

Applying Recyclable Waste Tire for Crude Oil Absorption

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Received: March 07, 2018; Accepted: March 12, 2018; Published: March 18, 2018

Abstract

Crude oil spillage is a major environmental pollution in the world. Tire rubber is flexible and has hydrophobic (oil-philic) characteristics, making it a good candidate as oil absorbent. This study is used ASTM F726-99 method to evaluate oil absorbing capability of tire powder. In this paper, the possibility of applying waste tire powder as an absorbent for the recovery of spilled oil was investigated. The results indicate that averagely 1.75 g of crude oil can be absorbed to each gram of 120 mesh tire powder. Due to its elastic property, waste tire powder is re-usable for several times only down to 50% decreasing its oil absorption efficiency. The best absorption was obtained at pH 7. The results of this study showed that sorption efficiency increased as the over time, and decreased as the environmental temperature increases. The results indicated the low-cost tire powder can be used in any water oil-spill conditions.

Keywords: Waste tire powder; Oil absorbent; Crude oil; Oil spillage; Recycling

Introduction

In recent years, frequent oil-spill accidents have caused severe ecological problems, including nearly irreversible damage to ecological systems. There has been an increasing concern about the environmental risk of industrial activities associated with oil extraction [1]; accidental and intentional oil discharges have been reported frequently during the transportation, production, and oil refining, and these have a severe negative impact on organisms and the wider environment and ecology [2-4].

Numerous approaches for the removal of oil from oily water emulsions have been reported in the literature, including filtration (ultra and micro), reverse osmosis, gravity separation, activated sludge treatment, various flotation methods (dissolved air, column flotation, gasaphrons, electro and induced air), membrane bioreactors, biological treatment, chemical coagulation, electro-coagulation and coalescences [5,6].

Absorbent materials are attractive for some applications because of the possibility of collection and complete removal of the oil from the oil spill site [7,8]. The addition of absorbents to oil spill areas facilitates a change from liquid to semi-solid phase and once this change is achieved, the removal of the oil by removal of the absorbent structure then becomes much easier. Furthermore, these materials can, in some cases, be recycled. Some properties of good absorbent materials include

Citation: Zamiraei Z, Golriz M, Parsa M. Applying Recyclable Waste Tire for Crude Oil Absorption, Iran. J Curr Chem Pharm Sci. 2018;8(1):110.

hydrophobicity and oleophilicity, high uptake capacity, high rate of uptake, retention over time, oil recovery from absorbents, and the reusability and biodegradability of the absorbents [9].

According to Gunasekara et al., tires are primarily composed of rubber (40-45%) vulcanized with sulfur (1.5-2.5%), steel, and carbon black (27-33%) [10]. The carbon black, used to strengthen the rubber, is similar to activated carbon, a good sorbent to remove dissolved organic substances from wastewater [11].

It was further investigated the use of ground discarded tires to remove naphthalene and toluene from water [10]. Moreover, tire rubber is a flexible and hydrophobic (oil-philic), making it a good candidate as an oil sorbent. In this research, the possibility of utilizing waste tire powder as oil sorbent for the recovery of spilled oil has been explored.

Materials and Methods

Materials

Crude oil was obtained from Tehran Oil Refining Company, Iran. The 120 mesh tire powder was obtained from a local scrap tire recycling facility in Tehran, Iran. A fine mesh which allowed the passing of oil was used to package in polypropylene during the sorption experiments.

Method

The American Society of Testing and Materials F726-99 method was referenced for oil sorption capability tests.

1-L beakers were used for the absorption test [12]. Each of the set of five beakers contained 100 cm³ of crude oil. In all cases the ratio of crude oil to water was 1:5 by volume. One gram of recycled rubber of particle sizes 0.1 mm was used.

All tests were performed at 24°C room temperature. First, the waste tire powder in polypropylene package (package_25 × 25 × 10 mm³) was immersed in the crude oil/water mixture (100:500 ml) for about 15 min. Then the package was removed from the solution, held for 2 min s to allow the surface residual liquid to drip away, and then weighed.

The sorption capacity of the waste tire powder was expressed in grams of the pollutant (crude oil) absorbed by per gram of the waste tire powder (g g⁻¹):

$$Q_t = \frac{m_t - m_o}{m_o}$$

where Q_t (g g⁻¹) is the sorption capacity of the waste tire powder package at a certain time t (s), m_t (g) is the weight of the waste tire powder package after absorption, and m_o (g) is the initial weight of the waste tire powder package.

