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Efficiency of Agricultural Wastes for the Removal of Gasoline from Water

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Abstract. In this work, we report polyurethane foam, sunflower husk and rice husk ash prepared via a thermal treatment process used as oil sorbents for oil spill cleanup. The oil sorbent was studied on the basis of microstructure and morphology using optical digital microscopy and scanning electron microscopy (SEM). The results of the SEM and optical microscopy studies strongly indicate that thermal treatment is a suitable method to improve structure of husk particles regarding porosity compared to virgin samples. The dependence of the sorption capacity of the sorbents on the amount of sorbent, sorption time and the thickness of the oil film, as well as the number of cycles of the sorbents were investigated.

Introduction

Oil pollution has become one of the most serious global environmental issues during the last 30 years; it exists in different forms and is generated by various sources. The major sources of oil pollution in the ocean and other waterways include the runoff of oil and fuel from land-based sources, accidental spills from tankers, and oil drilling accidents [1]. This can cause major environmental problems due to the toxicity of many compounds in oil to aquatic organisms, birds and humans [2-4]. Thus, clean-up of oil spills from the water surface is an important task.

In recent years, there has been a growing interest in the production of adsorbents from agricultural wastes for oil spills clean-up such [2-6]. The adsorbents on the base of agricultural wastes are widely used in various processes including the purification and recovery of valuable substances from liquid and gaseous media [7-14].

The advantages of oil adsorbents obtained from agricultural wastes are their ecological safeness, origin from a broad source of raw materials, floatability after oil sorption, high hydrophobicity, low costs and porous structure after thermal treatment that provides a high sorption capacity.

The aim of the present study was to investigate the oil sorbent efficiency of thermally treated agricultural wastes for the removal of gasoline from the water surface and the physicochemical characteristics of the obtained adsorbents.

Materials and methods

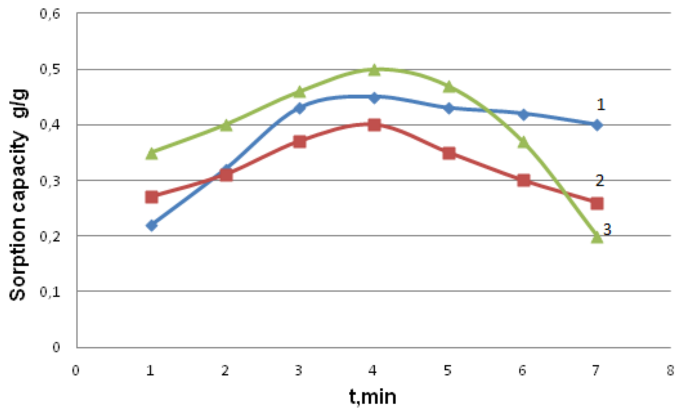
The samples were carbonized according to the procedure developed at the Laboratory of Oxidation Hydrocarbon raw material in the Institute of Combustion Problems (Almaty).

The microstructures and microanalysis of adsorbents were investigated with an SEM (Quanta 3D 200i, USA) at an accelerated voltage of 20 kV and a pressure of 0.003 Pa (performed by National Nanotechnological Laboratory of Open Type of Kazakh National University). The surface appearance of thermally treated rice husk was also observed in Optical Digital Microscopy (Leica DM 6000 M).

For creating an oil film in the laboratory was poured into a Petri dish about 40 ml of water with a salt concentration of 17-20 g/l (seawater) is dropped on the surface of which a few drops of gasoline. As the formation of an oil slick determined diameter and thickness of the resulting film.

Results and discussion

The effect of contact time on the sorption capacity of sorbents was studied. The results as shown in figure 1 explains the effect of sorption time on oil uptake and as expected, sorption capacity increases with the contact time from the first 1 mins. One can see comparing the obtained experimental data that the highest sorption ability is exhibited by carbonizate rice husk, while the lowest is exhibited by polyurethane foam, which is likely to be connected with high porosity of rice husk. The time to reach equilibrium for oil on carbonizate rice husk was 4 min and absorbed approximately 0,5 g/g of gasoline.

