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Evaluation of the Stability of a Non-Toxic Biodetergent for the Removal of Petroderivates in Industries

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In the industrial environment, it is common to use toxic and petroleum-derived oils, which are difficult to remove from various surfaces on which they are adhered. For the cleaning of machines, equipment and other surfaces impregnated with these oils, the industries use products of high cost and that, some of them present high toxicity, presenting risk to the health of the workers and to the environment. In this context, the advancement of sustainable technologies has increasingly driven the search for natural and biodegradable surfactant compounds, which reduce impacts on the environment and guarantee the health of workers. This led to the development of natural detergents / degreasers, formulated from renewable / sustainable sources. Therefore, this work aimed to evaluate the stability of a biodetergent produced from non-toxic components such as organic vegetable solvent, natural surfactant and stabilizing gum for large-scale production for application in the removal of type 1 fuel oil (OCB1). The effect of the variation in the stirring time (5, 6, 7, 8, 9 and 10 minutes) of the mixture was evaluated in relation to the volume increase (4, 5 and 6 liters) at 80 ºC using a rotor stirring equipment approximately 3,200 rpm. After mixing, the stability in relation to the storage time (48 and 96 hours) and the removal efficiency of OCB1 fuel oil on a smooth surface were evaluated. The results obtained demonstrated the interaction between the processing conditions, which directly influenced the final characteristics of the product after 96 hours of storage. All tests showed excellent results, with emphasis on the stirring time of 7 minutes, reaching almost 100% stability. The evaluation of the biodetergent for the removal efficiency of the OCB1 fuel oil showed satisfactory results, with removal of 100% of the oil impregnated on the smooth surface. Thus, it can be concluded that the formulation of the biodetergent showed reliability in increasing the scale of production, since it did not show variation when subjected to the investigation of physical factors in the production process.

1. Introduction

The increasingly automated industrial processes use a large amount of oil to make their activities feasible, as in the case of the thermoelectric plants that. for example, they use some engines that consume about 212 kg/MWh or 53 t/hour of fuel oil 1 (OCB1). Thus, the generation of oily waste arising from the operation, maintenance and cleaning of parts, floors and equipment arouses the concern of companies with the environment and the health of workers (Rocha e Silva et al., 2019; Geetha et al., 2018; Eia Viana, 2007). The detergents that have been commonly used by industries powered by fuel oil in the main stages of the washing process of parts, equipment, floors and machines, are synthetic derivatives of petroleum, and therefore have a high degree of toxicity, which can generate secondary hazardous waste such as BTEX and HAP's, which can cause irreversible effects over time in different work environments (Rocha e Silva et al., 2020; Santos et al., 2016). In addition, most of these commercial detergents / degreasers contain petroleum-based solvents, many of which are not biodegradable and persist in the environment (Soares da Silva et al., 2018; Rocha e Silva et al., 2019). In this context, the advancement of sustainable technologies has increasingly driven the search for natural and biodegradable surfactant compounds, which reduce impacts on the environment and guarantee the health of workers (Durval et al., 2019; Santos et al., 2020). Therefore, this work aimed to evaluate the stability of a biodetergent produced from non-toxic components such as organic vegetable solvent, natural surfactant and stabilizing gum for large scale production for application in the removal of OCB1 fuel oil.

2. Material and Methods

2.1 Material

The Biodetergent formulated consists of thickener, organic vegetable solvent (fatty acid ester), natural surfactant, stabilizing gum and water. All compounds were purchased from local stores (Recife-PE/Brazil).

2.2 Evaluation of the interaction between stirring time / volume parameters of the Biodetergent

Variations of the physical parameter stirring time of the mixture (5, 6, 7, 8, 9, 10 minutes) in relation to the volume increase (4, 5 and 6, liters) were developed to evaluate the interaction of the mixture, regarding the formation of phases and pour point of the formulated Biodetergent. The tests were carried out with agitation of 3200 rpm and, at a temperature of 80 ºC, to ensure dispersion between the formulation phases and the formation of a stable emulsion. At the end of the mixing process, the samples were stored in bottles and kept at room temperature (23 - 26 ºC) for 48 hours. Then, the stability and efficiency of removing OCB1 oil on a smooth surface were evaluated.

