Researchers suggest using urchin-like particles to accelerate cell biochemical reactions

October 21 2020

Urchin-like particles directed by a magnetic field. Credit: Dmitry Lisovsky

Research from ITMO suggests using urchin-like particles controlled by a magnetic field to accelerate chemical reactions in cells. This new technology will allow them to increase cell membrane permeability and

at the same time preserve the cell's initial structure. This can simplify substance delivery and increase the rate of biocatalysis. The research was published in the *Journal of Physical Chemistry Letters*.

To turn one substance into another, it is necessary to infiltrate a biological system, like a cell, with a substrate—a chemical substance that can launch a series of reactions. As a result of these reactions, a product is created that can be used in subsequent chemical transformations both inside the cells themselves and in manufacturing medical treatments or food products. The main difficulty with controlling cell biocatalytic processes is the fact that cell membranes limit the rate of diffusion—or the substrate's penetration of cells.

"We can increase cell membrane permeability to overcome this barrier. Often, various chemical substances are used for this purpose. However, those can be rather toxic and are hard to control, while other methods can cause permanent damage to the cell's structure," explains Daniil Kladko, a Master's student at SCAMT and one of the authors of the paper.

ITMO researchers used the biochemical reaction of ethanol fermentation to demonstrate that membrane permeability can be increased—and thus, biocatalysis can be controlled—by using special urchin-like particles directed by a magnetic field. These particles got their name for the sharp spikes on their surface that make them look like sea urchins. Baker's yeast was chosen as a model organism for the experiment.

To turn the substrate (glucose) into alcohol using yeast, the researchers first added the urchin-like particles to the mixture, then incubated it, and placed it into a magnetic set-up that can subject it to an alternating magnetic field of a specified frequency, intensity, and direction. The researchers were able to permeate the membrane and deliver the substrate inside the cell without disturbing its structure or vital

capacities. Moreover, it turned out that the process can be controlled by turning the magnetic field on and off.

"A rotating magnetic field makes the yeast and the urchin-like particles rotate around its axis, which results in the 'urchin' interacting with the membrane: It transforms the energy of the magnetic field into mechanical stress on the membrane. Thus, when it's on the membrane, it creates a moment of force, allowing the membrane to open. The time and frequency play an important role in this experiment. We need the field to work and 'tug' on the membrane for some time, because it is still a considerably dense structure despite its seeming fragility," says Daniil Kladko.

The resulting technology can be applied in various fields: For instance, food manufacturing, pharmaceutical industry, and biotechnology. For instance, when working with yeast, accelerating biocatalysis with a magnetic field would make it possible to cut down on the prices of yeast production and thus increase the number of yeast-based products on the market. The same goes for drugs based on biosynthesis, as the new method will increase their production volumes and lower their market price.

More information: Daniil V. Kladko et al. Magnetic Field-Mediated Control of Whole-Cell Biocatalysis, *The Journal of Physical Chemistry Letters* (2020). DOI: 10.1021/acs.jpclett.0c02564

Provided by ITMO University