Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 12 (2017) 17 – 21

Procedia MANUFACTURING

International Conference on Sustainable and Intelligent Manufacturing, RESIM 2016, 14-17 December 2016, Leiria, Portugal

Obtaining superhydrophobic sand on the basis of soot synthesized during combustion of oil waste

Nazhipkyzy, M.[a,b]*, Temirgaliyeva T.S.[a,b], Lesbayev B.T.[a,b], Prikhodko N.G.[a,b,c], Mansurov Z.A.[a,b]

[a]*Institute of Combustion Problems, 172 Bogenbai Batyr St., 050012, Almaty, Kazakhstan*
[b]*Chemistry-Chemical Technology Faculty, al-Farabi Kazakh National University, 71 al-Farabi av.,050040, Almaty, Kazakhstan*
[c]*Almaty University of Energetics and Communications, 126 Baytursinova St., 050013, Almaty, Kazakhstan*

Abstract

In this work, a number of experimental studies to determine effective soot by burning waste oils were carried out. The raw materials used waste oil from service stations to replace oil cars. Used oil burned using a conventional wick, by impregnating carbon and glass fiber fabric. The results showed that the surface of the soot produced by burning waste oil has a hydrophobic property to the wetting angle 145-150^0. The experimental research on the production of soot by burning waste oils showed that the combustion of 100 grams of oil, depending on the combustion conditions can be obtained from 0.5 to 1.5 grams of soot. And, also was determined the elemental composition and the surface functional groups of hydrophobic sand by IR-spectroscopy. Flexible hydrophobic self-destroying carpet on the basis of hydrophobic sand was developed and built. For comparison was conducted studies of growth process of potato in the soil layer of earth on the surface of the usual soil and on the surface-degradable hydrophobic carpet based on hydrophobic sand under greenhouse conditions.

Keywords: soot; waste oil; wetting angle; superhydrophobic sand.

* Corresponding author. Tel.: +7 777 900 42 48.
E-mail address:meruert82@mail.ru

doi:10.1016/j.promfg.2017.08.003

1. Introduction

The problem of recycling waste lubricating oil is acute throughout the world, as along with other hydrocarbons used lubricating oil significantly pollute the biosphere. Unlike oil and other petroleum products, waste oil when released into the environment is not rendered harmless by natural means (oxidation, photochemical reactions, biodegradation). In this regard, there is an actual problem of recycling waste oil.

It used oils include engine, transmission, hydraulic, industrial, transformer, mineral and synthetic oils contaminated by physical or chemical impurities. Depending on the application and the operating environment becomes dirty oil or degrades the properties, after which it becomes unsuitable for further use. Sources of waste oil are many, most are garages, metal production, power plants, etc. The significant environmental damage does drain used oil into the soil and water bodies, which according to the researchers, more than in terms of accidental discharges and oil losses during production, transportation and processing.

Hydrophobic sand is ordinary beach sand coated with tiny particles of pure carbon, which have been exposed to a special treatment with hydrophobic soot and polyurethane glue. Hydrophobic sand has been rated physiologically safe, and comes with a long time guarantee for its hydrophobic effect.

Hydrophobic sand can be used in agriculture, mixing it with soil in potted plants allows the roots to breath even when the plant has been over watered. A layer of hydrophobic sand at the bottom of the pot stops water from passing through and yet allows air to pass through the sand grains and provide the roots with the air needed to breath [1]. Once the additive is applied to the sand, it creates a capillary breaking, hydrophobic encapsulation of the sand, making it resistant to salts, particularly sodium chloride ions.

Agriculture farms can use the hydrophobic sand below their sweet soil to minimize water wastage. The water stops flowing through into the ground water, and instead, becomes trapped above the hydrophobic sand layer, allowing roots to reach into the pool of water collected below. Some of the previous studies explained the usage of different hydrophobic materials for reducing water shortages and conserving irrigation water in crop plants [2, 3].

1.1. Experimental

The raw materials used waste oil from service stations to replace oil cars. Used oil burned using a conventional wick, by impregnating carbon and glass fiber fabric. To check the resulting hydrophobic soot was soaked in an ethanol solution and after drying was tested for properties by the hydrophobic droplet reclining. The experimental research on the production of soot by burning waste oils showed that the combustion of 100 grams of oil, depending on the combustion conditions can be obtained from 0.5 to 1.5 grams of soot. Extraction of the resulting soot shows a benzene soluble content of the small parts, which indicates non-toxicity of the obtained product.

In continuation of research the synthesized soot from waste oils use to prepare the hydrophobic sand. We used sand 2-5 mm of coarse fraction and fine fraction to 0.5 mm, and 1% soot obtained from used oils. Experimental setup for the production of hydrophobic sand which consists of a stirring apparatus and the controlled power supply has been assembled.

