MOBILIZING MICROGEARS

We can make gears thinner than a hair. The hard part is getting them to move.

Alex Cannella, News Editor

We've been in the business of making things small and portable for a long time. But when it comes to shrinking things down, a team of scientists from Germany, Italy and Spain led by Roberto Di Leonardo decided to go big. They're working with microgears, gears the size of a red blood cell. Specifically, they're looking at ways to make fully functioning, autonomous micromachines, but before they can get there, they need to develop the parts that will compose the whole.

While microscopic gears are a mind-bogglingly cool and useful idea, the gears themselves aren't that revolutionary. Microgears have been manufactured before, but there's one problem that keeps them from being commercially viable: we still need to figure out a reliable way to keep them turning.

"In our group we study efficient strategies to build fully autonomous micromachines," Claudio Maggi, one of the team members at the University of Rome Sapienza, said. "In this context we have demonstrated that fully autonomous self-assembly and propulsion of the gears can be achieved by using Janus particles."

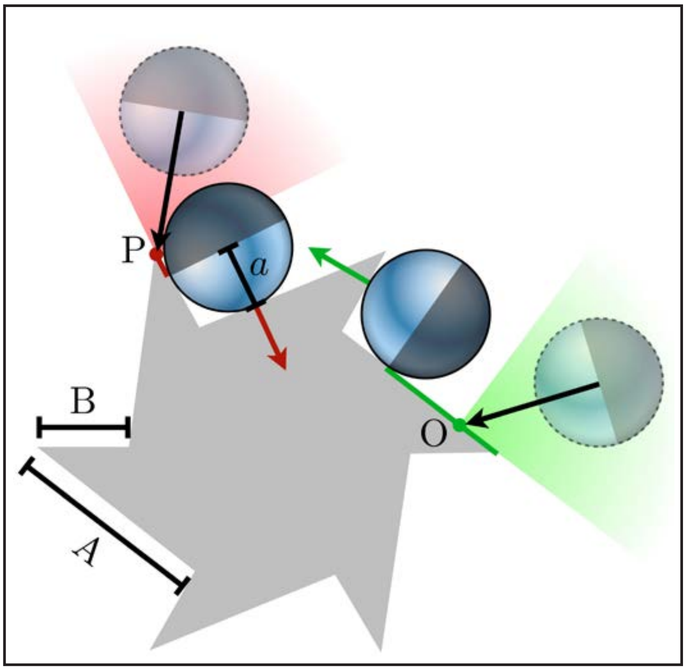
The generally established way to power a microgear is with an electrical or magnetic field, but that requires large, expensive equipment, which limits the number of applications you can use them for. In a static setting such as research laboratories, portability and cost aren't as much of a concern but it's hard to justify using microgears in many applications when you're still going to need a big, expensive machine to make them work. Microgears need an equally diminutive source of energy if they're to see more widespread use.

"What we wanted to demonstrate is that these particles do not only self-propel but can also self-assemble to autonomously rotate a microgear," Maggi said. "Which makes it quite a 'smart material.'"

The idea the team has hit on is to use Janus particles. Named after the two-faced Roman god, Janus particles similarly feature two halves composed of different materials. In the microgears' case, the particles are made of silica, but one half is thinly plated in platinum. The gears are placed in a solution of Janus particles and hydrogen peroxide (H_2O_2).

Now we start getting into some chemistry. Platinum is a catalyst that causes hydrogen peroxide to deteriorate into water and oxygen. But because a Janus particle is only half coated in platinum, this means that the hydrogen peroxide around the other half isn't deteriorating. So for a brief moment the particle is suspended in between two different solutions, one of hydrogen peroxide, and the other of water and oxygen.

While obviously this state doesn't last very long, it still puts two different levels of pressure on the Janus particle, which propels it forward — into more hydrogen peroxide, where the process repeats. Technically, the Janus particles are freely floating in the solution, meaning they aren't sitting between a gear's teeth just waiting to turn it, but the team has found they can still get the particles to make contact and rotate the gear.



That said, the science behind this particular application of Janus particles is still coming together. Though scientists generally agree on how the process works, there's less of a consensus as to why, and more study needs to be done, both by this team and by other researchers, before we start seeing Janus particle-driven microgears on the market.

"I would say we are still quite far [from commercial use]!" Maggi said. "However many potential applications for these self-propelled particles have been already envisioned (such as micro-cargo transport and drug delivery)."

While their current studies show promise, the research team hasn't ruled out other possibilities, including Janus particles with different compositions. According to Maggi, Janus particles that start catalyzing when illuminated are also promising. They're also investigating microfluidic systems to cycle the hydrogen peroxide, as the Janus particles eventually run out of solution to break down.

Maggi's team has published their findings in the January 2016 volume of Small, a scientific journal focused on all things micro- and nanoscale. If you're interested in the full nitty gritty report, you can purchase it at *onlinelibrary.wiley.com/wol1/doi/10.1002/smll.201502391/full*. The research was funded by two ERC Grants and combines recent advances in catalytic propulsion (Grant n. 311529) and statistical mechanics of active matter (Grant n. 307940).

For more information:
Roberto Di Leonardo
glass.phys.uniroma1.it/dileonardo