Maximizing the Performance of Surfactants in Hand Dish Wash Liquids

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December 18, 2014

Acknowledgements

First, I would like to thank Dr. Julia Wates, Mrs. Meiylin Antezzo, and Dr. Lingjuan Shen for giving me the opportunity to work with them during the summer of 2014 and mentoring me throughout my experimentation. I would like to thank Akzo Nobel Surface Chemistry, especially the labs located in Brewster, New York. I would also like to express my gratitude to Mrs. Elizabeth Stephens who taught “Introductory to Science Research” during the 2013-14 school year and taught me about the initial stages of researching and finding a mentor. I would also like to thank Mr. Dennis Quackenbush for teaching “Advanced Science Research” and supporting me in past competitions and continuing to do so now.

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Abstract

Surfactants are molecules that consist of a hydrophilic head and a hydrophobic tail. Many products today are expensive because they have high concentrations of surfactants. With a cost effective product for the consumer, more people would have access to buy hand dish wash liquids to clean their dishes, and be less likely to contract diseases spread by body fluids like saliva.

The objective of this study was to determine the concentrations and blends that specific surfactants would be most suitable for removing soil and grease from hard surfaces when added to a low-performing hand dish wash liquid. Different surfactants were added to budget hand dish wash liquids to determine if they had significant impacts on characteristics such as foaming, viscosity, pH, interfacial tension, and cleaning.

The best blends and concentrations included 0.5% cationic co-surfactants, 1% cationic co-surfactant, and 0.5% cationic co-surfactant with 0.5% anionic surfactants. The first two blends were expected and produced a significant increase in foaming, viscosity, and cleaning. They were also measured to have a decreased interfacial tension. The last blend indicated that the two surfactants created a complex that enabled it to clean as good as, if not better, than the first two blends.

Review of Literature

A surfactant is a **sur**face **act**ive agent: substances that have the ability to change the property of surfaces and interfaces where it is present (Rosen, 2000, p. 5). Interfaces refer to boundaries between any two immiscible, or unable-to-mix, phases. Surfaces refer to boundaries where one substance is a gas (Rosen, 2000, p. 6). Surfactants are molecules that are structurally composed of a hydrophobic, water-repelling group, and a hydrophilic, water-attracting group as shown in Figure 1.1.

When a molecule can act as both water repellents and attractants, the molecule is called amphipathic. Amphipathic substances, when dissolved in solvents, distort the structure of the solvent and increase the free energy of the system (Rosen, 2000, p. 9). Interfacial free energy is the minimum amount of work required to create that interface (Wang, 2008, p. 1238). This determines the interfacial tension between the two phases. When a surfactant changes the properties of a solvent, the minimum amount of work needed to change it decreases. Interfacial tension is defined as W min = γ1 x Δ interfacial area. (Rosen, 2000, p. 18). In other words, the minimum work needed to change the properties of a solvent is equal to a constant known as multiplied by the area of the interface. Surfactants continuously adsorb at all interfaces (Paternostre, 1995, p. 2480). At the edge of a substrate the surfactant molecule will reduce the contact angle, roll the particle off the surface, and cause the particle to become solubilized (Rosen, 2000, p. 18). (Figure 1.2) With a cost effective product for the consumer, more people would have access to buy hand dish wash liquids, clean their dishes, and be less likely to contract diseases spread by body fluids.

The objective of this experiment was to maximize the performance of surfactants in terms of its ability to foam, its thickness, and the tension at the surface that allows it to lift soil off of surfaces. It was to determine what concentrations were most suitable to maximize the components of the hand dish wash liquid. The negative control, or the budget hand dish wash liquid, and the positive control, a premium quality brand hand dish wash liquid, was tested for all the characteristics and served as templates for comparison.

A significant finding in my research can lead to an increased performance of hand dish wash liquids with lower concentrations of additives, cheaper products, and as a result, more sales. This research allows companies to create an enhanced product that is cheaply made. In addition, more people would be able to have access to hand dish wash formulations that work better, have fewer chemicals, and cost less.