2.3. Determination of the stability of Biodetergent

To determine the stability of the Biodetergent, the samples were analyzed according to the emulsification index, evaluating the level of phase separation of the formulation. The readings of the formulation's stable phase and the total formulation height in graduated containers were taken, and the readings expressed in centimeters. The stability index was calculated by the ratio between the height of the stable phase and the total height of the formulation, the value being multiplied by 100. The evaluation occurred after 48 hours of rest. All analyzes were performed in triplicate (Cooper and Goldenberg (1987). The stability was calculated using the formula:

$$I_E = \frac{(H_E)}{H_T} x\ 100 \qquad (1)$$

Where I_E is the emulsification index, H_E which represents the height of the emulsion and H_T which represents the total height of the emulsion

2.4. Oil removal test from contaminated surfaces

A sheet of known mass had part of its area uniformly contaminated with 100 µL of OCB1 oil. The contaminated section of the slide was immersed in the test solution (Biodetergent) for 3 minutes. Then, the slide was immersed in distilled water, removing excess test solution and destabilized residues from the surface. Finally, the slide was dried in an oven at 40 ° C for 30 minutes and its weight noted (Cavalcanti et al., 2020). The removal rate was calculated using the formula:

I = $\frac{(Mc-MI)}{(Mc-Mi)}\ x\ 100$ (2)

Where Mc represents the weight of the contaminated blade, MI the weight of the post-wash blade and Mi the initial weight of the blade.

2.5 Metal surface wash

The process was carried out with metallic pieces (nuts) uniformly impregnated by immersion in OBC1 oil. The impregnated parts were subsequently immersed in the test samples (Biodetergent) for 30 min, then the parts were immersed in distilled water, removing excess test solution and destabilized residues from the surface. The removal efficiency was visually qualified (Almeida et al., 2019).

3. Results and discussion

3.1 Evaluation of the interaction between physical parameters to scale up the Biodetergent production

After the production of the Biodetergent, it was observed that there was no change in the physical properties (stability of the emulsion, creamy aspect, uniformity, good fluidity and light tone) of the formulation when subjected to variation in the stirring time regardless of the volume increase of the batches (Figures 1 and 2).

According to the National Health Surveillance Agency (ANVISA, 2004), the physical characteristics of a product and its quality directly influence market acceptance. With this, the stability of the emulsions and their fluidity, after a certain period of storage are decisive for the choice of the most suitable form for the application of the product, which can be through the use of pressurized air, blasting or even by manual application.

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Figure 1: Biodetergent production tests to assess physical parameters for volumes of 4 and 5 liters. (A) aspect of the formulation right after production. (B) production tests for some investigated stirring times

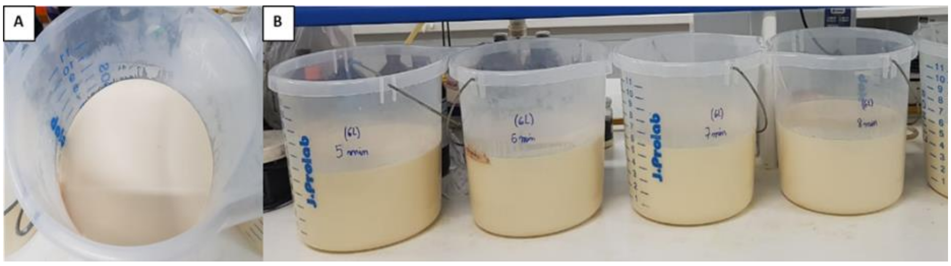

Figure 2: Tests of Biodetergent production to evaluate physical parameters for the volume of 6 liters. (A) aspect of the formulation right after production. (B) production tests for some investigated stirring times

In addition to these aspects right after production, it is also necessary to consider maintaining the characteristics of the product regarding the time of rest at room temperature. The processing conditions, such as the variation of the agitation time by volume, can directly influence the final characteristics of the product after hours of rest. For volumes of 5, 6 and 7 liters, the results presented below demonstrated that there was no phase formation after 96 hours of rest, proving the stability of the product in the face of the scale up process. There was a small increase in the pour point of the formulation, but without interference in the application of the product (Figures 3 and 4).

Figure 3: Biodetergent production tests to assess physical parameters in volume of 4 and 5 liters, after 96 hours of rest

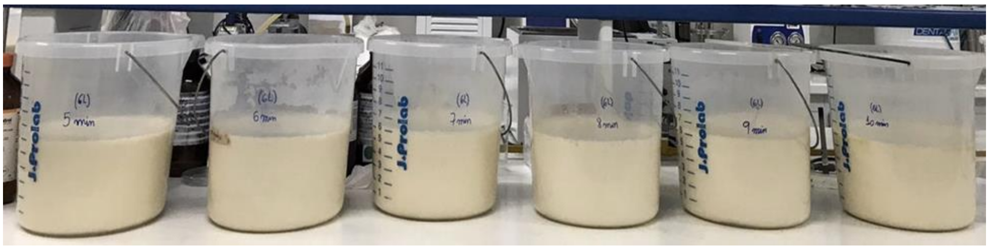

Figure 4: Biodetergent production tests to assess physical parameters in a volume of 6 liters, after 96 hours of rest

These events were expressed more accurately after determining the percentage of stability for all evaluated volumes. We briefly present all the production tests that showed excellent results. According to the graph (Figure 5), approximately 100% stability was achieved for all volumes, with emphasis on the stirring times of 7 and 8 minutes, reaching maximum stability in practically all volumes (4, 5 and 6 liters) tested.

