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TEST OF THE SUITABILITY OF CHOSEN MATERIALS IN TERMS OF THEIR USE FOR REMOVING OIL SPILLAGE FROM THE WATER ENVIRONMENT

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Abstract

The paper presents the study about impregnability of various loose materials dedicated as the fillers of oil absorbent socks and booms. Purpose of the survey was finding the material, which is characterized with the smallest hygroscopicity and the highest absorptivity towards typical fuels used in the marine techniques. The cause of take up the topic is the fact, that the contamination of sea areas with petroleum substances are unfortunately very often, are dangerous for natural environment and first of all are so hard to remove from the sea surface. The natural, mineral and synthetic sorbents were studied under laboratory conditions. Samples of the ten kinds of sorbent, each of 2 grams, were treated with the same amount of the diesel fuel, heavy fuel oil and the sea water also, each time in the same period-time (5 minutes). In order to determine the reliability of the results the authors carried out the test fivefold for the one of searched sorbents (recognized as the most hydrophobic-oleophilic substance). The results are presented in graphical form, based on which we are able to select sorbent that fulfils the greatest extent of required expectations. The results of performed tests show that the method that was described in the paper could be used to test the suitability of various materials for the production of devices for collecting the oil film from the surface of the water.

Keywords: *sorbents, fuel, seawater, maritime engineering, environmental protection*

1. Introduction

Uncontrolled penetration of an oil substances into the environment is always treated as dangerous pollution and have to be combated using all available methods [1]. If there are small, although visually noticeable amounts of such pollution, application of sorbent substances is the most reasonable. Relatively simply situation is when oil is spilled on the hard substrate – then the problem remains the only selection of the material, preferably if it is free-flowing material with an average granulation, efficiently absorbing oil substances [2]. In contrast, is much more difficult to remove the oil from the ground and even more difficult from the water surface.

In the case of spillage on calm water, for example, in the harbour basin, in the first phase of combating of oil spillage, it is possible to reduce contaminated area using movable floating barriers (booms), in order to then extract the oil from the water surface by the floating pump system (skimmer). However, in the last stage of purification of the water surface using of the sorbent socks and sleeves is required. The effectiveness of such "cleaning objects" depends on the materials, with which are filled. There are a lot producers and sellers of so-called oil-absorbent booms or sockets. Unfortunately, there is a considerable uncertainty how these products absorb oil in companion with water. The key is that the adsorbent had the in maximum extent oleophilic properties, while in minimum extent – hydrophilic. It was therefore examine various loose substances and solids in terms of water and oil substances absorption properties. The study described in this paper were performed using ten various sorbent materials provided with AWA Sp. z o. o. The tests were carried out within the Student Scientific Society „Nautica" (at Faculty of Marine Engineering of the Gdynia Maritime University in Poland).

2. Material and methods

There were ten various sorbents used, namely: two types of organic sorbents like Ecobark (bark) and Spill-Sorb (peat), mineral: two types of Vermiculite and synthetic: low-density polyurethane and high-density polyurethane. In described tests, 200 millilitres of seawater, heavy fuel oil and diesel fuel and 2 grams of various types of sorbents were applied. The sorbents were submerged in the liquid in the time of 5 minutes. Every sorbent was prepared in three containers with different liquid (seawater, heavy fuel oil and diesel fuel). Afterwards the sorbents were drained of excess of substance. Then the sorbents were weighted on precision balance. All the experiments were carried out in the room temperature (21-23°C).

