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PRODUCTION HYDROPHOBIC SAND BASED ON SOOT

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Abstract
Superhydrophobic materials have recently attracted attention from both academic and industrial circles because of their importance in fundamental research and potential industrial applications such as bio-surfaces, anti-biofouling, transparent and antireflective superhydrophobic coatings, structural color, fluidic drag reduction, enhancing water supporting force, controlled transportation of fluids, superhydrophobic valves, battery and fuel cell applications, prevention of water corrosion and oil-water separation corrosion protective coatings, preventing adhesion of water and snow to windows or antennas, self-cleaning, enhancing buoyancy, and coating films for electronic devices. The first appeared in the construction of water-proofing about 40 years ago. They were mostly silicone-based fluid polyhydro siloxane, etil silikonata sodium, sodium methyl siliconate. Since these formulations have certain negative qualities, they are now virtually disappeared from the market of construction materials. Relatively cheap raw material soot has hydrophobic properties and can be used as a filler in the creation of hydrophobic materials and coatings. The main disadvantage of soot is that its interaction with the water initiates the mobility of carbon nanostructure components and new structural formations lead to loss of hydrophobic properties. However, if the soot to obtain, under certain conditions, combustion of fuel, it can maintain hydrophobic properties after exposure to water, and such soot may be further used to impart water resistance to various materials. In recent publications appeared in public a lot of work related with synthesis hydrophobic carbon surfaces in flames. In this paper was created hydrophobic sand based on soot having superhydrophobic properties synthesized by burning of polyethylene waste.

Keywords: hydrophobicity, sand, soot, water resistant, flame

Introduction

Materials with appropriate surface roughness and low surface energy can form superhydrophobic surfaces, displaying water contact angles greater than 150°. Superhydrophobic carbon-based materials are particularly interesting due to their exceptional physicochemical properties.

Preparation of superhydrophobic materials is rapidly developing areas of modern science. Superhydrophobic materials and composites based on them have been widely used in various industries: construction, textile industry, instrument, paint production, and others. For Kazakhstan, the development of the technology of hydrophobic material is relevant, due to the lack of industrial plants for the production of this class of materials.

Excessive moisture is the main cause of the destruction of buildings and structures. With the penetration of water into the construction projects go on corrosion and deformation, with the appearance of cracks in porous building materials is reduced structural strength. However, this problem can be solved by means of hydrophobic waterproof materials which are able to provide materials such as brick, concrete, plaster, gypsum, asbestos cement, the properties of water repellency.

Also hydrophobic waterproofing materials can give for concrete and reinforced concrete structures such qualities as frost and corrosion resistance, especially in the context of being in aggressive and hostile environments. Assortment of modern hydrophobic materials is extremely high. This may be alkilsilikonaty of alkali metal, polimetilgidridsiloksan, various compositions and elastomers. Thus, the use of modern hydrophobic materials enables to provide a reliable protection from corrosive environmental components to reduce the water absorption of porous materials to improve the appearance of the building structures. But with the passage of time, the water washes away the hydrophobic compounds and, therefore, with a certain interval necessary to restore the hydrophobic coating. Taking into account the high cost of these materials, the economic part of the question plays an important role.

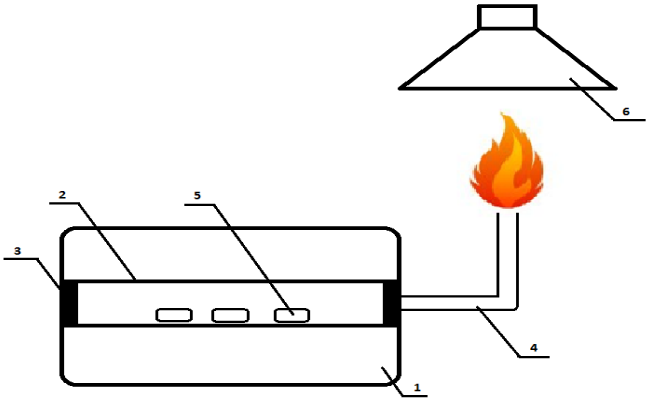
Thus, today there is a need in the hydrophobic composites whose production it would be advantageous and application effective. In this work were synthesized superhydrophobic soot through the combustion of polyethylene waste and created hydrophobic sand on the bases of obtained soot. Hydrophobicity is characterzed through the wetting angle for water droplets placed on a surface covered with obtained superhydrophobic soot.

