Better wastewater treatment? It's a wrap

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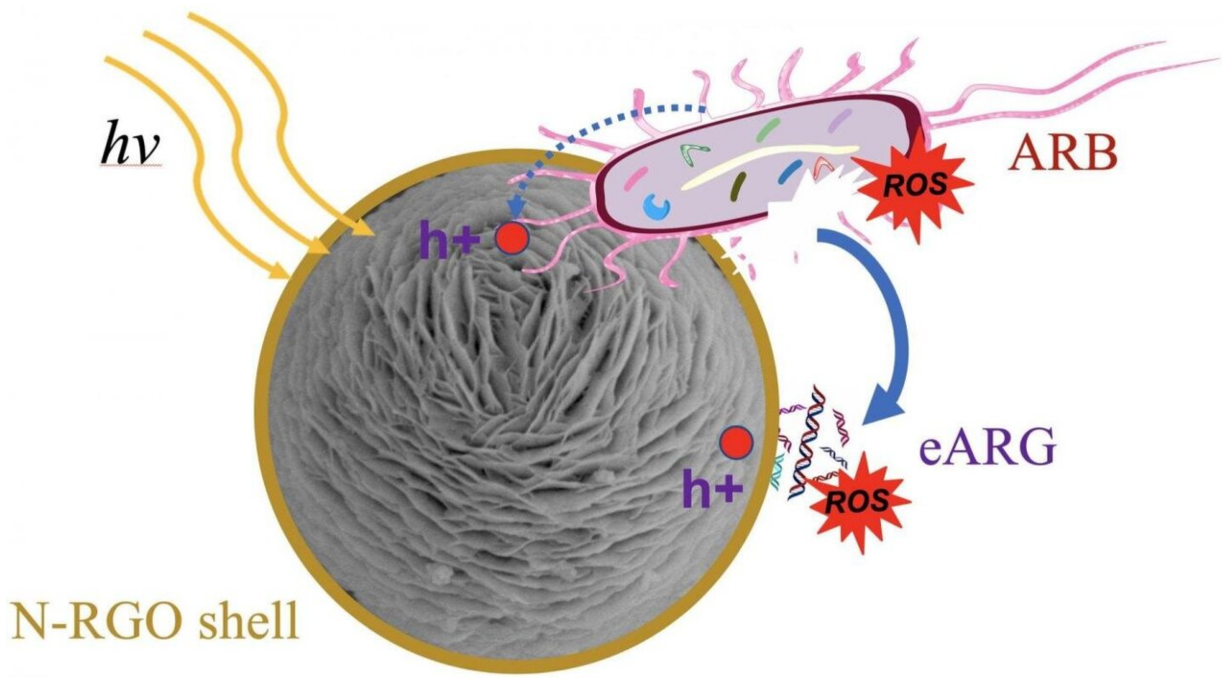


Improved bacterial affinity and reactive oxygen species generation enhances antibacterial inactivation in wastewater by graphene oxide-wrapped nanospheres developed by scientists at Rice University and Tongji University, Shanghai. Antibiotic resistance genes (eARG) released by inactivated antibiotic resistant bacteria (ARB) in the vicinity of photocatalytic sites on the spheres facilitates their degradation. Credit: Alvarez Research Group/Rice University

A shield of graphene helps particles destroy antibiotic-resistant bacteria and free-floating antibiotic resistance genes in wastewater treatment plants.