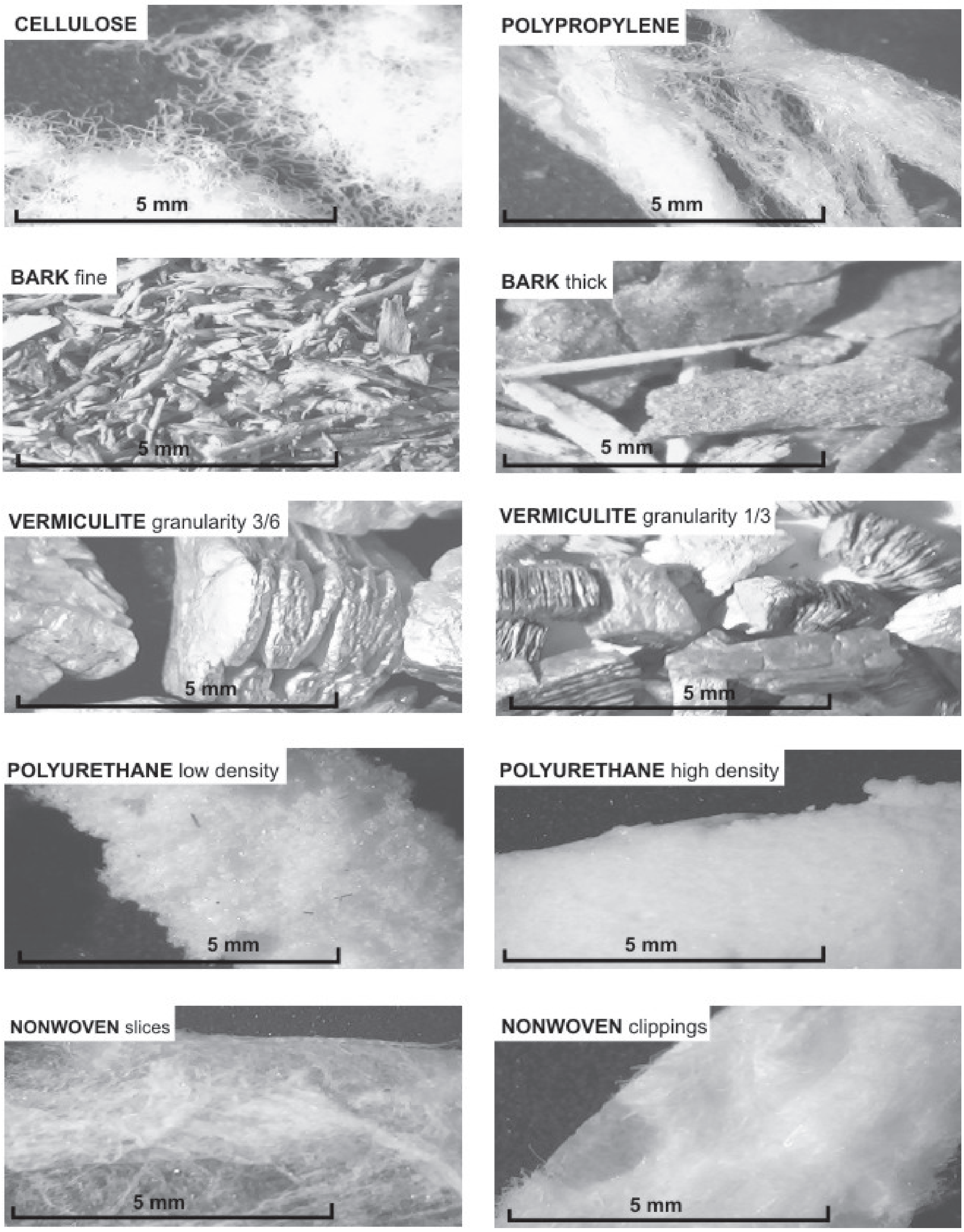

Fig. 1. Magnified pictures of studied sorbents

Tab. 1. Parameters of oils relevant for sorption processes

	Density [kg/m^2]	Kinematic viscosity coeff. at 50 °C [mm^2/s]
Light fuel oil „Eurodiesel”	0.822	2.47
Heavy fuel oil	0.923	39.2

3. Results and discussion

The mass of oil absorbed by studied material were calculated as the difference between the mass of clean sorbent and the mass of sorbent after contact with oil. Results of measurements are presented in Tab. 2 and additionally in Fig. 2 as the column chart. Definitely, the biggest oil absorbency shows the low-density-polyurethane (PUR LD). High-capacity oil absorption also shows the cellulose-wadding (CW) – two times lower than PUR LD. CW absorbs water as it absorbs oil.