Materials and methods

During combustion of hydrocarbon fuels particles of soot are a by-product of combustion. But if burn fuel under certain conditions, it is possible to produce a soot with specified properties [4, 5]. The photograph of experimental setup for synthesis of soot which having superhydrophobic properties shown in Fig.1.

Results and discussion

The obtained soot particles were investigated by Scanning electron microscope (SEM) and Transmission electron microscope (TEM), Fig.2.



1 – transformer; 2 - quartz tube; 3 – top; 4 – metal tube; 5 – polyethylene samples; 6 – soot collector

Fig. 1 – The photograph of experimental setup for synthesis of soot by burning a polyethylene waste

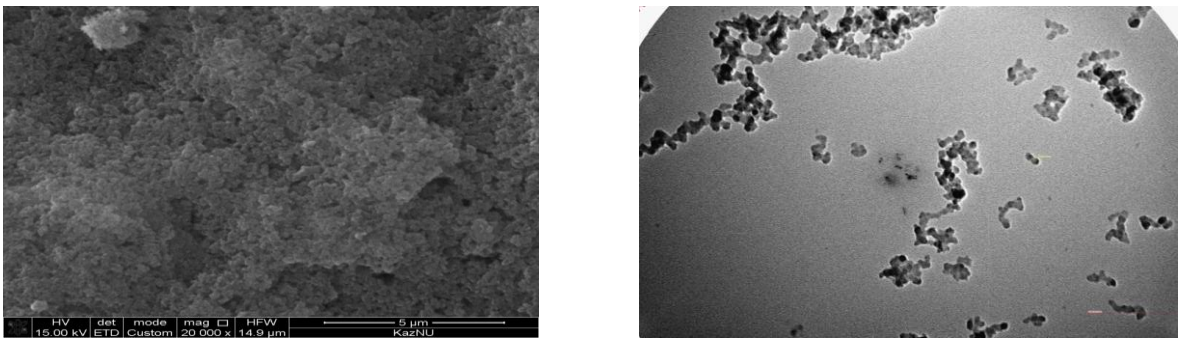


Fig. 2 – SEM and TEM images of soot particles

TEM studies have shown that the sizes of the soot particles are within 20-40 nm. Soot particles have clearly defined boundaries, and formed a chain, high concentration of forming chains and degree of structure.

The obtained superhydrophobic soot which used for create hydrophobic sand has been examined using Raman spectroscopy. The Raman spectra indicate the presence of various forms of carbon. Raman peak near 1350 cm^{-1} (marked as D is due to amorphous-C, while the peak at 1590 cm^{-1} (marked as G) is due to graphite, Fig. 3. The ratio between the intensities of the G and the D peaks provides information about the lateral dimensions of the flakes.

Particle size distributions of the hydrophobic soot were built up using method Monte Carlo, Fig.4.

