concentrated sulfuric acid, which reacts directly with the double bonds in fatty acids [5, 6]. Alternatively, sulfur trioxide can be used, offering more effective and controlled sulfonation, although it requires precise conditions (temperature and pressure) [7, 8]. Chlorosulfonic acid is another option, yielding selective sulfonation results [9, 10].

Sulfonation has a wide range of applications, including the manufacture of anionic surfactants, such as alkylbenzene sulfonates [11, 12], emulsifying agents for oil-in-water emulsions [13, 14], solubility modifiers for lipophilic drugs, and the production of water-soluble pesticides and fertilizers [15, 16].

Experimental

Preparation of a Surface Tension-Reducing Agent from Vegetable Ghee

The sulfonation process was performed using locally available vegetable ghee. A mixture of 90 mL of vegetable ghee and 60 mL of concentrated sulfuric acid was heated in a water bath at 70 °C for 6 hours. The mixture was then allowed to cool to room temperature, and sodium hydroxide (NaOH) was added to neutralize the solution to a pH of 6 (Figure 2). Finally, the surface tension of the resulting solution was measured.

Results and Discussion

The sulfonation process was carried out using locally available vegetable ghee. The mixture was analyzed using Fourier Transform Infrared Spectroscopy (FTIR) to identify the resulting functional groups. Subsequently, the surface tension was measured.

Surface tension was first measured before adding 20 mL of water, yielding a value of approximately 35.20 dyn/cm. Upon adding 20 mL of water to varying concentrations of the sulfonated solution, notable changes in surface tension were observed.

Table 1. The surface tension values for different concentrations of the material prepared from sulfonation.

Surface tension value dyn/cm	Concentration of sulfonated solution ml
51.01	**1**
51.04	**2**
51.22	**3**
50.87	**4**
48.22	**5**
50.2	**6**

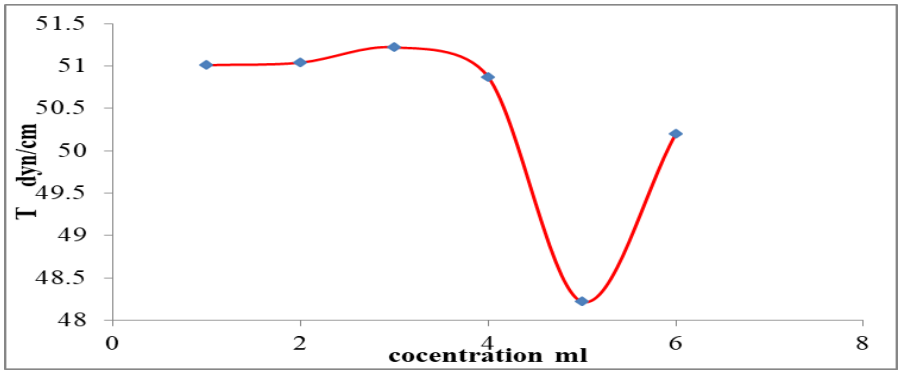

Fig. 3. Surface tension values curve for different concentrations of the material prepared from sulfonation.

Observation: Figure (3) shows that surface tension values remained relatively constant at lower concentrations of the prepared material, decreased to their lowest point at a concentration of 5 mL, and then increased again to 50.2 dyn/cm at 6 mL.

The surface tension was studied at various concentrations of the sulfonation product solution, with a constant concentration of poly(acrylic acid) (4 ml) and a fixed volume of water (20 ml). The results showed a clear variation in surface tension values with the concentration of the sulfonation product solution. The highest surface tension value, 50.79 dyn/cm, was recorded at a concentration of 1 ml, while the lowest value, approximately 45.6 dyn/cm, was observed at a concentration of 4 ml. This suggests that increasing the concentration of the sulfonation product solution negatively affects the surface tension value, likely due to saturation of the water surface molecules with the added product. This may indicate that further increases in concentration are not beneficial. (Table 2 and Figure 4).

Table 2. The surface tension values for different concentrations of the sulfonated solution.