Tab. 2. The amount of oil absorbed by the sorbent whose weight is 2 g

	DIESEL [g]	HEAVY FUEL [g]	SEAWATER [g]
low density polyurethane (**PUR LD**)	91.498	92.150	14.295
high density polyurethane (**PUR HD**)	8.905	11.579	8.194
thick bark (**BARK T**)	4.854	*unmeasurable*	3.981
fine bark (**BARK F**)	9.520	*unmeasurable*	6.126
3/6 granulation vermiculite (**VER 3/6**)	3.151	*unmeasurable*	6.090
1/3 granulation vermiculite (**VER 1/3**)	7.853	*unmeasurable*	9.996
cellulose wadding (**CW**)	26.394	34.419	36.610
nonwoven clippings (**NW C**)	29.119	18.283	3.373
polypropylene thread (**PP**)	35.500	17.600	2.370
nonwoven slices (**NW S**)	14.054	45.823	2.778

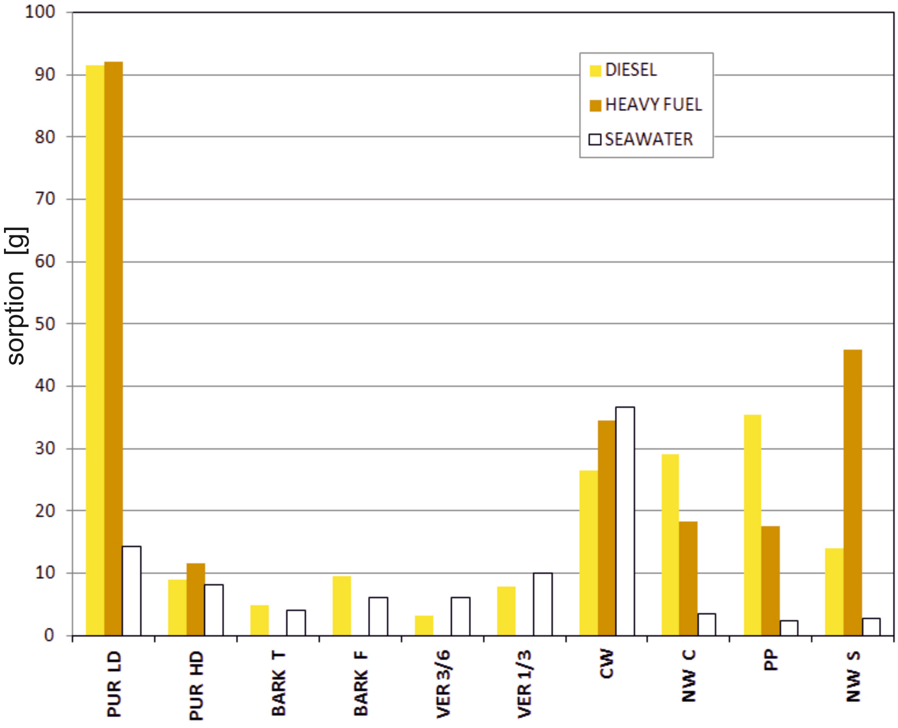

Fig. 2. The amount of oil absorbed by the sorbent whose weight is 2 g (acronyms are explained in the Tab. 1)

In order to assess the accuracy of the method, measurement for chosen sorbent (PP) was performed five times (Tab. 3). There was determined confidence interval for the mean value (the Student's test) at a significance level of five, which is indicated in Fig. 3.

Tab. 3. Mass of oil absorbed by the sorbent PP – measurement repeated 5 times

DIESEL [g]	HEAVY FUEL [g]	SEAWATER [g]
36.1667	16.0048	2.4667
34.3733	18.4973	2.2821
35.5427	16.6302	2.4101
36.1947	16.104	2.3042
35.0845	17.5662	2.4007

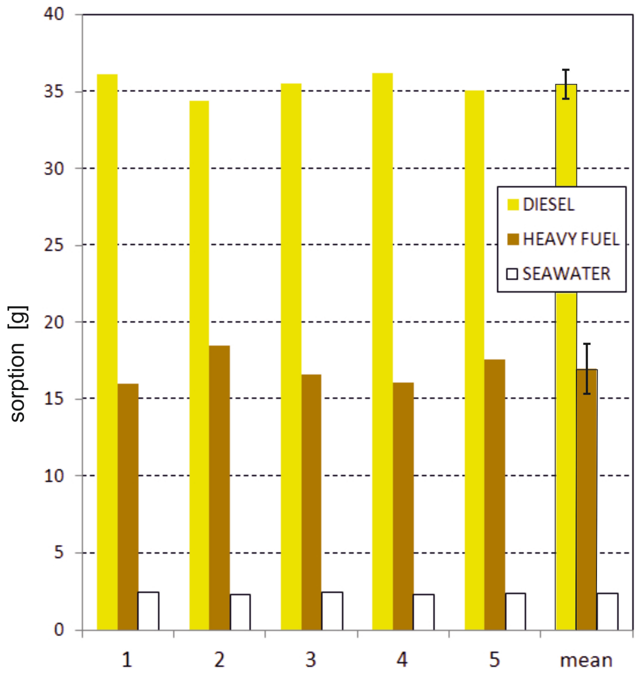

Fig. 4. The amount of oil absorbed by the sorbent PP – measured 5 times (based on the data in Tab. 2)

