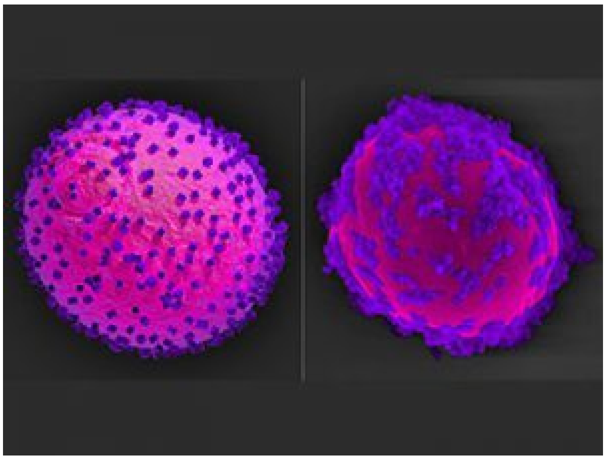
Nano “Solar Panels” Turn Yeast Cells into Biofactories

By decorating the outside of baker’s yeast cells with light-harvesting semiconductor nanoparticles, a research team from Harvard University and the University of Pennsylvania, USA, has turned the cells into tiny factories to churn out substances relevant to pharmaceutical and fine-chemical manufacture. The semiconductor fragments act as tiny “solar panels” that shunt photogenerated electrons into the yeast cell and thereby throw a natural process of biosynthesis into high gear. Beyond yeast, the research team believes that its technique enables a “mix and match approach” that could be extended to a range of cellular systems for chemical processing.



The need for speed

Chemical industries already use bacteria and fungi to provide a range of drugs and fine chemicals at scale. Baker’s yeast (*Saccharomyces cerevisiae*) is one such platform. In addition to puffing up loaves of bread, the organism’s complex metabolism allows it to produce commercially useful substances including shikimic acid, a precursor of the antiviral drug Tamiflu and a number of other medicines and fine chemicals. But there’s a catch—the shikimic acid reaction also depletes the cell of another important molecule, NADPH, involved in a redox reaction that's key to providing the energy to drive production in the first place. That makes the whole process self-limiting; the faster the cell produces shikimic acid, the faster it "runs out of gas" to do so. Indeed, the researchers note that regeneration of NADPH is "a common bottleneck in the production of metabolites through microbial cell factories," not just in yeast.

InP nanoparticles build a better biofactory

To get past that bottleneck, the research team hit on the idea of providing the cells with an external electron source to help them rebuild NADPH. Light-harvesting semiconductors seemed a natural choice. The team settled on indium-phosphide (InP) nanoparticles, which have a direct band gap that enables them to harvest energy from a broad swath of the solar spectrum. In principle, the InP particles, when attached to yeast cells and exposed to light, could serve as a source of photogenerated electrons that could boost NADPH levels in the cells, providing renewed energy to keep their production of shikimic acid going. The team then took those nanoparticles and assembled them in suspension onto *S. cerevisiae* cells, keeping the suspension well mixed to maximize the potential for collisions between the nanoparticles and the yeast. Finally, they tested the ability of the now-souped-up baker's yeast cells to pump out shikimic acid under a variety of light and dark conditions.

An eleven-fold production increase

The researchers found that, when exposed to light, their hybrid yeast-InP system was able to churn out 11 times more shikimic acid than the hybrid cells without illumination. That showed, according to team leader Joshi, that "the energy transfer from light into the cell works very efficiently.” While the researchers worked specifically on yeast and shikimic acid, the team stresses that its system is “a modular bioinorganic hybrid platform,” and that the polyphenol-functionalized InP nanoparticles could be used with other microorganisms to boost production of other chemicals. The paper suggests that the technique should be “compatible with existing workhorse cellular chassis and a wide range of particle-cell combinations.” Indeed, lead author Guo, in a press release, argued that the approach “creates an entirely new design space for future biohybrid technologies.”

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