SUPERHYDROPHOBIC SAND ON THE BASIS OF NANOSOOT OBTAINED BY COMBUSTION OF WASTE OIL

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Abstract: Furthermore, the obtaining of soot from waste oils used for synthesis of nanostructured soot with hydrophobic properties. It was conducted a number of experimental studies to identify optimal conditions for increasing the hydrophobic properties of nanostructured soot particles during the combustion of waste oils, depending on the soot collecting height of the flame front. The gas flow rate ranged from about 250-300 cm^3 / min, collecting the nanostructured soot produced by the flame height 2, 2.3, 2.5, 3 and 4 cm. Macroscopic soot deposition on the substrate surface starts at a distance of 2.3 cm from the beginning of the flame front. Increasing the distance of 3 cm increases the amount of soot, but the soot surface contact angle less than composes 120^{O}. It was found that the optimal regime of nanostructured soot having superhydrophobic properties with wetting angle 150^{O} over a distance of 2.5 cm collection. Nowadays known work on the production of the hydrophobic sand covered with nanoparticles of pure silica which were obtained by evaporation of silicon compounds called trimethyl siloxane, which are expensive. Thus, we can say that we have obtained cheap sand with hydrophobic properties from waste oil.

Key-Words: nanostructured soot, combustion, hydrocarbon, waste oil, wetting angle, superhydrophobic sand

1 Introduction

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.

Carbonaceous soot in the atmosphere is a major potential concern with regard to its climate impact. Soot aerosols may impact the atmospheric radiative balance (temperature change), atmospheric chemical composition and cloud formation via their action as nuclei for water and ice cloud formation. However, at present there are no reasonable quantitative estimates of the soot exhaust effect from industry/commercial sources, transport, and domestic home heating to compare it with natural sources from biomass burning and forest fire plumes. A major source of uncertainty in assessing the impact of aircraft soot emissions on climate change is their role in contrail formation and secondary effects on later cirrus formation through potential action as ice nuclei.

An estimate of the maximum number concentration contribution of aircraft - generated soot particles results in an increase of the potential ice nuclei number concentration of up to 50% at the main aircraft flight altitude [2]. A potentially strong soot indirect effect has also been inferred when including such additional numbers of heterogeneous freezing ice nuclei along with the predominant homogeneous freezing process (for sulfate aerosols) in microphysical models of cirrus clouds [3, 4]. Modification of ice crystal formation rates and subsequent lowering of ice crystal concentrations compared to a scenario controlled only by homogeneous freezing enhances wet deposition (removal of aerosols from the atmosphere or from an atmospheric layer by cloud processing), thus causing a decrease in cloud lifetime and cover [2]. While the quantification of potential soot impacts on cold clouds has been advanced through modeling studies, the state of scientific understanding is still poor mainly because only a very few studies [5, 6] have examined the hydration and cloud activation properties of soot aerosols that are representative of those that might form contrails and cirrus clouds. Field campaigns and aircraft-based measurements have demonstrated that black carbon is found within contrail and cirrus ice crystals, [7-9] but no mechanistic information is available attributing this to microphysical and chemical processes at the surface of soot aerosols that cause ice nucleation. Therefore, laboratory studies on the role played by the soot surface in the interaction with water are important.

The presence of water in the building or structure leads to the appearance of moisture on the base of the walls, under the floor slabs, rust at the base of steel poles, efflorescence, discoloration or rotting wood panels and other objects near the floor, wall or ceiling, there is mold on concrete, plaster, furniture, carpeting, or wallpaper, efflorescence (“white powder”) on concrete; dilapidated floor slabs, the smell of dampness, “fogging” of the walls (condensation or excessive humidity), water condensation on the windows, the growth of moss and the like. Moisture can penetrate the structure vertically, for example, due to the accumulation of water on the roof or horizontally through the water flowing through the exterior walls of the building due to extreme weather conditions.