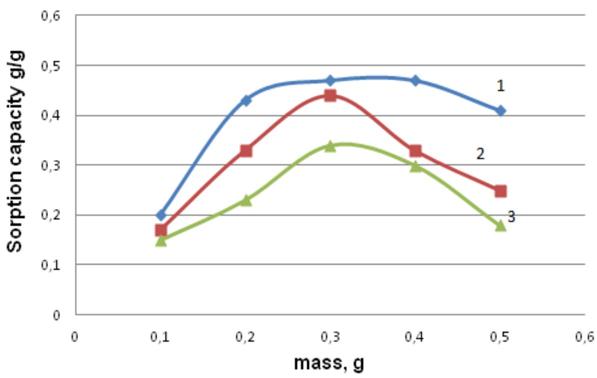


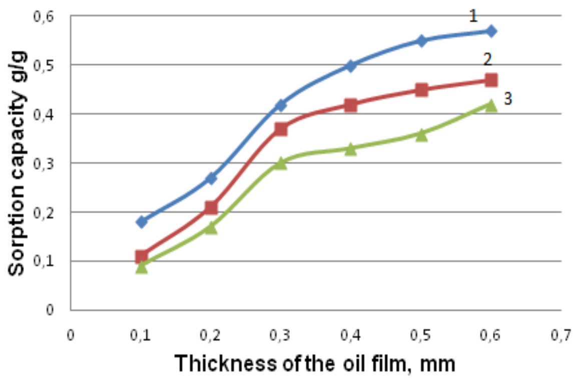
1 – polyurethane foam + carbonizate sunflower husk (PFCSH-300), 2- modified polyurethane foam (MPF-300), 3- Styrofoam + carbonizate rice husk (SCRH-400)

Fig. 1 Effect of contact time on sorption of gasoline on sorbents

The sorption capacity of agricultural wastes without polymers was investigated. Figure 2 shows the dependence of sorption capacity on the amount of the sorbents. With the increasing of amount of the sorbents the sorbed oil is gradually increasing. After reaching optimal sorption time (4 hours), the rate of active sorption significantly reduced, due to the oil saturation of sorbents, on the one hand the beginning of desorption process.

We investigated the dependence of the sorption capacity of the sorbents on the thickness of the oil film. As seen in Figure 3 increasing the thickness of the oil film increases sorption capacity of the sorbents.





1-Styrofoam + carbonizate rice husk (SCRH-400), 2 – polyurethane foam + carbonizate sunflower husk (PFCSH-300), 3- modified polyurethane foam (MPF-300)

Fig. 2 The mass effect on oil sorption capacity of the sorbents

Fig. 3 The film thickness effect on oil sorption capacity of sorbents

The photographs in Figure 4 depict the microstructure of virgin and carbonizate rice husk. The SEM image of virgin rice husks (Figure 4 a) shows spherical silica particles of varying form on the organic matrix that consists of cellulose, hemicelluloses and lignin. Furthermore, it is visible that virgin rice husks are compact and do not contain any pore.

The external wall of carbonizate rice husk shows the occurrence of a large number of button-like structures, which were not found in the virgin rice husk particles (Figure 4 b). The emerging of button-like structures may be caused by the fast removal of volatile organic components from the particle. The particles underwent drastic changes in this process of high–temperature treatment. Figure 4 (c) shows the optical microscopy images of the carbonizate rice husk. In figure 4 (c) some particles of carbon and amorphous silica can be seen

