A 'smart dress' for oil-degrading bacteria

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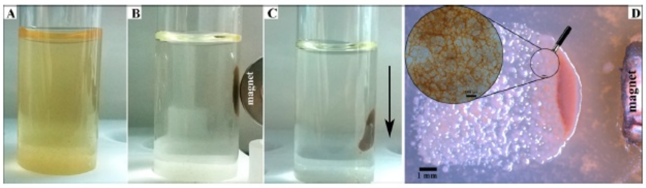

(a,b) Targeted movement of magnetic cells was facilitated byexternal magnetic field (in liquid media); (c) sedimentation of magnetically concentrated cells; (d) targeted movement and growth of magnetic cellson solid surface (inset shows a higher-magnification view of cells arranged on the surface). Credit: Kazan Federal University

Bionanotechnology research targets functional structures synergistically combining macromolecules, cells, or multicellular assemblies with a wide range of nanomaterials. Providing micrometer-sized cells with tiny nanodevices expands the uses of the cultured microorganisms and requires nanoassembly on individual live cells.

Surface engineering functionalizes the cell walls with polymer layers and/or nanosized particles and has been widely employed to modify the intrinsic properties of microbial cells. Cell encapsulation enables fabricating live microbial cells with magnetic nanoparticles onto cell walls, which mimics natural magnetotactic bacteria.

For this study, researchers from Kazan Federal University and Louisiana Tech University chose Alcanivorax borkumensis marine bacteria as a target microorganism for cell surface engineering with magnetic nanoparticles for the following reasons: (1) These hydrocarbon-degrading bacteria are regarded as an important tool in marine oil spill remediation and potentially can be used in industrial oil-processing bioreactors. Therefore, the external magnetic manipulations with these cells seems to be practically relevant; (2) A. borkumensis are a marine Gram-negative species having relatively fragile and thin cell walls, which makes cell wall engineering of these bacteria particularly challenging.

Rendering oil-degrading bacteria with artificially added magnetic functionality is important to attenuate their properties and to expand their practical use.

Cell surface engineering was performed using polycation-coated magnetic nanoparticles, which is a fast, straightforward process utilizing the direct deposition of positively charged iron oxide nanoparticles onto microbial cells during a brief incubation in excessive concentrations of nanoparticles. Gram-negative bacterial cell walls are built from the thin peptidoglycan layer sandwiched between the outer membrane and inner plasma membrane, with lipopolysaccharides rendering the overall negative cell charge. Therefore, cationic particles will attach to the cell walls via electrostatic interactions.

Rod-like 0.5-?m diameter Gram-negative bacteria A. borkumensis were coated with nanoscale magnetite shells. The deposition of nanoparticles was performed with extreme care to ensure the survival of magnetized cells.

The development of biofilms on hydrophobic surfaces is a very important feature of A. borkumensis cells, because this is how these cells attach to the oil droplets in natural environments. Consequently, any cell surface modification should not reduce their ability to attach and proliferate as biofilms. The authors of the study detected similar biofilm growth patterns. Overall, the magnetized cells were able to proliferate and exhibited normal physiological activity.

The next generations of the bacteria have a tendency to remove the artificial shell, returning to their native form. Such magnetic nanoencapsulation may be used for the A. borkumensis transportation in the bioreactors to enhance the spill oil decomposition at certain locations.

More information: Svetlana A. Konnova et al, Nanoshell Assembly for Magnet-Responsive Oil-Degrading Bacteria, *Langmuir* (2016). DOI: 10.1021/acs.langmuir.6b01743

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