A major problem is the depth of wall applications where the hydrostatic pressure in the surrounding soil leads to horizontal infiltration of water into the building. The penetration of moisture through the concrete wall due to the porosity of the concrete (about 12% - 20%) occurs during the curing process, excess water when creating a network of interconnected capillaries, about 10 - 100 nm in diameter. Because of the moisture occurs corrosion depth of objects, such as underground pipes, gas tanks, tunnels and cables caused by electrolysis of corrosive substances, insects or microorganisms rapidly proliferating in the wet ground it all leads to a considerable reduction of operating these facilities. Waterproofing is also necessary reservoirs, particularly an issue in arid areas, where it is desirable to preserve the contents of the reservoir as long as possible. Almost all of the water, up to 85%, is spent in the desert areas of our planet for irrigation of agricultural land, creating a shortage of water for drinking and hygiene needs, while, according to scientists from the company DIME Hydrophobic Materials, water is consumed irrationally. Thus, today there is universally recognized need in the hydrophobic composite materials, the production of which would be beneficial, and used effectively [10-11].

By burning of hydrocarbon fuels obtained soot particles are an accessory product of combustion. But if burn fuel under certain conditions, it is possible to produce carbon black with desired properties [12]. Globally, every year it produces hundreds of tons of different modifications of soot, which are widely used in the production of rubber, paint, components, copiers, as well as soot is used as a filler in nanocomposite materials. In this paper, the task of creation of hydrophobic sand based on soot, resulting from the combustion of propane and plastic wastes which have a superhydrophobic properties is set. This problem is closely related to the study of the conditions of formation of soot having hydrophobic properties during combustion of propane and plastic waste. Industrial manufacturing methods of carbon black based on the decomposition of hydrocarbons under the influence of high temperatures, soot formation occurs in some cases in a flame of burning material with limited access to air, in others - by thermal decomposition of materials in the absence of soot combustion air Preparation materials with limited access of air is essentially in two methods. According to the most popular method for raw materials are burned in furnaces, burners equipped with various devices.

2 Experimental part

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. Waste 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.

Figure 1 shows a schematic representation of the experimental setup for the combustion of waste oil, which consists of a burner and a metal substrate.

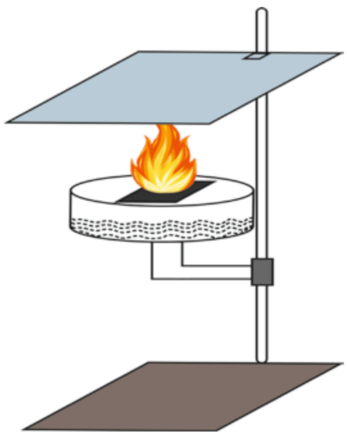


Figure 1 - Schematic representation of the experimental setup for the burning of waste oils

From the Raman spectra of the carbon sample it has been seen that the sample contains two carbon modifications: amorphous carbon 1350 cm^{-1} (D - amorphous), graphite, and 1590 cm^{-1} (G - graphite), Figure 2.

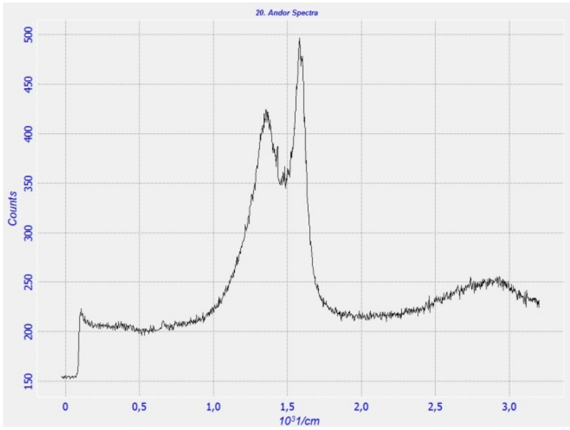


Figure 2 - The Raman spectrum of the soot

Also, the resulting samples of hydrophobic soot were investigated by a scanning electron microscope. Figure 3 shows SEM image obtained soot by combustion waste oils. As seen from SEM images, the soot particles are spherical, the diameter of the soot particles are in the range of 20-40 nm.