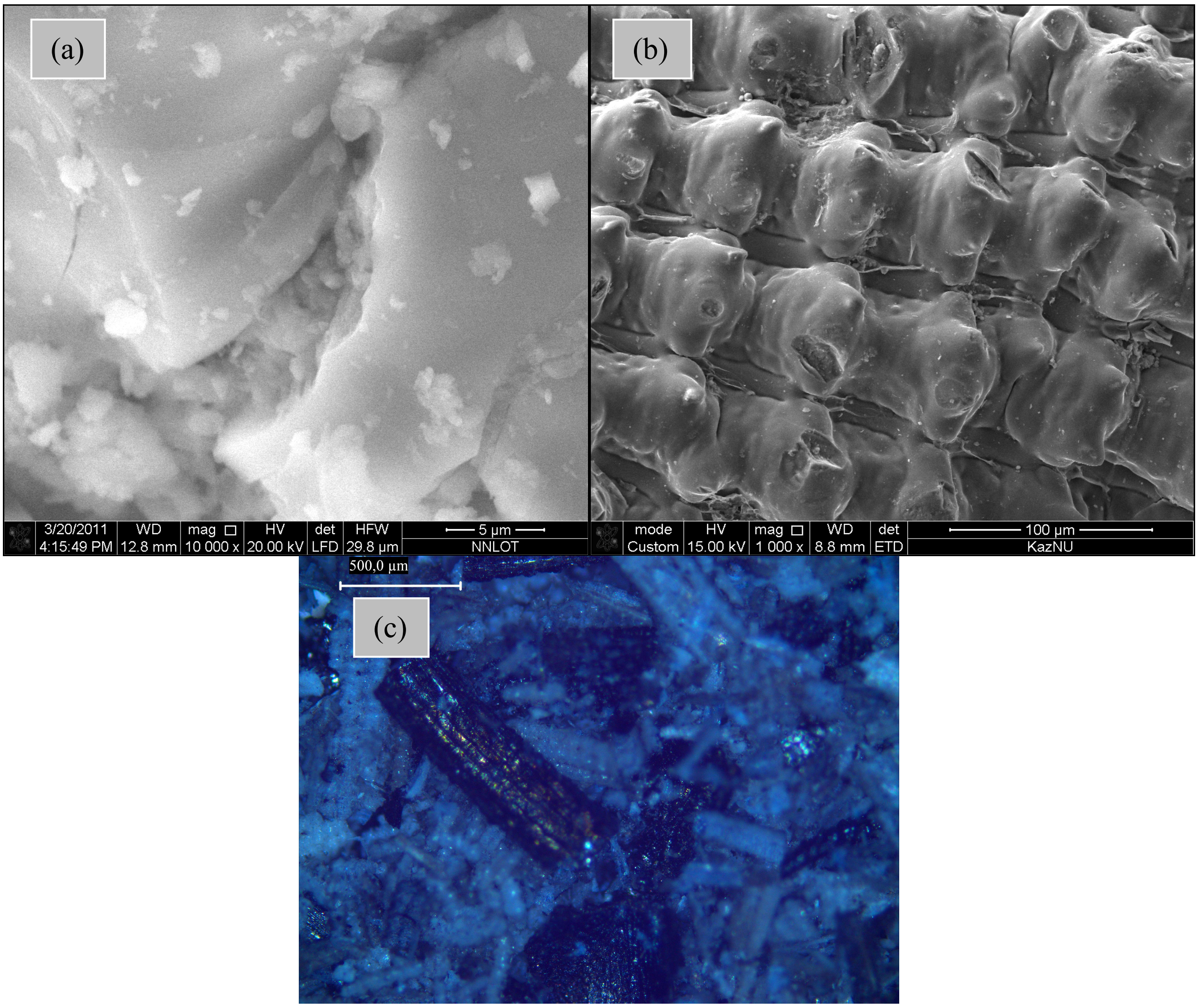


Fig. 4 Microstructure of virgin (a) and carbonizated rice husk (b, c)

High oil sorption ability is determined by the porous structure of adsorbents, as well as by the physical and chemical interactions of their functional groups with the crude oil components. One can see in SEM and optical microscopy images that thermal treatment allows to obtain a drastically modified structure with higher porosity compared to the virgin husk samples.

Figure 5. shows the sorption of oil using styrofoam + carbonizate rice husk. The sorption can be accelerated by moving the carbonizate rice husk over the hydrophobic spot. The carbonizate rice husk absorbs more than 95% of the oil on the water surface in less than 15 s [15].

Fig. 5 Sorption of oil using styrofoam + carbonizate rice husk (SCRH-400)

Summary

In conclusion, this study demonstrates the possibility to obtain effective oil adsorbents from rice husks, which are currently considered to be an agricultural waste.

References

[1] D. Wanga, E. McLaughlin, R. Pfeffer and Y.S. Lin: Sep. Purif. Tech. 99 (2012), p. 28–35

[2] S.A. Sayed, A.M. Zayed: Desalination 194 (2006), p. 90-100

[3] A. Gammoun, S. Tahiri, A. Albizane, M. Azzi, J. Moros, S. Garrigues, M. de la Guardia: J. Hazard. Mater. 145 (2007), p. 148-153

[4] M. Husseien, A.A. Amer, A. El-Maghraby and N.A. Taha: Int. J. Environ. Sci. Tech. 6 (1) (2009), p. 123-130

[5] X. Sun, R. Sun and J. Sun: J. Agric. Food Chem. 50 (2002), p. 6428-6433

[6] N.E. Thompson, G.C. Emmanuel, K.J. Adagadzu and N.B. Yusuf: Arch. Appl. Sci. Res. 2 (5) (2010), p. 142-151

[7] M. Akhtar, M.I. Bhanger, Sh. Iqbal and S.M. Hasany: J. Hazard. Mater. B 128 (2006), p. 44-52

[8] S. Kumagai, K. Sasaki, Y. Shimizu and K. Takeda: Sep. Purif. Tech. 61 (2008), p. 398-403

[9] S.H. Yoon, M. Kim and B. Gil: LWT - Food Sci. Tech. 44 (2011), p. 1572-1576

[10] M. Kim, S.H. Yoon, E. Choi and B. Gil: LWT - Food Sci. Tech. 41 (2008), p. 701-706

[11] A.H. Mahvi, A. Maleki and A. Eslami: Am. J. Appl. Sci. 1 (4) (2004), p. 321-326

[12] D.H. Lataye, I.M. Mishra and I.D. Mall: J. Hazard. Mater. 154 (2008), p. 858-870

[13] S.A. Abo-El-Eneina, M.A. Eissab, A.A. Diafullahc, M.A. Rizkc and F.M. Mohamed: J. Hazard. Mater. 172 (2009), p. 574-579

[14] K.K. Kudaybergenov, E.K. Ongarbayev, Z.A. Mansurov and Y.O. Doszhanov: J. Non-Cryst. Solids 358 (2012), p. 2964–2969

[15] M. Likon, et al. Waste Manage. (2011), doi:10.1016/j.wasman.2011.01.012