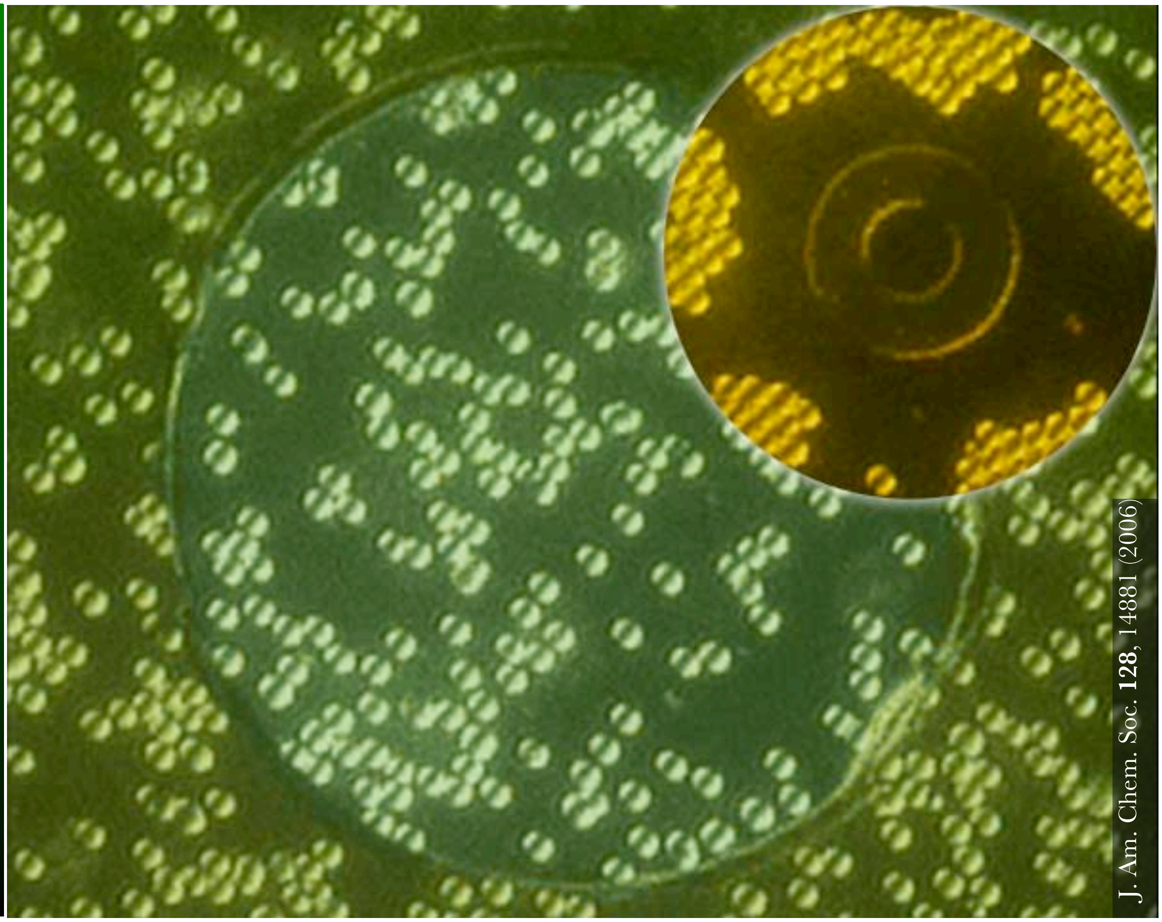
CATALYTIC PUMPING

Penn State MRSEC



Silica microsphere tracer particles are pushed away from a silver ring on a gold surface, but when an insulating layer is introduced under the silver to cut the electrical connection, the tracers spread freely.

Electrokinesis arrested
no current, no flow

IRG2

In 2004, a Penn State MRSEC team showed that bimetallic platinum/gold nanorods could swim at speeds up to 20 microns per second by catalyzing the decomposition of hydrogen peroxide. Nickel stripes added to the motors allowed them to be steered using weak magnetic fields as a "remote control". Microgears formed from platinum and gold rotated in hydrogen peroxide solutions.

In 2005, MRSEC researchers† have inverted the system: instead of moving catalytic structures through a static solution, a static silver/gold catalytic structure pumps the solution past it. The action of these micropumps is revealed by tracer particles in solution. These particles not only respond to the drag forces from the convecting fluid, but also respond electrophoretically to the electric fields created by the catalytic electrochemical cell: particles with different surface charges follow different paths in the fluid. If an insulating barrier is interposed between the silver disk and the gold substrate, then the fluid motion stops, thus providing definitive proof of an electrochemical mechanism. Current work on catalytic pumps and motors is expanding the capabilities of these autonomous microscale and nanoscale machines with light-induced catalytic motion and new fuels such as hydrazine, a high energy density molecule used in rocket propulsion.

†This research team includes Walter Paxton, Tim Kline, Paul Lammert, Ayusman Sen, Tom Mallouk, Jeff Catchmark and Vincent Crespi.