Surface tension value dyn/cm	**Concentration of sulfonated solution ml**
51.4	**1**
50.79	**2**
48.32	**3**
45.6	**4**
49.01	**5**

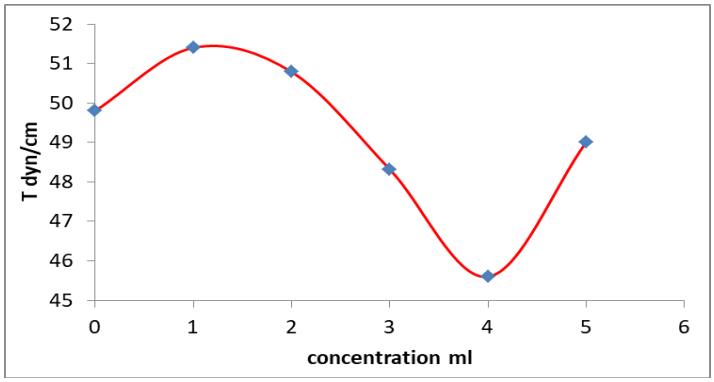

Fig. 4. Surface tension values curve for different concentrations of the sulfonation product solution.

Infrared spectroscopy (FT-IR) examinations were conducted on vegetable ghee before and after sulfonation, showing the active groups that appeared after the sulfonation process, as new groups of S=O appeared at 1217 and 1228, indicating the presence of a sulfonic group, the atrophy of the ester group, and the appearance of active groups at 3261, which indicates the SO3-H group. The first does not contain the sulfone group, and the second confirms the sulfone group at peaks 835, 1087, and 1228.

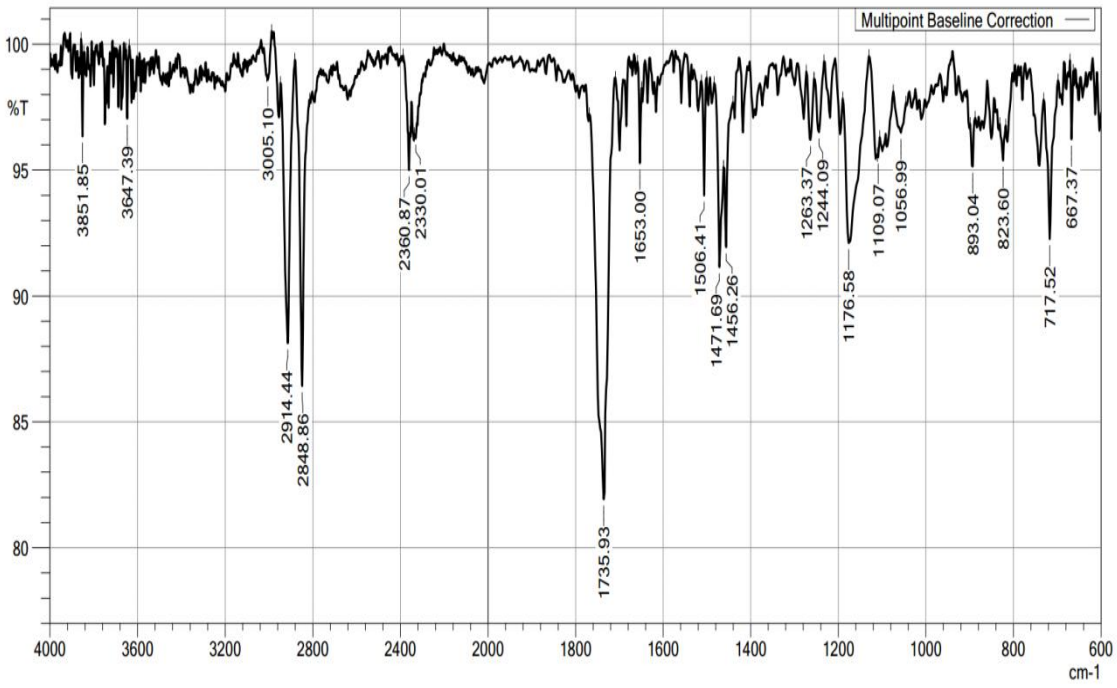

Fig. 5. Infrared spectroscopy of margarine.