Materials and Methods

A budget dish wash liquid and a premium dish wash liquid were purchased. The student conducted an ingredient analysis. The compositions of the two different hand dish wash liquids were analyzed. The independent variables were the types of additives and the concentration each additive was added. The dependent variables were the characteristics of hand dish wash liquids such as foaming, cleaning, viscosity, and interfacial tension. The control groups were the negative and positive controls: a budget hand dish wash liquid and a premium hand dish wash liquid respectively. Controlled variables included same temperature and container for storage, same amount of each additive combined, and same machinery used to measure data.

*Materials*

The three surfactants to be tested: cationic cosurfactant, anionic alkyl ether sulfate, nonionic surfactant were obtained. A functioning balance, SITA Foam Tester, pH meter, Brookfield Viscometer, oven, and Interfacial Tracker Tensiometer were used. Canola oil, corn starch, olive oil, and lard were obtained to create a sample of dirt. Pipets, glass jars, sponges, porcelain tiles, beakers, a camera, tap water, deionized water and a paintbrush was also used.

*Creating Solutions*

Four different blends were made for each surfactant by weight (0.5%, 1.0%, 1.5%, and 2.0%) and mixing it with the budget hand dish wash liquid.

*Process of Cleaning*

Each blend was then dissolved to make 1% solutions with tap water to imitate the setting of a kitchen. Forty milliliters of the solutions were placed in 150 ml. beakers. This was to control the height so that each sponge was soaked with the same amount of the blend. A sample of soil to signify as the soil and/or grease found in kitchen sinks was made by combining 30 grams of canola oil, 40 grams of corn starch, 1 gram of black dye, 10 grams of extra virgin olive oil, and 20 grams of lard. The soil solution was painted in thin layers onto porcelain tiles and baked for an hour at 120°C. After the plates cooled, sponges of the same size and type were dipped into the beakers of two different solutions (blends) for 5 seconds. The same force was used to press the sponge up and down the porcelain tile and a picture was taken by the camera every two scrubs.

*Testing Viscosity*

Spindle #12 was used to carry out the Viscosity testing on the Brookfield LVT Viscometer. The machine was calibrated and the temperature remained constant. Each blend, located in its own container, was placed on the base of the machine and the spindle was lowered into the solution. The speed was adjusted to measure a reading that did not produce an error. If the spindle spun too fast, an error resulted, and the speed was decreased to record a measurable number. The data on the screen was recorded. After the spindle was screwed off and cleaned, it was put back on to test another blend.

*Testing Foaming Ability*

A solution containing 1% of the blend with tap water was made to imitate the conditions of a kitchen. The drain-tube connection to the storage tank was disconnected, raised, and taken out. The blend to be tested was poured into the storage tank and the tank was placed back on the machine. The drain-tube connection was re-connected. The program on the computer was edited to set the parameters of the foaming test. The following parameters were used to conduct the foaming test:

Sample Volume: 250 ml.

Rotor RPM: 1000 R/min

Stirring Time: 10 s

Temperature: not tempered

Cleaning Mode: short

Stir Count: 10

The green triangle was clicked to start the experiment and the machine began to operate. Data was saved in the form of excel sheets.

*Testing Interfacial Tension*

The program WDROP\_2013 was used to complete the experiment. A low light source was used. The camera was focused and the optical calibration was carried out. The vertical setup of the needle was achieved until the needle was parallel to the reticule of the CCD Camera. Volumetric calibration was carried out to confirm the machine’s capability to measure volume. The needle was taken out and cleaned with ethyl alcohol. The syringe was filled with vegetable oil and placed in the machine. A small beaker of the blend to be tested in a 1% solution with water was placed underneath the apparatus. The needle was replaced back into the machine and lowered so that the tip was submerged into the beaker containing the blend to be tested. The computer automatically executed a continuous growth of the volume of the bubble, calculated the volume of the bubble in real time in micro-milliliters and drew the calibration curve on the graph.

Results/Discussion

The best blends and concentrations included 0.5% cationic, 1% cationic cosurfactant, 0.5% cationic cosurfactant plus 0.5% anionic surfactant.

