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The Role of Polyurethane Foam Modified with Feather as an Oil Sorbent

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ABSTRACT

Polyurethane is a leading member of the wide-ranging and highly diverse family of polymers or plastics. It can be a solid or can have an open cellular structure, in which case it is called foam. It has different application including: rigid and flexible foams, varnishes and coatings, adhesives, electrical potting compounds, and fibers such as spandex and absorption. The purpose of the study is to investigate the oil spill removal capability of pure and modified polyurethane. Polyurethane foam was modified by using the feathers (Both fluffs and wing) of three different birds (Anserinae Swamphens, and chicken). The results showed that the absorption ratio was slightly different due to the differences in the capillary structure of both pure and modified polyurethane foams, and the feathers' particular composition. In the absorption ratio, the influence of viscosity was apparent as the viscous oils move further into the sorbent than the less viscous oil. Despite the significant increase in immersion time, there was no discernible influence on the absorption ratio of modified polyurethane foam. Although, two kinds of bird feathers were used to alter polyurethane foam, the absorption ratio was not significant, but even with this modest effect, the absorption rate of oils was higher than that of water. The absorption ratios of foam modified with Anserinae or Swamphens, and chicken feathers was increased significantly, because the feather acts as a pipe that takes the absorbed oil into the polyurethane matrix.

Keywords: Modified polyurethane, Feather, Crude oil, Oil spill, Qurna, Capillary structure.

Introduction

Water contamination caused by oil spills or leaks during transportation and storage has recently sparked widespread concern around the world. Roughly, 5 million tons of oil are shipped overseas each year by tankers, posing a risk of oil spillage or leakage to the marine environment.[1-3] Oil spill has been described as one of the major environmental problems on the high seas. Due to the negative effects of spilled oil on the environment and the long-term effects of contamination, there is a pressing need to improve a wide variety of accessories for effectively cleaning up oil from affected regions, as the curing should vary depending on the season, the type of oil, and the number of spills.[4,5] There were many oil spill incidents because of the rig, war, less care and overseas tankers accidents.[6,7] Oil spill remediation effectiveness varies depending on the type of oil, the amount of spilled oil, the time since the spill occurred, the location, and the weather conditions, among other factors.[8,9] Even though spills have been happening for decades, there is still a need for the development of materials to clean them up.[10] Sorbents are insoluble materials or mixtures of materials used to recover liquids through absorption, adsorption, or both mechanisms. Sorbents must be both oleophilic (oil-attracting) and hydrophobic to be effective in preventing oil spills (water-repellent).[11] Oil sorbents material can be divided into three major classes: inorganic mineral products, organic synthetic products, and organic vegetable products; Mineral products include perlite, graphite, vermiculites, sorbent clay, and diatomite.[12,11]

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Synthetic products include polypropylene and polyurethane foam. The major drawback of synthetic products is their very slow degradation in comparison to vegetable products and they are not naturally occurring as a mineral product.[13,14] Solidifiers, dispersants, absorbents, booms, and skimmers,[15,16] have all been used in the oil remediation method.[17,18] Numerous natural materials and wastes, such as untreated sugarcane bagasse, sawdust, feathers, rice husk ash, and banana trunk fibers have been used to handle an oil spill as crude oil sorbents.[19] Several experiments have been conducted to compare the use of chicken feather waste as an absorbent for the separation of crude oil from crude oil-contaminated water to commercial Sorbents. According to the findings of such tests, chicken feathers are an effective sorbent for the cleanup of crude oil spills in water. Despite the publication of many reports on the use of agricultural waste as adsorbent, there is a scarcity of knowledge on the use of chicken feather waste for the removal of crude oil from crude oil-polluted water, which is why this research was conducted.[20-21]
The present study, focused on the union of both natural sorbent feathers to modify synthetic sorbent's polyurethane foam and test the modified foam as spill oil sorbent.

Materials and Methods

Sample collection
The used feathers were obtained from the Swamphens, Anserinae, and Chicken birds. In November 2020, these feathers were brought from the marshes of the Medinah district in northern Basrah governorate, Iraq. The Crude oil was brought from Qurna west oil field with A.P.I. equal to 22.2 – 27.[22] Besides crude oil, hydraulic oil and motor oil were used in the sorbent experiment.[21]

Preparation of pure and modified polyurethane foam
The three types of feathers were used as a filler to modify the polyurethane foam to study their effect on the polyurethane foam ability as an oil sorbents material. Polyurethane foam was made by reacting di-isocyanates (part B) and polyols (part A). A mixing ratio of

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1:1 (50:50) was used. The synthesis of feather-filled polyurethane foam was done by mixing 160 g of part A and 140 g of part B in a container and adding 15 g of Swamphens feather into the mixing container and the mixing process was done for 3 minutes. The same preparation process of modified polyurethane foam was repeated with the same chemicals, but with a different type of feather (Anserinae or Chicken birds). The modified foam was left in the laboratory for 24 hours. After one day the foam obtained was cut into small pieces to investigate their sorption capacity.