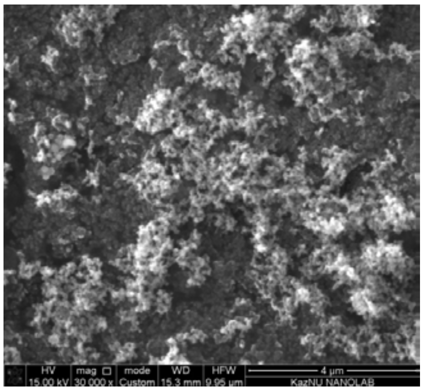
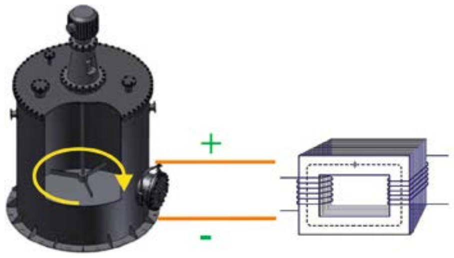


Figure 3 - SEM image of soot

Thus, studies have shown that the burning method from the surface of the impregnated carbon cloth or glass cloth allows to obtain soot having high hydrophobic property. In continuation of these works synthesized soot from waste oil was used to prepare the hydrophobic sand.

It was used sand with 2-5 mm coarse fraction and fine fraction to 0.5 mm, and 1% soot obtained from used oils. The pilot plant for the production of hydrophobic sand which consists of a stirring apparatus and the controlled power supply has been assembled. The photo of the experimental setup is shown in Figure 4.

For study the physicochemical properties of the obtained hydrophobic sand was investigated with a scanning electron microscope and element analysis.

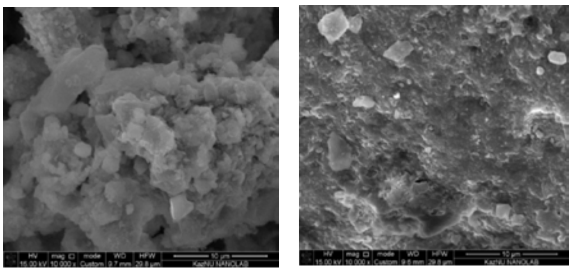


a б

a - mixing device; b - regulated power supply

Figure 4 - The pilot plant for the production of hydrophobic sand

Figure 5 shows SEM images of ordinary river sand (a) and the obtained hydrophobic sand based on carbon black having hydrophobic properties (b). From the SEM images of the resulting sand is observed even enveloping the entire surface of the sand superhydrophobic soot.



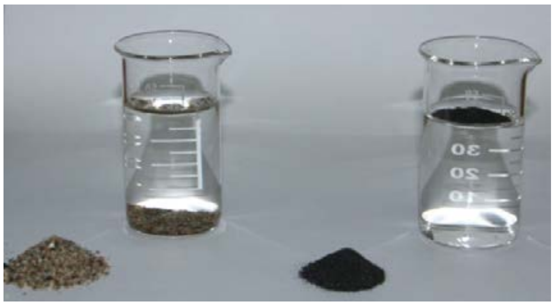
a b

a - clean river sand, b - hydrophobic sand obtained on the basis of soot by burning waste oils

Figure 5 - SEM images of the samples from the coarse fraction of sand

3 Results and Discussion

Before use in plant breeding experiments, the hydrophobic sand tested under laboratory conditions and its properties are presented in Figure 6.



a б

a - regular river sand on the bottom of the glass,
b - hydrophobic sand on the surface of the water

Figure 6 - The properties of the hydrophobic sand

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, figure 7.

Figure 7 - Photograph of water droplets on the sooting surface obtained by burning of waste oils

Initial river sand absorbs water instantly until complete wetting. Applied to the surface of the resulting hydrophobic sand water is distributed on the surface in the form of droplets and not absorbed hydrophobic sand until complete evaporation.

Figure 8 shows a photograph of coarse hydrophobic sand. The resulting hydrophobic sand has a wetting angle of more than 145^0.

Figure 8 - Photo of water droplets on the surface of the hydrophobic sand

Figure 9 shows the results of analysis EDAX hydrophobic sand coated with a polyurethane coating and the hydrophobic soot. The sample contains metal particles such as Na, Mg, Al, Si, Cl, K, Ca, Fe.