The reusability of the tire powder packaging was characterized by simple squeezing operations. After a saturated sorption, the tire powder was squeezed for 10 s under press process. Then the package was weighed and reused for subsequent sorption tests.

Result and Discussion

The selection of cost-effective hydrophobic absorbents depends on many factors. The precursor should be easily available, inexpensive, and non-hazardous. Necessary physical characteristics include high abrasion resistance and high thermal stability, while small pores lead to a high exposed surface area and, hence, to a high surface capacity for absorption [6]. The tire powder includes most of them.

Effect of time on absorption

The oil absorption of tire powder was investigated at the different time. FIG. 1 shows the results of the sorption tests for the 60 min and, as expected, sorption increases for the over time, from 5 to 60 min.

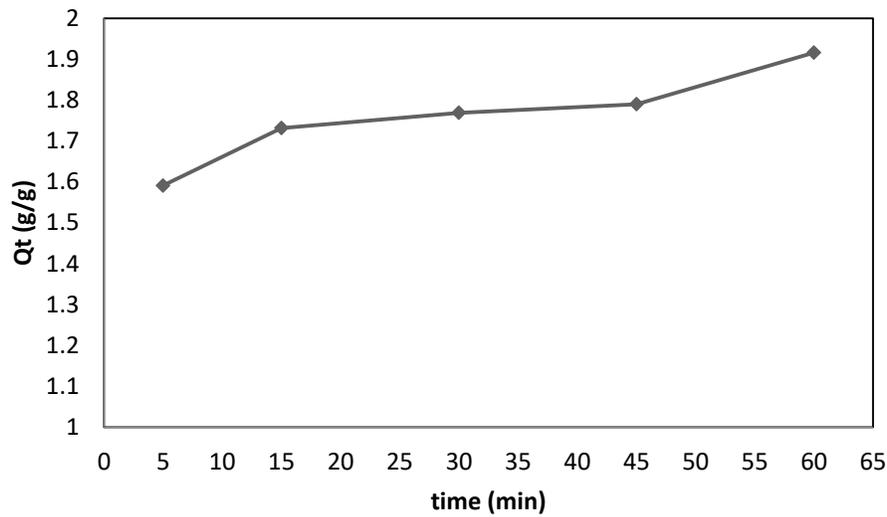


Figure 1: Crude oil absorption of tire powder for 60 min

Effect of the pH on absorption

The pH factor is very important in the absorption. The crude oil absorption of tire powder was tested at different pH levels ranging from 5 to 8. The maximum absorbance was obtained at pH 7 (FIG. 2).

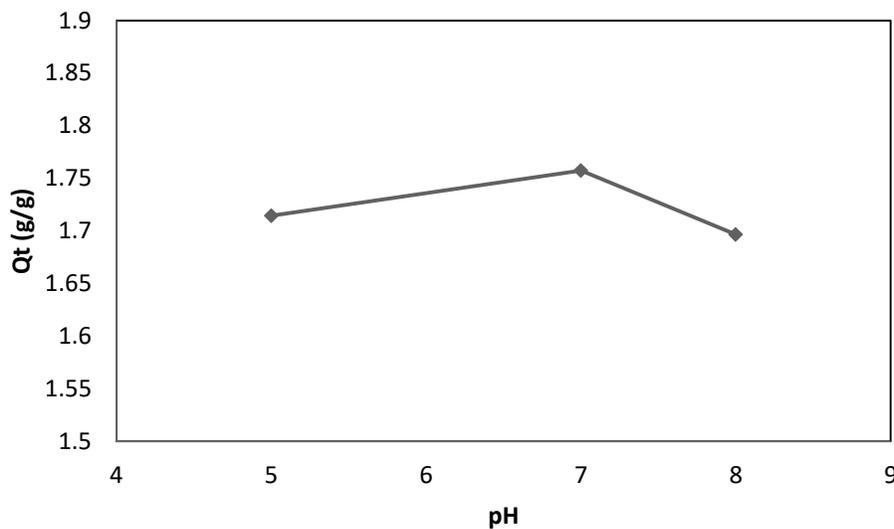


Figure 2: Crude oil absorption of tire powder at different pH

Effect of the Temperature on absorption

FIG. 3 shows the oil sorption capacity of the tire powder decreases with increases in temperature. Higher temperatures lead to a low viscosity in oil, making it difficult for the oil to adhere to the sorption material. When the temperature decreases, oil

viscosity increases and making much more sorption of oil possible, suggesting that the tire powder would recover more oil in cold regions than in warm regions.