In order to access suitability of the defined sorbent for removing oil in aquatic environment the parameter oil/water efficacy described by the following definition (1) is presented in Fig. 5.

$$oil\,/\,water\ efficacy = \frac{mass\ of\ oil\ absorbed}{mass\ of\ water\ absorbed}\,. \quad (1)$$

Highest value of *oil/water efficacy* is observed for non-woven absorbing heavy-oil. Lowest – for *bark*, *vermiculite* and *cellulose-wadding*. It seems that in aquatic environment useful appear *polyurethane*, *non-woven* and *polypropylene*.

Operations related to accuracy of measurements were transformed into *oil/water efficacy*. There was calculated uncertainty intervals assuming the most adverse situations, respecting the boundaries of variation ranges marked in Fig. 4. This shows that results been read from graph on Fig. 5 are reliable, that means that we know which sorbent-substances from the used set (ten sorbents) are suitable to use in aquatic environment, despite of every tested sorbent is fully useful when oil in spilled on the hard substrate. It has just visually shown in Fig. 6 in which one can notice that after contact of tested substances with oil, it is absorbed with well efficiency. Entirely different behaviour show of certain substances during contact with water – an example is presented in Fig. 7.

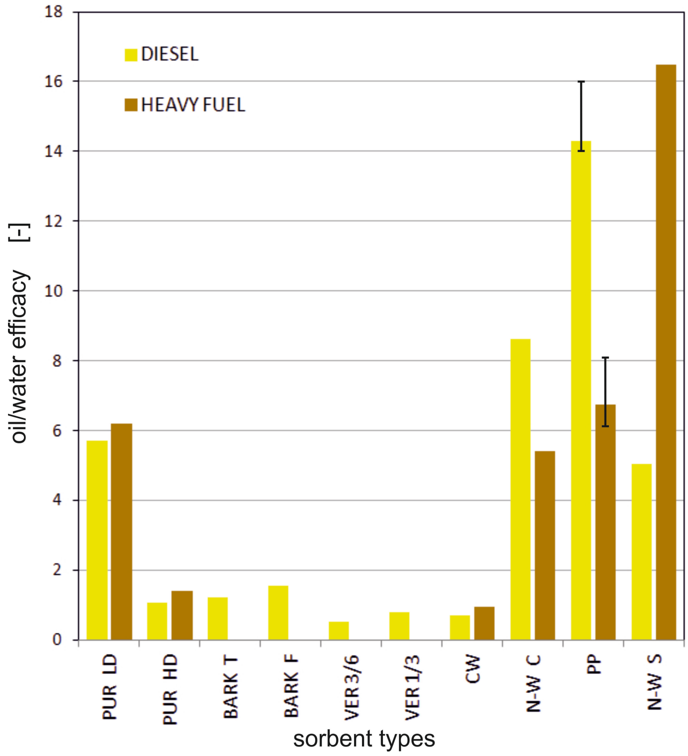

Fig. 5. Mass of absorbed water as the function of the time of contact of the sorbent with water