*Viscosity*

The most viscous blend was the 1% Anionic S1, 2% Anionic S2, and the combinations of Nonionic and Anionic S2. This is an expected result because these surfactants are anionic and therefore create more resistance to flow. The molecules of these surfactants tend to be larger with more branches of amides sticking off of the backbone. The viscosity differences after the Anionic S1 blend were minimal. These blends were mostly combinations. This shows that interacting surfactants create complexes which deteriorate viscosity but at the same time, has enough viscosity to be better than the negative control. Viscosity is a measure of resistance to flow so the higher the resistance, the higher the viscosity.

*Foaming*

The blend that produced the most foam was in fact, the Premium. The blends with the highest height of foam after Premium were the combinations of the cationic and anionic surfactants. These would form more foam since they consist of a combination of oppositely charged surfactants and therefore would form more micelles. More micelles generated would contribute to an increase in the process of creating more foam. The foaming levelled off after the Anionic S1 most likely because the makeups of the blends were similar. The highest ranking blends for foaming included those with cationic surfactants and the combinations of anionic and cationic surfactants.

*Cleaning*

The cleaning tests indicate that the cationic cosurfactants cleaned the best. Over time, the soil on the plates was removed faster using sponges soaked with the cationic surfactants. The cationic cosurfactants used have a positively charged functional group allowing it to pick up organic, non-polar soil molecules better. The combinations of cationic and anionic surfactants also improved cleaning. The combined chemicals form micelles which trap soils effectively in the hydrophobic nonpolar regions of the molecule. The soil is wrapped around with the rest of the hydrophilic parts of the molecule and protected by the hydrophobic parts. Cleaning was thus indicated to be better for most of the blends when a surfactant was added to the budget hand dish wash liquid.

*Interfacial Tension*

For the cationic cosurfactant and combination blends, interfacial tension decreased over a time span of 300 seconds. Interfacial tension directly correlates to the performance of cleaning. The lowered interfacial tension mirrors that of the improved cleaning and provides as scientific evidence. There is a significant difference in the interfacial tensions between the budget hand dish wash liquid and the 1% cationic cosurfactant according to the Chi-Square Test.

Conclusion

This research tested the effects of different additives on the performance of a hand dish wash liquid. The experiments were carried out to maximize the performance of a hand dish wash liquid in terms of viscosity, foaming, interfacial tension, cleaning, and pH. Hand dish wash liquids with a high viscosity, high foam build, low interfacial tension, easier cleaning, and high pH work better and are sold better in markets around the world. This research indicated that cationic surfactants at 1% and 0.5% added to a budget hand dish wash liquid maximized its performance. Combinations of an anionic surfactant and cationic cosurfactant also showed enhanced performance. This research allows companies to create an enhanced product that is cheaply made. More people would have access to hand dish wash formulations that work better, have fewer chemicals, and cost less. Future research could include testing the effects of various additives on specific types of soils. It could also include testing different formulations on different surfaces (e.g. cloth, metals, and porcelain).

References

Paternostre, M., Meyer, O., Grabielle-Madelmont, C., Lesieur, S., Ghanam, M. & Ollivon, M.

(1995). Partition coefficient of a surfactant between aggregates and solution: application to the micelle–vesicle, *Biophysical Journal* 69, 2476–2488. Retrieved May 31, 2014, from ProQuest.

Rosen, M., & Dahanayake, M. (2000). *Industrial utilization of surfactants principles and*

*practice* (pp. 1-15, 22, 34-49). Urbana, Ill.: AOCS Press.

Shoeb, E., Akhlaq, F., Badar, U., Akhter, J., & Imtiaz, S. (2013). Classification And

Industrial Applications of Biosurfactants. *Academic Research International*, 4(3), 243-252. Retrieved May 30, 2014, from ProQuest.

Wang, P., & Keller, A. (2007). Adsorption of Hydrophobic Organic Compounds onto a

Hydrophobic Carbonaceous Geosorbent In The Presence Of Surfactants. *Environmental Toxicology and Chemistry,* *27*(6), 1237-1243. Retrieved June 7, 2014, from ProQuest.