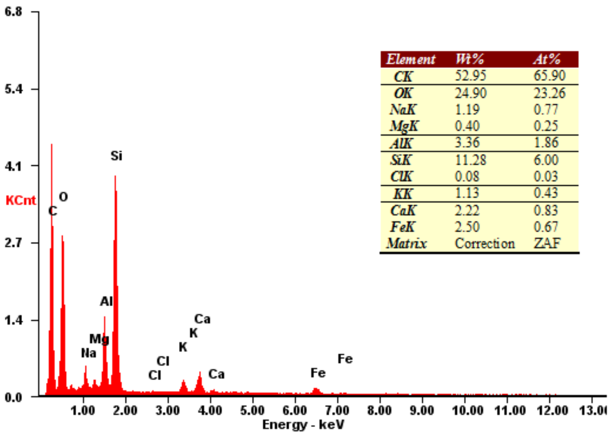


Figure 9 - Results-EDAX microanalysis of hydrophobic sand

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

At 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 ≡S-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. Acquisitions at 797.15; 778.71; 725.61 cm^{-1} due to vibrations deferential 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 fluctuations -C = O group and stripes on 2346.67 cm^{-1}, P-H group. The IR spectra of the samples are observed characteristic absorption bands C–H (2850,71 cm^{-1}), and -OH (2919,45 cm^{-1}, 3428,36 cm^{-1}).

4 Conclusion

Thus, the study of the obtained samples of physical and chemical methods has shown that the hydrophobic sand of polyurethane and hydrophobic coated soot is not wetted by water and the surface of the sand grains completely enveloped nanoscale layer superhydrophobic soot. It was determined the elemental composition and the surface functional groups of hydrophobic sand. Created sand can be used as bedding layer to retain moisture in the upper layers of sandy soil for growing of edible root vegetables. Hydrophobic sand is coarse fraction is recommended for filling the floors in basements of buildings to maintain a dry floor in the cellars.

[1] X2. Author, *Title of the Book*, Publishing House, 200X.

References

[1] J. Hendricks, B. Karcher, U. Lohmann and M. Ponater, Geophys. Res. Lett., 2005, 32, 12814, DOI: 10.1029/2005GL022740.

[2] P. J. DeMott, D. C. Rogers and S. M. Kreidenweis, J. Geophys. Res., 1997, 102, 19575.

[3] E. J. Jensen and O. B. Toon, Geophys. Res. Lett., 1997, 24, 249.

[4] M. Gysel, S. Nyeki, E. Weingartner, U. Baltensperger, H. Giebl, R. Hitzenberger, A. Petzold and C. W. Wilson, Geophys. Res. Lett., 2003, 30, 1566.

[5] R. Hitzenberger, H. Giebl, A. Petzold, M. Gysel, S. Nyeki, E. Weingartner, U. Baltensperger and C. W. Wilson, Geophys. Res.Lett., 2003, 30, 1779, DOI: 10.1029/2003GL017294.

[6] A. Petzold, J. Strom, S. Ohlsson and F. SchroË der, Atmos. Res., 1998, 49, 21.

[7] Y. L. Chen, S. M. Kreidenweis, L. M. McInnes, D. C. Rogers and P. J. DeMott, Geophys. Res. Lett., 1998, 25, 1391.

[8] J. Strom and S. Ohlsson, J. Geophys. Res., 1998, 103, 11355.

[9] B. T. Lesbayev, M. Nazhipkyzy, N. G. Prikhodko, M. G. Solovyova, G. T. Smagulova, G. O. Turesheva, M. Auyelkhankyzy, T. T. Mashan, Z. A. Mansurov. Hydrophobic Sand on the Basis of Superhydrophobic Soot Synthesized in the Flame Journal of Materials Science and Chemical Engineering, 2014, 2, 63-65.

[10] A. Levesque, V. T. Binh, V. Semet, D. Guillot, R. Y. Fillit, M. D. Brookes, *et al.*, Mono Disperse Carbon Nanopearls in a Foam-Like Arrangement: A New Carbon Nano-Compound for Cold Cathodes, *Thin Solid Films*, Vol. 464-465, 2004, pp. 308-314.

[11] M. A. Salem, W. Al-Zayadneh, H. F. Schulze and A. J. Cheruth, Effect of nano-hydrophobic sand layer in datepalm (*Phoenix dactylifera* L.) cultivation in aridlands, Journal of Food, Agriculture & Environment Vol.11 (2): 591-595. 2013.

[12] S. Sen and I. K. Puri, "Flame Synthesis of Carbon Nanofibers and Nanofiber Composites Containing Encapsulated Metal Particles," *Nanotechnology*, Vol. 15, No. 3, 2004, pp. 264-268.