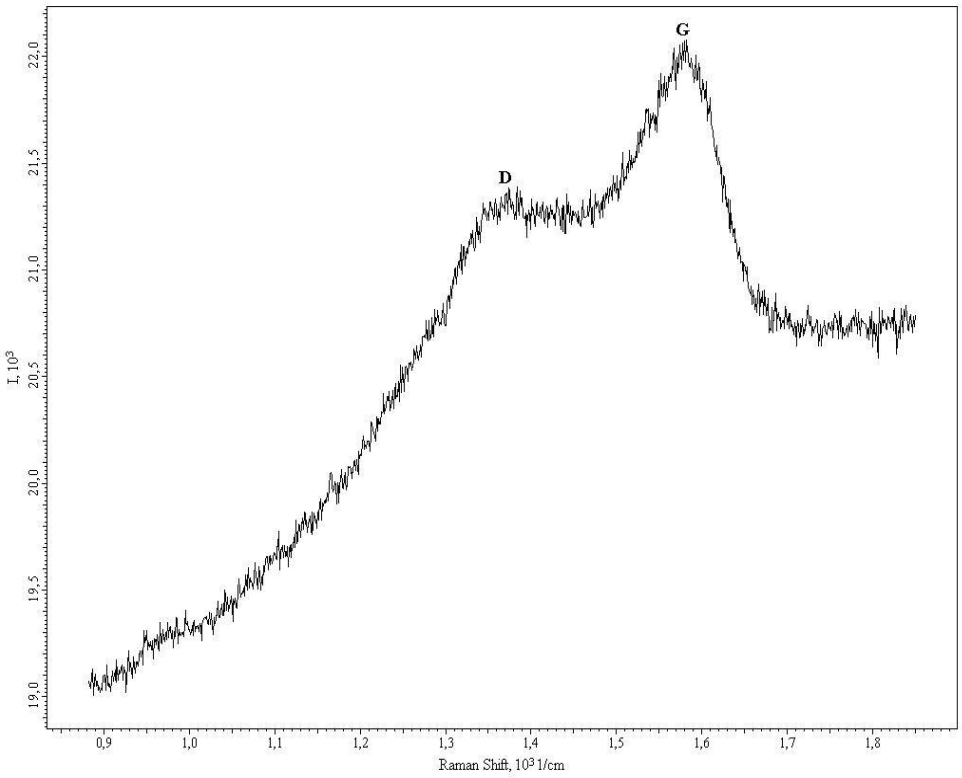


Fig. 3 – Raman spectra of soot having superhydrophobicity properties

The proposed work was to create a hydrophobic composite building material which was created based on soot having superhydrophobic properties obtained by burning a polyethylene waste.

For polyethylene flame plastic waste was placed in a hermetic rector and was exposed thermally decomposed without access to air at a temperature of 900 - 970 K. As a result of decomposition of polyethylene form easily a condensable gas having white colour, which, when burned, burns resistant smoky flame. The obtained soot was precipitated on the surface of the nickel substrate. A method of producing a superhydrophobic soot by proposed method is described in detail in [6].

The production technology of hydrophobic sand includes some stages. In the first of all on a surface of sand was placed the glue, the next step was processing by a hydrophobic filler. After goes process of hardening. We used usual washed river sand, as a glue of basis was applied polyurethane glue which dissolved in ethyl acetate. The content of glue mass no more than 5% from the weight of hydrophobic sand. The sticky layer is put on a surface of sand for subsidence of a polyurethane film from solvent. For what sand with the polyurethane glue which was dissolved in ethyl acetate, is exposed to intensive hashing, volatile solvent is evaporated and on a surface of sand is formed the nanodimensional film of polyurethane.

In the obtained thus sand with adding 1% of superhydrophobic soot and calcium stearate, the received weight at a temperature of 40-90 °C mixes up with a speed of 60 turnover / sec. within 30 minutes.

During hashing the surface of grains of sand is enveloped by a nanodimensional film from a mix of hydrophobic soot. The role of superhydrophobic soot consists in increase of degree of adhesion of a hydrophobic film on surface grains of sand, their hydrophobic properties and reduction of time of hardening.

The results showed that the particles of hydrophobic soot have spherical structures. In Fig. 5. presented a photograph of the behaviour of water droplets on the surface of obtained hydrophobic sand. The wetting angle of water droplets were more than 150 degrees.