Determination of oil sorption

The modified foam was poured into an uncovered glass jar of 3-liters capacity and a diameter of 14.8 cm. In each experiment, the container was filled with 2 liters of water and 250 mL of crude oil. The modified foam sample that was prepared to be used as crude oil sorbent was put into the container. The dry weight of the polyurethane foam pieces was measured before immersing them into the jar. Each piece was gently placed on the material's surface. The samples were periodically removed from the test jar after a certain time interval (5, 10, 15, 30, 60, 120, and 180 minutes). The wet surfaces of the material were dried between filter paper and weighed after five minutes. The samples were placed back immediately into the test jar and the process of wetting and drying was repeated at timed interval until the 180th minutes. The experiment was repeated at the same conditions using modified polyurethane. The feather attached to modified polyurethane foam is shown in figure 1. The oil sorption of sorbent on a weight basis was calculated using the formular below.[23]

Oil sorption (g/g) = $(S_t - S_0)/S_0$ (1)

Where S_0 is the initial dry weight of a sorbent, S_t is the weight of sorbent with oil absorbed.

Figure 1: The modification of polyurethane foam with a feather

Results and Discussion

One way to know the effect of added feathers on polyurethane ability as crude oil sorbent is to measure the changes that result from the use of different types of feathers in the modification process. The changes in the absorption ratio of the Polyurethane foam were developed with the addition of Anserine bird's feathers, these changes were noted in terms of the absorption of water, hydraulic oil, motor oil, and crude oil obtained from the west Qurna oil field, the results were presented as the effect of the immersion time on the absorption ability (Figure 2). Of course, the effect of feathers on absorption ability is related not only to the modified polyurethane, but it is also related to the type of feather used. The results obtained demonstrated how feathers influence the absorption ability of the modified foam. Figure 3 shows the absorption ratio of the samples that were modified with Swamphen's bird feathers and as in the previous table, there was no clear effect of this type of feather on absorption ratio. The absorption of water was less than the absorption of other oils used. Figure 4 shows the changes of absorption ratios observed with Polyurethane foam modified with Swamphens feathers and sawdust, demonstrating the absence of a clear influence of these additives on absorption capabilities. Figure 5 shows the polyurethane foam absorption rate modified by the addition of chicken feathers. The impact of this increased absorption ability is clearer than in prior situations on the absorption of water, hydraulic oil, engine oil, and Western qurna crude oils. When using both chicken feathers and sawdust as an additive to modify the foam, the absorption ability was slightly increased as compared to the foam modified with only chicken feathers. The results as presented in Figure 6 shows the absorption ratio of foam modified with both chicken feathers and sawdust. We observed a slight increase in absorption ability caused by the addition of sawdust to the Polyurethane foam matrix. It can be said that the difference in the type of feathers necessarily work to change the absorption rate as noticed in Figure 7 and Figure 8 that the absorption ability and ratio depend on the exact composition of each feather. The type of feathers due to their polymer matrix affects the passage of crude oil and the oil may be trapped in the matrix. While there are many types of feathers, the perforated tube work help to transport and distribute crude oil to the whole polymer matrix. It is well known, that Natural organic sorbents depend on pallets, plumes, straw, peat moss and other carbon-founded products.[24-27] The unfavorable properties of natural sorbents are that they are dusty, uneasy to use under stormy conditions, and have a few oil absorbencies. Also, some natural organic sorbents absorb both oil and water, causing the sorbents to the cesspool. In such a manner the modified foam seems to be a solution to the difficult use under windy conditions, but the little absorption capacity is still a problem.[5,28]

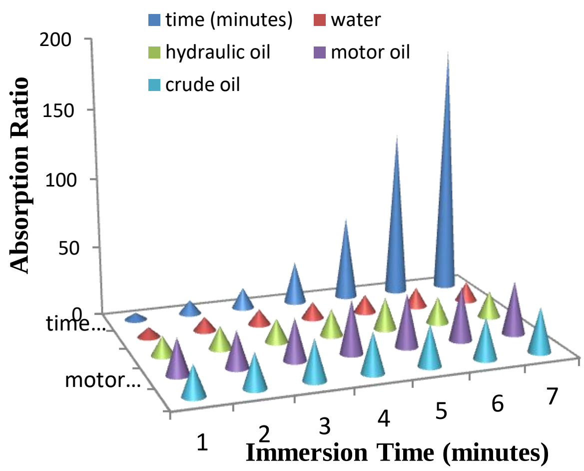

Figure 2: The effect of Anserinae feather on absorption ratio of modified polyurethane foam.