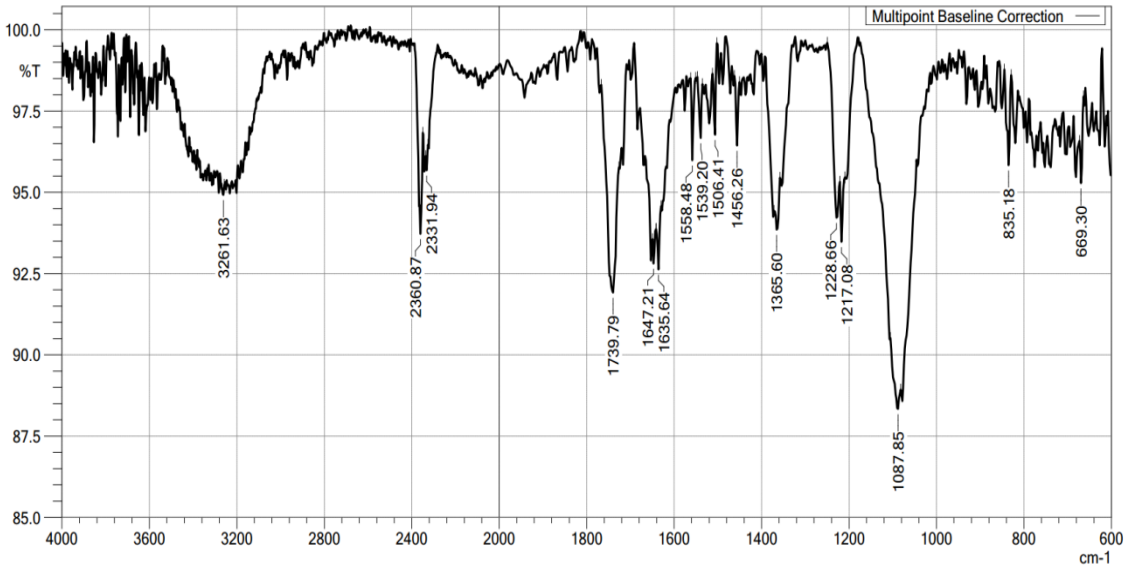

Fig. 6. Infrared spectroscopy of the sulfonated solution.

Conclusions

- The surface tension value of the sulfonated solution was approximately 35.20 dyn/cm.
- The maximum surface tension value, 51.22 dyn/cm, was recorded at a concentration of 3 mL, while the minimum, 48.22 dyn/cm, was at 5 mL.
- When mixed with 4 mL of poly(acrylic acid) and 20 mL of water, the maximum surface tension was 50.79 dyn/cm at 1 mL of the sulfonated solution; the minimum value was 45.6 dyn/cm at 4 mL.

References

[1] Ghoufi, A., Malfreyt, P., & Tildesley, D. J. (2016). Computer modelling of the surface tension of the gas–liquid and liquid–liquid interface. Chemical Society Reviews, 45(5), 1387-1409.
[2] Pomeau, Y. (2013). Surface tension: from fundamental principles to applications in liquids and in solids (Doctoral dissertation, Warsaw School of Statistical Physics).
[3] Ortega, J. A. T. (2012). Sulfonation/sulfation processing technology for anionic surfactant manufacture. Advances in Chemical Engineering, 9(1), 269-294.
[4] Stein, W., & Baumann, H. (1975). α-Sulfonated fatty acids and esters: Manufacturing process, properties, and applications. Journal of the American Oil Chemists Society, 52(9), 323-329.
[5] Nkwor, A. N., Ukoha, P. O., & Ifijen, I. H. (2021). Synthesis of sulfonated Sesamum indicum L. seed oil and its application as a fatliquor in leather processing. Journal of Leather Science and Engineering, 3, 1-13.
[6] Ashar, N. G., & Golwalkar, K. R. (2013). A practical guide to the manufacture of sulfuric acid, oleums, and sulfonating agents.
[7] Tully, P. S. (2000). Sulfonic acids. Kirk-Othmer Encyclopedia of Chemical Technology.
[8] Testa, M. L., & La Parola, V. (2021). Sulfonic acid-functionalized inorganic materials as efficient catalysts in various applications: a minireview. Catalysts, 11(10), 1143.
[9] Roberts, D. W. (2003). Optimisation of the linear alkyl benzene sulfonation process for surfactant manufacture. Organic Process Research & Development, 7(2), 172-184.
[10] Zolfaghari, R., et al. (2016). Demulsification techniques of water-in-oil and oil-in-water

emulsions in petroleum industry. Separation and Purification Technology, 170, 377-407. [11] Sousa, A. M., et al. (2022). Oil-in-water and water-in-oil emulsions formation and demulsification. Journal of Petroleum Science and Engineering, 210, 110041. [12] Thakur, S., et al. (2020). Biosurfactants as a novel additive in pharmaceutical formulations: current trends and future implications. Current drug metabolism, 21(11), 885-901. [13] Rani, N., et al. (2023). Are nano-pesticides really meant for cleaner production? An overview on recent developments, benefits, environmental hazards and future prospectives. Journal of Cleaner Production, 411, 137232.