As part of work about practical application of the developed hydrophobic sand based on superhydrophobic soot, it was developed and built a flexible hydrophobic self-destroying carpet on the basis of hydrophobic sand. Study is about a choice of self-destroying bedding material. For comparison was conducted studies of growth process of potato in the soil layer of earth on the surface of the usual soil and on the surface-degradable hydrophobic carpet based on hydrophobic sand under greenhouse conditions.

1.2. Results and Discussion

In Fig.1. shown behavior of water droplets on the surface of hydrophobic sand. As we can see that the surface of the soot produced by burning waste oil has a hydrophobic property to the wetting angle 145-150^0.

Fig. 1. Water droplets on the surface of hydrophobic sand

A qualitative assessment of the presence of functional groups on the surface of the hydrophobic sand obtained by based on hydrophobic soot formed during combustion of waste oils were examined by IR spectroscopy. Fig. 2. shows IR spectroscopy data of hydrophobic sand.

On the IR spectra of the samples are observed characteristic absorption bands in the frequency range of 463.13; 532.48; 587.60 cm $^{-1}$ correspond to the stretching vibrations of Si-O group. Antisymmetric stretching vibrations ≡C-H contributed to the appearance of the peak at 648.23 cm $^{-1}$, band at 695.10 cm^{-1} corresponds to the Si-C vibrations. Adsorbtion peaks at 797.15; 778.71; 725.61 cm^{-1} contributed to appearance of Si-H groups.

In analyzing the infrared spectrum of the hydrophobic sand was also noted the occurrence of an absorption peak at 1875.05 cm^{-1} characteristic to fluctuations of -C = O group and to stripes on 2346.67 cm^{-1}, P-H group. On The IR spectra of the samples are observed characteristic absorption bands of the CH (2850.71 cm^{-1}), and CH-OH (2919.45 cm^{-1}, 3428.36 cm^{-1}).

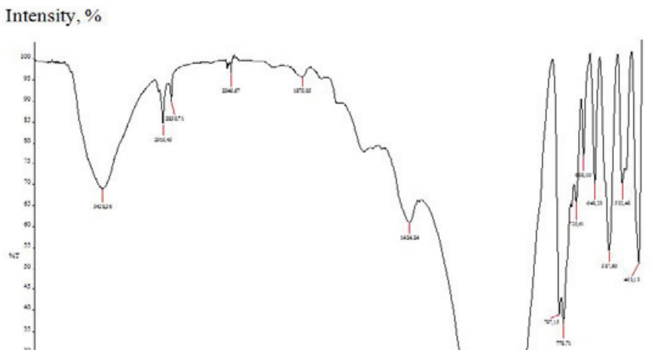

Fig. 2. IR spectra of hydrophobic sand

The results of study showed (Fig. 3.) when watering of standard specimen planted potatoes, twice as large amount of water, conservation of soil moisture on potato with hydrophobic self-destroying carpet is more effective than from the potato without hydrophobic sand. The water stops flowing through into the ground water, and instead, becomes trapped above the hydrophobic sand layer, allowing roots to reach into the pool of water collected below.

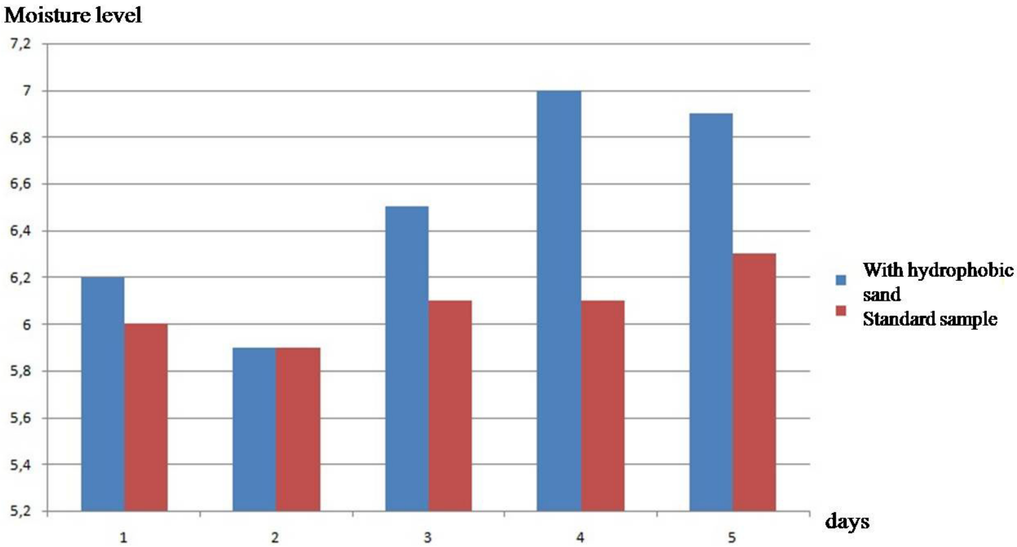

Fig. 3. Moisture level of potato crop with hydrophobic soot and standard sample

Fig. 3. clearly shows that the use of as the litter layer hydrophobic sand do not miss moisture and promotes the use of 2 times less amount of water for the cultivation of potatoes.