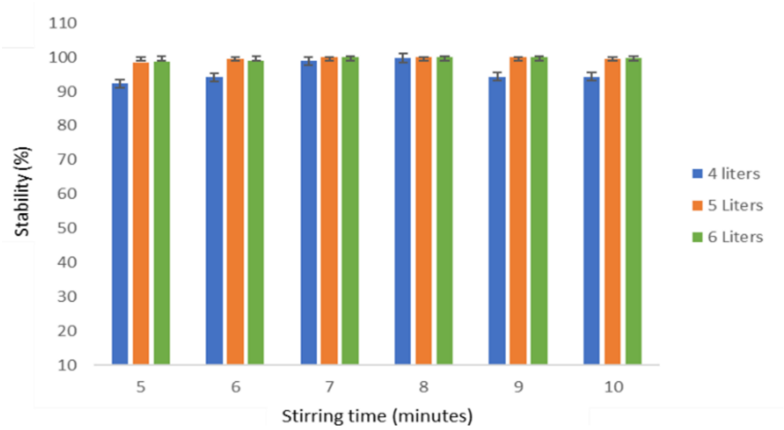

Figure 5: Stability percentages of agitation times in relation to the volumes investigated in the production process of Biodetergent, after 96 hours of rest

It is possible to find in the literature results similar to those obtained in this study. When evaluating some parameters around the stability of some emulsions, it was found that after 5 minutes of agitation, the emulsified system was able to acquire its stability, with no significant variability in the properties of the emulsions when studying longer times (Karcher et al., 2015). The Biodetergent evaluation for the OCB1 oil removal efficiency, presented satisfactory results, with 100% removal of the oil impregnated on the glass surface (Figure 6) and on the metallic surface (Figure 7). Thus, it is understood that the product's effectiveness has not changed in relation to the physical factors investigated in the production process. A formulation developed in a similar way to Biodetergent also showed satisfactory results in the removal of heavy oil, when compared with other commercial products, showing that the use of a biodegradable solvent, associated with a thickener and surfactant has the potential to be a viable product (Rocha and Silva et al., 2020).

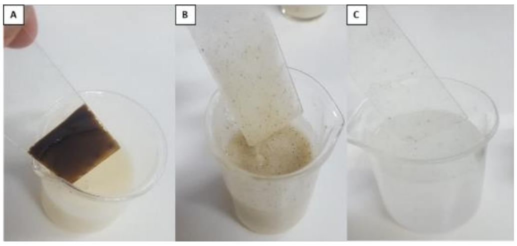

Figure 6: Illustration of the removal of OCB1 oil by Biodetergent on a glass surface. (A) glass slide impregnated with OCB1 oil. (B) removal of OCB1 after immersion in the formulation. (C) OCB1 removal completed after the slide is submerged in water

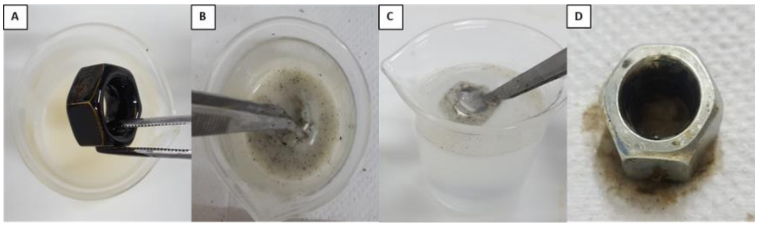

Figure 7: Illustration of the removal of OCB1 oil by Biodetergent on a metallic surface. (A) metal part impregnated with OCB1 oil. (B) removal of OCB1 after immersion in the formulation. (C) removal of destabilized oil residues in the part after immersion in water. (D) Removing oil on the finished metal surface

The efficiency of the obtention process of an emulsion depends on the physicochemical and thermodynamic principles in which there is transfer of mechanical energy (and, eventually, also thermal energy) and differences in density and volume of the mixture. The number of occurrences of these phenomena in the interval and the contact time between the ingredients are fundamental (Dhiman and Prabhakar, 2021).

Conclusion

The results presented confirm the direct influence of the investigated physical parameters on the visual properties of the final product. From this study, the time factor demonstrated greater interaction regardless of the volumes evaluated for the production and efficiency tests of the Biodetergent. Thus, the best processing condition (time) selected for all volumes studied was 7 minutes of agitation at 3200 rpm for the laboratory-scale process, which will be maintained ensuring greater quality control of the final product.

Acknowledgments

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