Magnetic field points the way for metallic nanorods with hydrogen peroxide propulsion

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Remote Control Nanomotor

Like their normally sized analogues, nanoscale machines and robots need motors to function. Some time ago, a team at Pennsylvania State University developed a clever engine to "drive" nanoscopic metal rods; however, until now, these tiny "submarines" roamed at random through the solution. Now the research team headed by Ayusman Sen has made more progress: their "sequel" can be steered by remote control.

How do these steerable nanoscopic submarines work? First, it is important that the nanorods be made of "stripes" of different metals: one end of gold, followed by a very narrow band of nickel, a band of gold, another very narrow band of nickel, and the other end of platinum. The platinum end is responsible for the propulsion because it is here that the "fuel" is converted. The fuel in question is hydrogen peroxide that is present in the solution. It is catalytically converted by the platinum, producing oxygen, which also dissolves in the solution.

Having a high oxygen concentration, the solution surrounding the platinum end is less polar than the solution surrounding the other end of the nanorod. The surface tension between the solution and the metal surface is thus no longer equal at both ends of the rods and the rod is pulled inescapably in the direction of the oxygen-containing region of the solution. Because oxygen is constantly being formed, the gradient is maintained and the rod moves through the solution with its platinum end in front. The orientation of the nanorods in the solution is random; the overall motion is thus undirected.

This is where the "remote control"-an external magnetic field-comes in. The "receiving antennas" are the previously magnetized nickel bands in the nanorods. The crucial trick here is that the width of the bands must be smaller than their diameter, so that the nanorods can be magnetized crosswise, rather than along their long axis. When the magnetic field is switched on, the nanorods line up at right angles to its field lines and maintain this orientation as they zip around under hydrogen peroxide power. By changing the direction of the magnetic field, the researchers can vary the orientation of the nanorods-and thus the direction of their movement-at will. The nanorods are steerable.

"In principle, we should also be able to couple our nanorod motors to other nano-objects in order to drive them," says Sen. "This opens up new possibilities for a whole new class of micro- and nanomachines." The dimensions and magnetic properties of the nanorods are comparable to magnetotactic bacteria, which are oriented and steered by the magnetic field of the earth. Sen: "Thus, our nanorods are functional models for such organisms."

Source: Pennsylvania State University

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