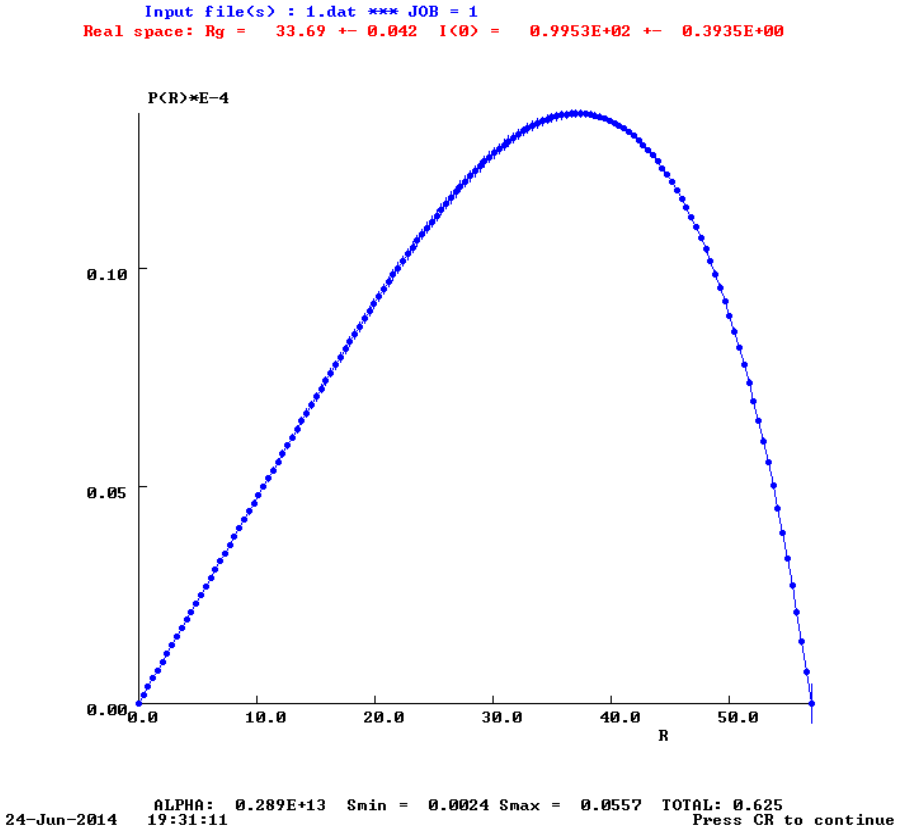


Fig. 4 – Particle size distribution of the hydrophobic soot

The most important and reliable information on the structure of the resulting hydrophobic particulate material can give scanning electron microscopy (SEM). The samples of hydrophobic loose materials were investigated by SEM. SEM studies showed that soot fully envelops surface of grains regardless of their size, Fig.6.

Studies have shown that soot having superhydrophobic properties completely envelops the surface of grains of sand with uniform layer thickness of 20 nm.

were conducted on the mechanical abrasion the soot particles from the surface of grains.

Tests showed that the process of stirring for 2 hours does not lead to a reduction in film thickness of the soot.

Optical and electron microscope images of the surface of sand shown in Fig. 7.

Surface of hydrophobic sand was investigated on the optical (DFC 490) and scanning (Quanta 3D200i) microscopes.