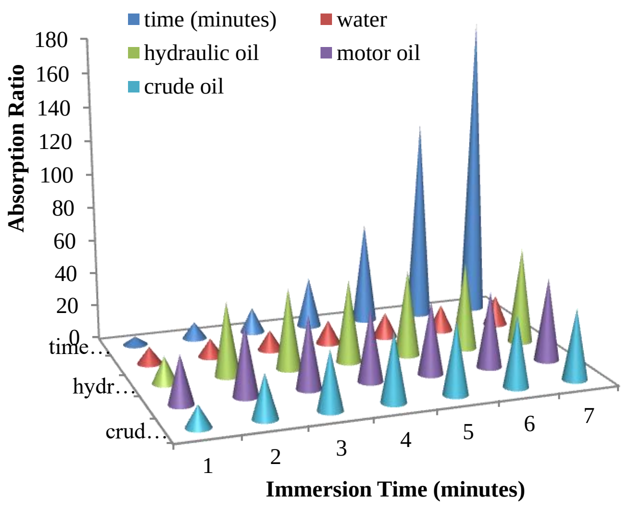

Figure 3: The effect of Swamphens feathers on absorption ratio of modified polyurethane foam.

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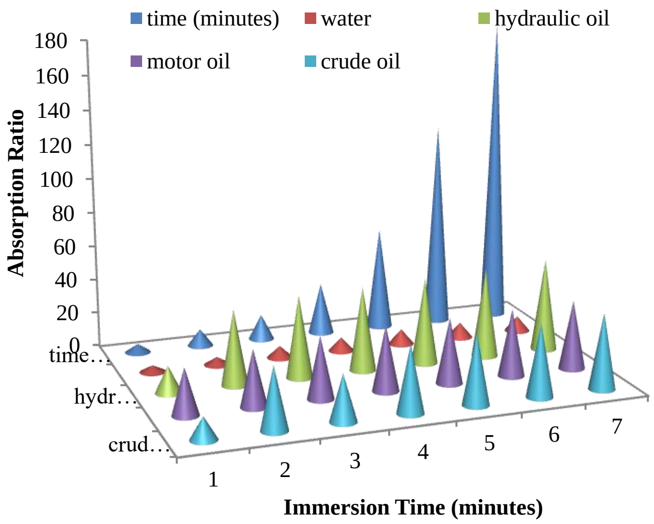

Figure 4: The effect of both swamphens fathers and sawdust on the absorption ratio of modified polyurethane foam.

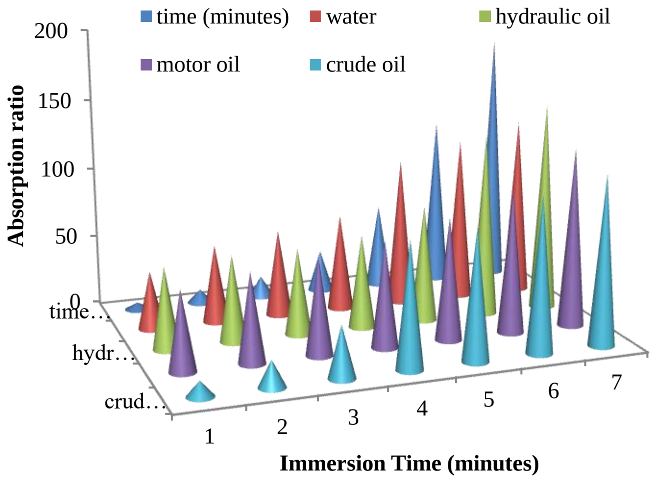

Figure 5: The effect of chicken Feathers on the absorption ratio of modified polyurethane foam.

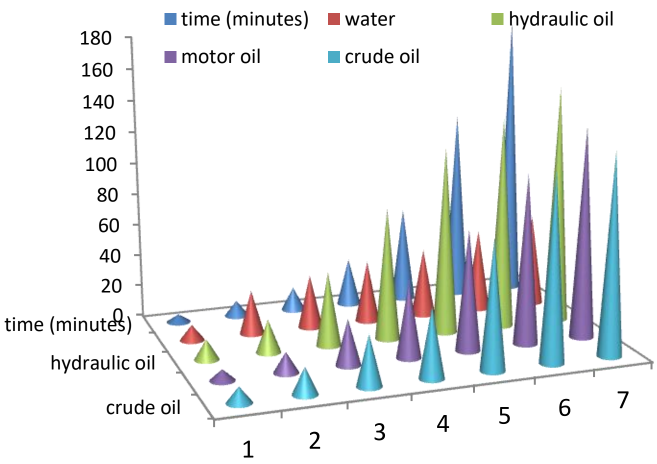

Figure 6: The effect of both Chicken feathers and sawdust on the absorption ratio of modified polyurethane foam.

Figure 7: The effect of swamphens feather on crude oil absorption.

Figure 8: The effect of chicken feathers on crude oil absorption.

Conclusion

The types of bird feathers added to the polyurethane foam have a slight effect on the absorption ratio. This slight effect differs from one feather to other according to their capillary structure. The added sawdust affects this absorption ratio. The viscosity of the oil also affects the absorption ability of the modified polyurethane.

Conflict of interest

The author declares no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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