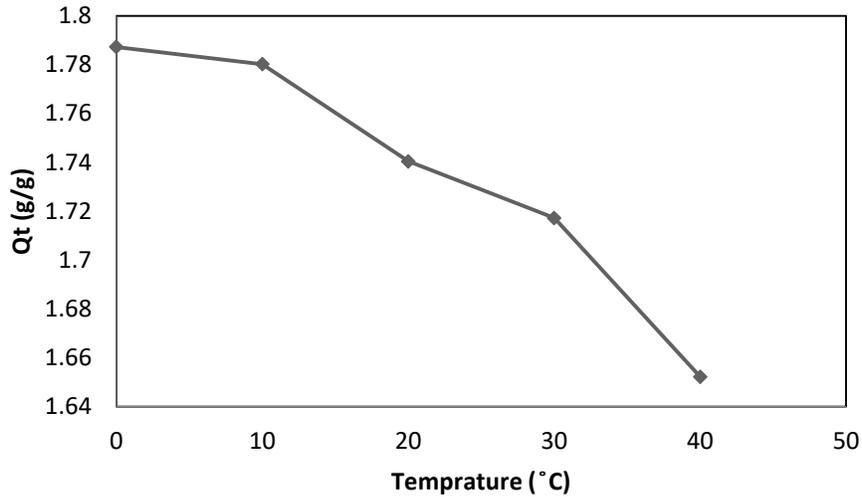


Figure 3: Crude oil absorption of tire powder at different temperature

Repeated use of tire powder

FIG. 4 shows the oil absorption for 1 g 120-mesh tire powder after each use for the several reuses. Because tire powder has good elasticity, it was able to maintain its oil sorption capacity at 50% of earlier after 5 times uses.

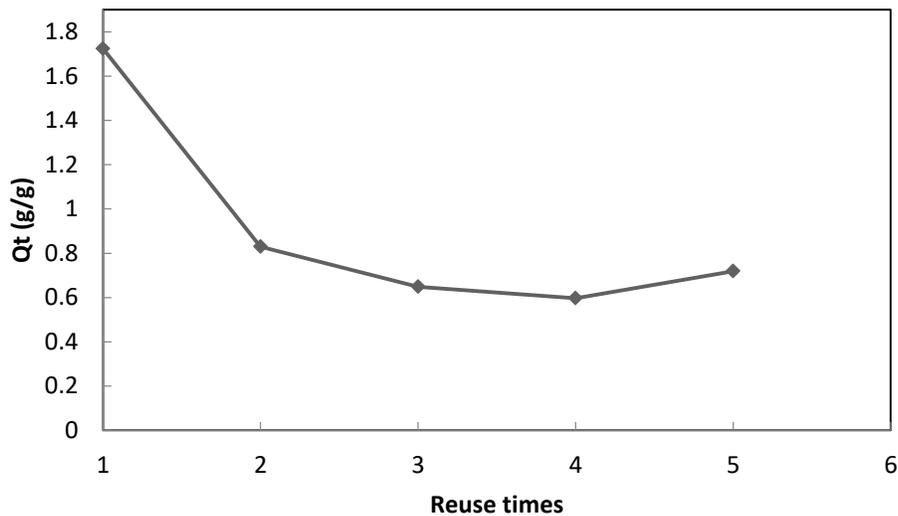


Figure 4: Re-usability of waste tire powder for crude oil absorption.

Conclusions

Waste tire powder is flexible and has oil-philic characteristics, making it a suitable candidate as oil absorbent for the recovery of oil spills. The use of tire powder as sorbents of crude oil was investigated in various conditions, in different pH,

temperature, time and reusability of tire powder. The best sorption capacity of the tire powder was obtained at pH 7. The oil sorption capacity of the tire powder decreases with increases in temperature. As expected, absorption increased over time from 5 to 60 min. Because tire powder has good elasticity, it was able to maintain its oil sorption capacity at 50% of earlier after 5 times uses. The tire powder showed a rapid oil sorption due to high degree of hydrophobicity and low water uptake. The results indicated the low-cost tire powder can be used in any water oil-spill conditions and the best method for applying the waste tire powder.

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