Tests

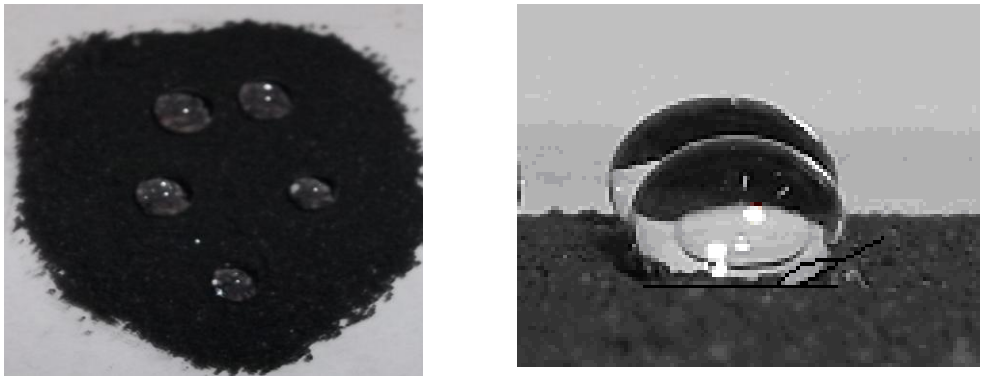


Fig. 5 – Water droplets on the surface of created hydrophobic sand

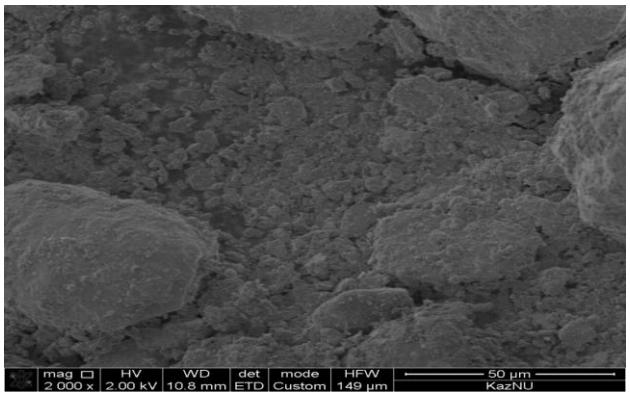


Fig.6 – Electron microscope images of the surface of hydrophobic sand

Conclusions

Thus perfected technique of synthesis of soot having a superhydrophobic properties by burning plastic waste.

Obtained soot was used for creating hydrophobic sand, the proposed method allows hydrophobize not only the surface layer of grains of sand, but its bulk density, which significantly improves the quality of protection against the ingress of moisture.

The obtained hydrophobic sand is offered to be used as filler in construction materials for external finishing and in agriculture for prevention of infiltration of irrigation water in the bottom layers of soil or its evaporation.