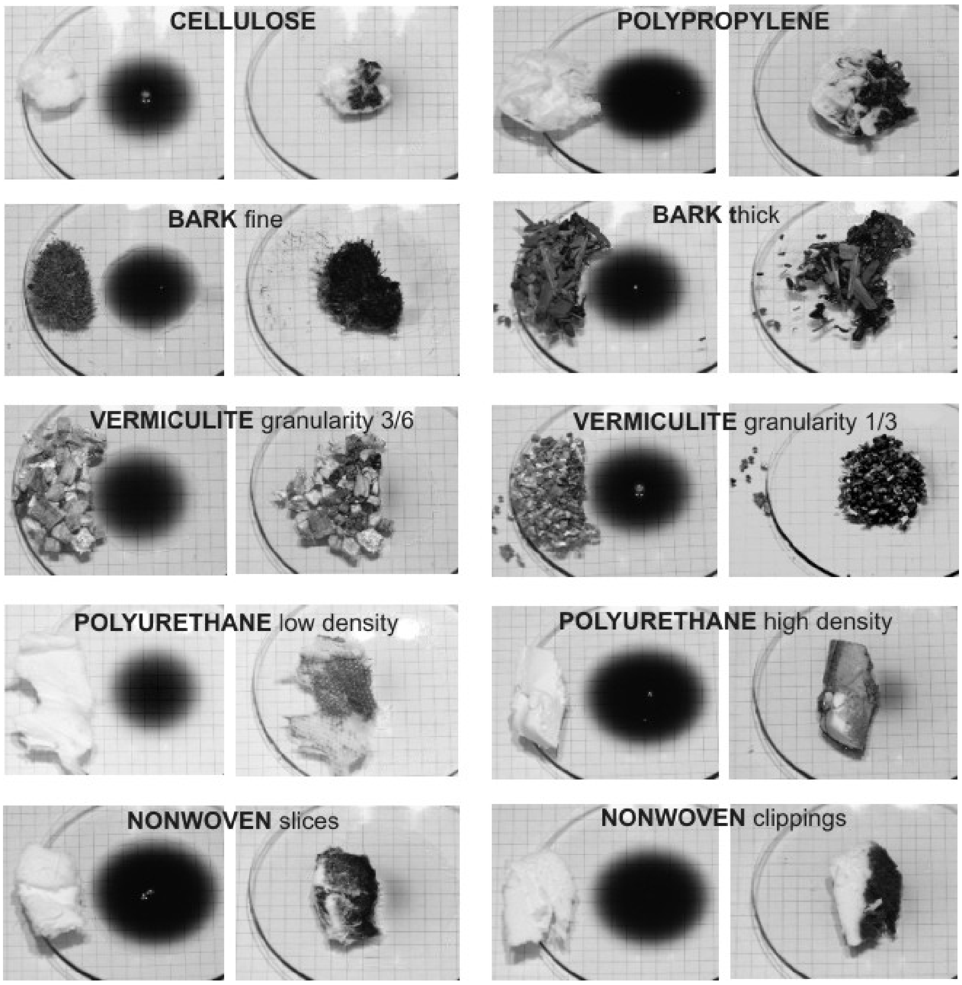

Fig. 6. Visualisation of absorption of oil spilled on hard substrate with every substance tested

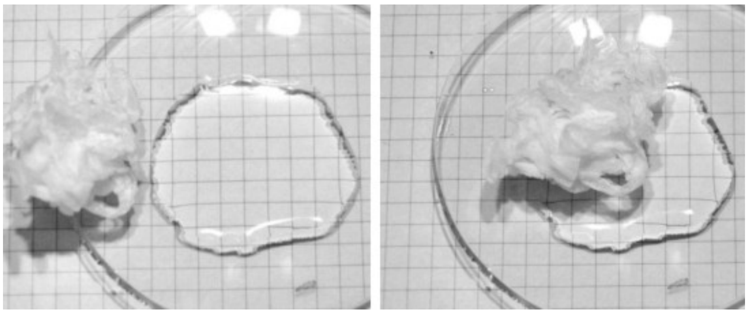

Fig. 7. Visualisation of hydrophobicity of polypropylene (PP)

There were tested only ten sorbent-substances in this paper. In the word they are used various sometimes even strange materials. The example would be the kenaf (*Hibiscus cannabinus*) fibre [3] or rice straw, corncob, wood fibre, sawdust, cotton fibre, kapok fibre, wool fibre, kenaf fibre, milkweed, rice husk, coconut husk, cattail fibre, hay, feathers and bagasse [4]. However, quite for economic reasons, in common use as oil sorbents meet the natural (biological) substances [5]. Another argument in favour of natural sorbents is that they are environmentally friendly [6]

4. Conclusions

In the study here described simply gravimetric method of selection the material suitable for oil removing from aquatic environment is applied. Unfortunately, loose materials cannot be tested in relation to high-viscosity oil. Among the tested sorption-material, the best was propylene produced in the wadding form, while the worst was cellulose wadding and vermiculite, which absorb water better than oil.

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