The results of chromatogram of potato crop with using as bedding layer of hydrophobic sand and standard sample are presented in the Fig. 4 and Fig. 5.

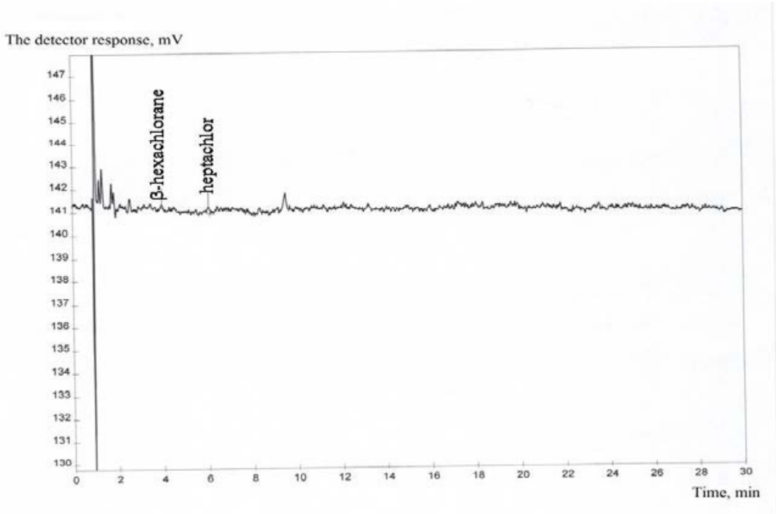

Fig. 4. Chromatogram of the potato crop with use as bedding layer hydrophobic sand

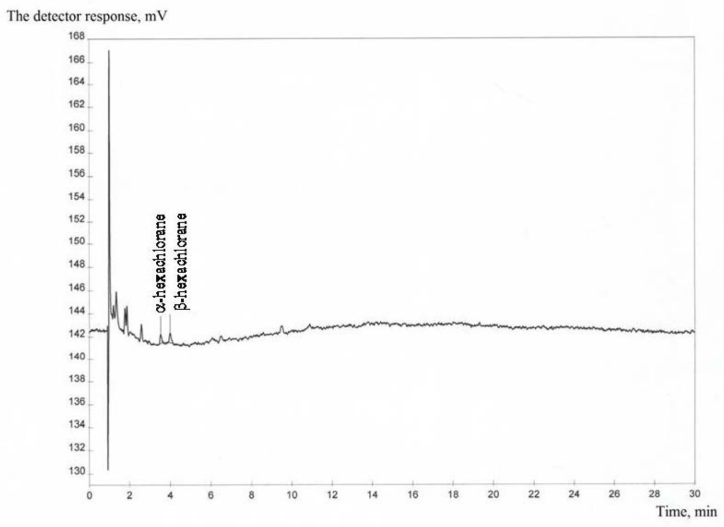

Fig. 5. Chromatogram of the standard potato crop

The maximum allowable rate of hexachlorane is 0.01 mg/kg and heptachlor is 0.05 mg/kg. As shown from chromatogram analysis concentration of hexachlorane in potato crop sample with using as bedding layer hydrophobic sand is 0.00042 mg/kg and heptachlor is 0.00015 mg/kg. The concentration of α- and β- hexachlorane in standard sample of potato crop is about 0.00029 mg/kg and 0.00282 mg/kg. As shown from chromatogram analysis of potato amount of heptachlor and hexachlorane which was used as an insecticide does not exceed the permissible norms.

1.3. Conclusion

A number of experimental studies to determine effective soot by burning waste oils were carried out and synthesized soot from waste oils use to prepare the hydrophobic sand. The study of obtained samples showed that the hydrophobic sand coated with polyurethane and hydrophobic soot is not wetted by water and the surface of the sand grains completely enveloped with nanoscale layer of superhydrophobic soot. The results of evaluation water losses showed reducing water shortages and conserving irrigation water in crop plants.

References

[1] Mohammed A. Salem, Wasef Al-Zayadneh, Helmut Friedel Schulze, A. J. Cheruth, Effect of nano-hydrophobic sand layer in datepalm (Phoenix dactylifera L.) cultivation in aridlands, Journal of Food, Agriculture & Environment 11 (2) (2013) 591-595.
[2] J.E. Fernández, F. Moreno, J.M. Murillo, M.V. Cuevasa, F. Kohler, Evaluating the effectiveness of a hydrophobic polymer for conserving water and reducing weed infection in a sandy loam soil, Agricultural Water Management 51 (1) (2001) 29-51.
[3] L.A. Thwaitesa, G. H. de Rooij, S. Salzman, G. Allinson, F. Stagnitti, R. Carr, V. Versace, S. Struck, T. March, Near-surface distributions of soil water and water repellency under three effluent irrigation schemes in a blue gum (Eucalyptus globulus) plantation, Agricultural Water Management 86 (1-2) (2006) 212-219.