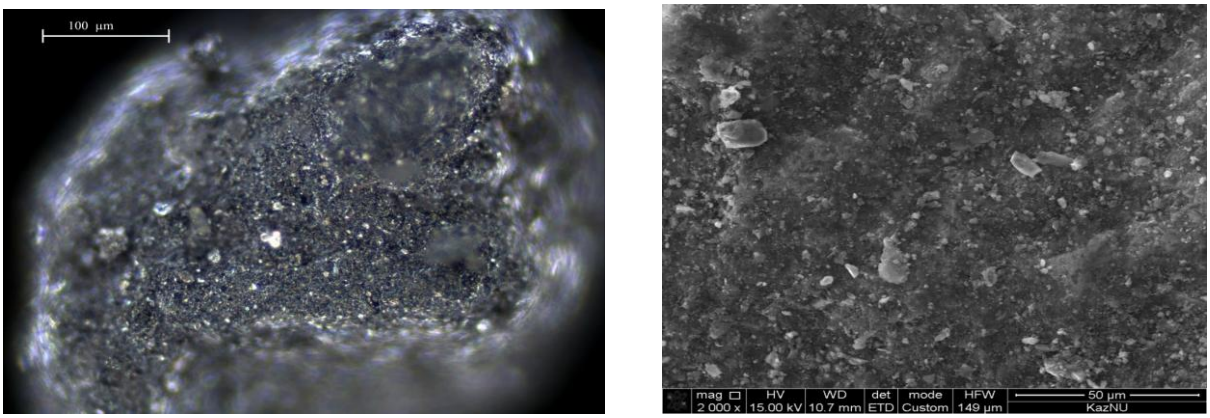


Fig. 7 – Optical and electron microscope images of the surface of sand

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ПОЛУЧЕНИЕ ГИДРОФОБНОГО ПЕСКА НА ОСНОВЕ САЖИ

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Аннотация
Супергидрофобные материалы в последнее время привлекают внимание как академических, так и промышленных кругов из-за их важности в фундаментальных исследованиях и потенциальных промышленных приложений, таких как био-поверхностей, анти-обрастания, прозрачных и просветляющих супергидрофобных покрытий, структурного цвета, жидкостного уменьшения сопротивления, повышение воды поддержку силу, контролируется перевозки жидкостей, супергидрофобных клапанов, аккумуляторов и топливных элементов, предотвращения коррозии воды и коррозии разделение нефть-вода защитных покрытий, препятствующих адгезии воды и снега на окнах или антенн, самоочищения, увеличиние плавучести и пленочных покрытий для электронныхустройств. Первые гидрофобизаторы появились в строительстве около 40 лет назад. В основном это были кремнийорганические жидкости на основе полигидросилоксана, этилсиликоната натрия, метилсиликоната натрия. Так как данные составы имеют определённые негативные качества, сейчас они практически исчезли с рынка строительных материалов. Сравнительно дешевое сырье – сажа, обладает гидрофобными свойствами и может быть применена в качестве наполнителя при создании гидрофобных материалов и покрытий. Главным недостатком сажи является то, что ее взаимодействие с водой инициирует подвижность наноструктурных составляющих углерода и появляющиеся новые структурные образования приводят к потере гидрофобных свойств. Но если сажу, получать при определенных условиях сжигания топлив, то она сможет сохранять гидрофобные свойства после взаимодействия с водой, и такую сажу в дальнейшем можно использовать для придания различным материалам водостойкости. В последние годы появились много публикации, связанные с синтезом гидрофобных углеродных поверхностей в пламени. В данной работе был создан гидрофобный песок на основе сажи, имеющей супергидрофобные свойства синтезированных путем сжигания полиэтиленовых отходов.

КҮЙЕ НЕГІЗІНДЕГІ ГИДРОФОБТЫ ҚҰМ ӨНДІРУ

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Аннотация
Супергидропобты материалдар соңғы кезде академиялық, сондай-ақ өндірістік ортаның назарын өзінің маңызды алғашқы зерттеу және ілгері өндірістік жағыдайымен, және де био бетті, анти-обрасталды, мөлдыр және боялатын супергидропобты жабынды, жарық құрлымы, сұйықтың азаюына қарсы, судың қарсылық күшін жоғарлату, сұйықтың тоқтап қалуын бақылау, супергидропобты канал, аккумуляторлардың және отын элементтерінің судың корозиясын азайту мұнай мен суды ажырату судың және қардың терезеге немесе антеннаға жабысуын болдырмау, өзін-өзі тазалау, жандануы және электрондық құрылғылар үшін қабыршақ жабынды. Бірінші гидрофобизаторлар шамамен 40 жыл бұрын құрлыста пайда болды. Олар негізінен полигидросиликон негізіндегі кремнийорганикалық сұйық, натридың этилсилоконаты болды. Осы құрамдар белгілі теріс қасиеттерге ие болғандықтан, олар қазір іс жүзінде құрылыс материалдары нарығынан алынып тасталды. Салыстырмалы арзан шикізат күйе гидрофобты қасиеттерге ие және гидрофобты материалдар мен жабындарды құрушы ретінде пайдаланылуы мүмкін. күйеден негізгі кемшілігі сумен оның өзара көміртегі нанокұрылымды компоненттермен іс-қимылында және жаңа құрылымдық гидрофобты қасиеттері жоғалтуға әкеп соғады. Алайда, күйе алу, егер белгілі бір шарттарды, отын жану астында, ол суға шомылғаннан кейін гидрофобты қасиеттерін сақтауға болады, және мұндай күйе одан әрі түрлі материалдарға су қарсылық үйрету үшін пайдаланылуы мүмкін. Соңғы басылымдарында жалын синтез гидрофобты көміртегі беттермен байланысты жұмыс қоғамдық көп пайда болды. Бұл жұмыста полиэтилен қалдықтарды жағу бойынша синтезделген superhydrophobic қасиеттері бар күйеден негізінде гидрофобты құм құрылды.