Desorption of microorganisms with hydrophobized surfaces

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Abstract: One of the most promising areas in the fight against oil pollution is the use of microorganisms. When eliminating oil pollution, an important task is the selection of surfactants that facilitate the interaction of oil-oxidizing microorganisms with oil products. Dispersion of hydrophobic substances, in particular petroleum hydrocarbons, dramatically increases their surface. In turn, this significantly increases the area of interaction of hydrophobic compounds with oxygen and oil-oxidizing microorganisms. In this work, the effect of humic substances on the aggregate state of various hydrophobic substances is studied. The bioagents were taken strains: Yarrowia lipolytica and Bacillus thuringiensis. Sodium dodecyl sulfate, melanin and humates were chosen as classic surfactants. As sorbing surfaces, slides that were pretreated with silicone or paraffin were used in the work. Experiments have shown that in the presence of sodium dodecyl sulfate, the sorption of cells and spores of microorganisms significantly decreased. With longer exposures, the concentration of cells and spores on the glasses not only did not increase, but even decreased. Moreover, the higher the content of sodium dodecyl sulfate, the weaker the cells and spores of the microorganisms were bound to the hydrophobic surface, and the rate of desorption was higher. It was shown that humates at certain concentrations, like twin, dispersed diesel fuel and fuel oil, and also reduced the amount of cell adhesion. This work was financially supported by the RFBR grant 19-29-05213 mk «Mechanisms for the integrated interaction of soils with oil, oil products and surface-active substances in oil pollution and bioremediation processes».

1. Introduction

The main source of energy at the moment is oil and petroleum products. Therefore, in the context of growing energy consumption, oil pollution is a significant problem. The basis of natural mechanisms of oil decomposition and the most effective and environmentally friendly biotechnological methods of liberation from hydrocarbons are microbiological processes. Petroleum products in the inhibitory substance are hydrophobic. Therefore, the transformation of oil pollution by microorganisms is closely related to their ability to interact with hydrophobic substrates. In soils in one quantity or another, humic substances are always present. It was previously assumed that one of the possible mechanisms underlying the biological effects of humic derivatives is their ability to act as surface active agents [2, 3]. In this regard, the effect of humates on the desorption of microorganisms from hydrophobic surfaces was studied [4].

2. Materials and equipment

For research, spores of B. thuringiensis strain [1] and yeast cells, Y. lipolytica, were taken. As sorbing surfaces, slides were used in the work, which were pretreated with silicone or paraffin. At the first stage, a drop of a suspension of microorganisms was applied to hydrophobized glasses. After 30
minutes, the glasses were rinsed twice by dropping them into a glass of water (control). Then placed in solutions with different concentrations of sodium dodecyl sulfate or humate 0.5 g/l; 1.0 g/l; 1.5 g/l and 2.0 g/l [5]. At certain intervals, the surface of the adsorbent was microscopic with a 40 * objective, both before and after appropriate treatment. Counting the cells and spores of microorganisms remaining attached to the hydrophobic surfaces of the adsorbent was performed in ten fields of view with finding the average value.

All experiments were performed in at least 5 independent experiments with 3 parallel measurements in each. Conclusions are made on the basis of the results of statistical processing with the probability of an error-free forecast P > 0.95.

3. Results and discussion

The experiments showed that in the presence of humate there was a significant decrease in the number of cells of microorganisms adhered to the surface of the glasses. For example, after 3 hours, Powhumus humate solutions at a concentration of: 1.5 g/L reduced the number of Y. lipolytica cells on waxed surfaces by 19%, and 2.0 g/L by 41% with respect to the control. The increase in exposure time was accompanied by a decrease in the number of attached Y. lipolytica cells and B. thuringiensis spores to the hydrophobic surface. At all used humate concentrations, after 24 hours, the number of cells on the model surface coated with paraffin significantly decreased. At concentrations: 1.5 and 2.0 g/L, Y. lipolytica cells were not detected at all after 24 hours. In the case of siliconized glasses, a similar decrease in the number of Y. lipolytica cells was observed in the presence of Powhumus. For example, after 3 hours at a concentration of 1.0 g/L, the number of cells fell by 46%, and at a concentration of 1.5 g / L by 52% compared with the control (water). A day later, with a humate content of both 1.5 and 2.0 g/L, the siliconized glass surfaces were already free of Y. lipolytica cells. A similar pattern with Y. lipolytica was observed with B. thuringiensis. With an increase in concentration to 2 g/L after 24 hours, spores of B. thuringiensis strain were no longer found on the glass surface.

At the next stage, we studied the effect of one of the most characteristic surfactants - sodium dodecyl sulfate on desorption from siliconized and paraffin-coated glasses. It was found that three hours after the start of exposure in concentrations: 0.5; 1.0; 1.5; and 2.0 g/l, the number of cells attached to the surfaces of hydrophobilized glasses was significantly reduced. An increase in the exposure time was also accompanied by a decrease in the number of attached Y. lipolytica and B. thuringiensis cells to the hydrophobic surface. After 24 hours from the start of the exposure, the number of cells on the model surface coated with paraffin was significantly reduced. At a concentration of sodium dodecyl sulfate 2 g/l, the cells on the glasses were absent.

The results of experiments with silicone sealant also showed a significant decrease in the number of microorganism cells of the culture of Y. lipolytica and spores of B. thuringiensis. After 24 hours, the number of Y. lipolytica and B. thuringiensis cells adhered to the surface of hydrophobilized glasses significantly decreased in all the presented concentrations of sodium dodecyl sulfate.

It should be noted that a decrease in the number of attached cells and spores of the studied microorganisms was recorded in the control. But in the absence of humate and sodium dodecyl sulfate, the desorption rate was incomparably lower than in their presence.

In the work, as a humic substance, “Powhumus” was used, which is a sodium salt of humic substances. Therefore, in order to find out whether the “Powhumus” effect is related, the effects of sodium chloride (NaCl) on sorption were studied by the humic nucleus or sodium cation.

The experiments showed that in the presence of NaCl, a significant decrease in the number of microorganism cells adhered to the glass surface did not occur. An increase in exposure time was also not accompanied by a decrease in the number of attached Y. lipolytica cells and B. thuringiensis spores to the glass surface. At all NaCl concentrations used in the work, no significant increase in desorption was observed. Therefore, humic substances are responsible for the described effects.
4. Conclusion
In certain concentrations (0.5; 1.0; 1.5; 2.0 g per l), humate, although with a slightly lower intensity, like surface-active substances such as sodium dodecyl sulfate, enhanced the desorption of cells of the microorganisms *Y.lipolytica* and spores *B.thuringiensis*, from surfaces hydrophobized with paraffin and silicone. Sodium chloride in concentrations: 0.5; 1.0; 1.5; 2.0 g per liter did not affect the desorption of microorganisms.

The obtained materials indicate that biological desorption processes are based on the ability of humic substances to act as surfactants.

References
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