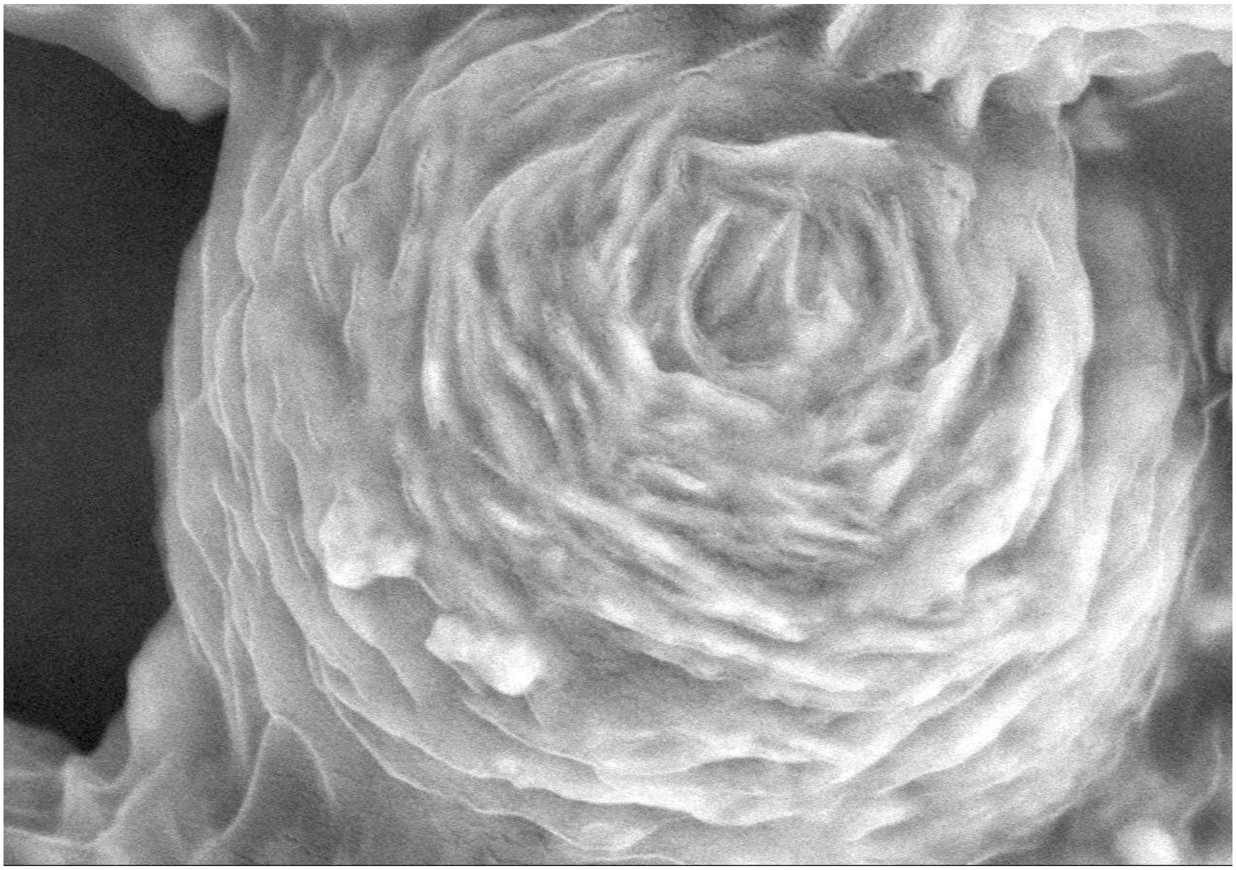
Think of the new strategy developed at Rice University as "wrap, trap and zap."

The labs of Rice environmental scientist Pedro Alvarez and Yalei Zhang, a professor of environmental engineering at Tongji University, Shanghai, introduced microspheres wrapped in graphene oxide in the Elsevier journal *Water Research*.

Alvarez and his partners in the Rice-based Nanosystems Engineering Research Center for Nanotechnology-Enabled Water Treatment (NEWT) have worked toward quenching antibiotic-resistant "superbugs" since first finding them in wastewater treatment plants in 2013.

"Superbugs are known to breed in wastewater treatment plants and release extracellular antibiotic resistance genes (ARGs) when they are killed as the effluent is disinfected," Alvarez said. "These ARGs are then discharged and may transform indigenous bacteria in the receiving environment, which become resistome reservoirs.

"Our innovation would minimize the discharge of extracellular ARGs, and thus mitigate dissemination of antibiotic resistance from wastewater treatment plants," he said.



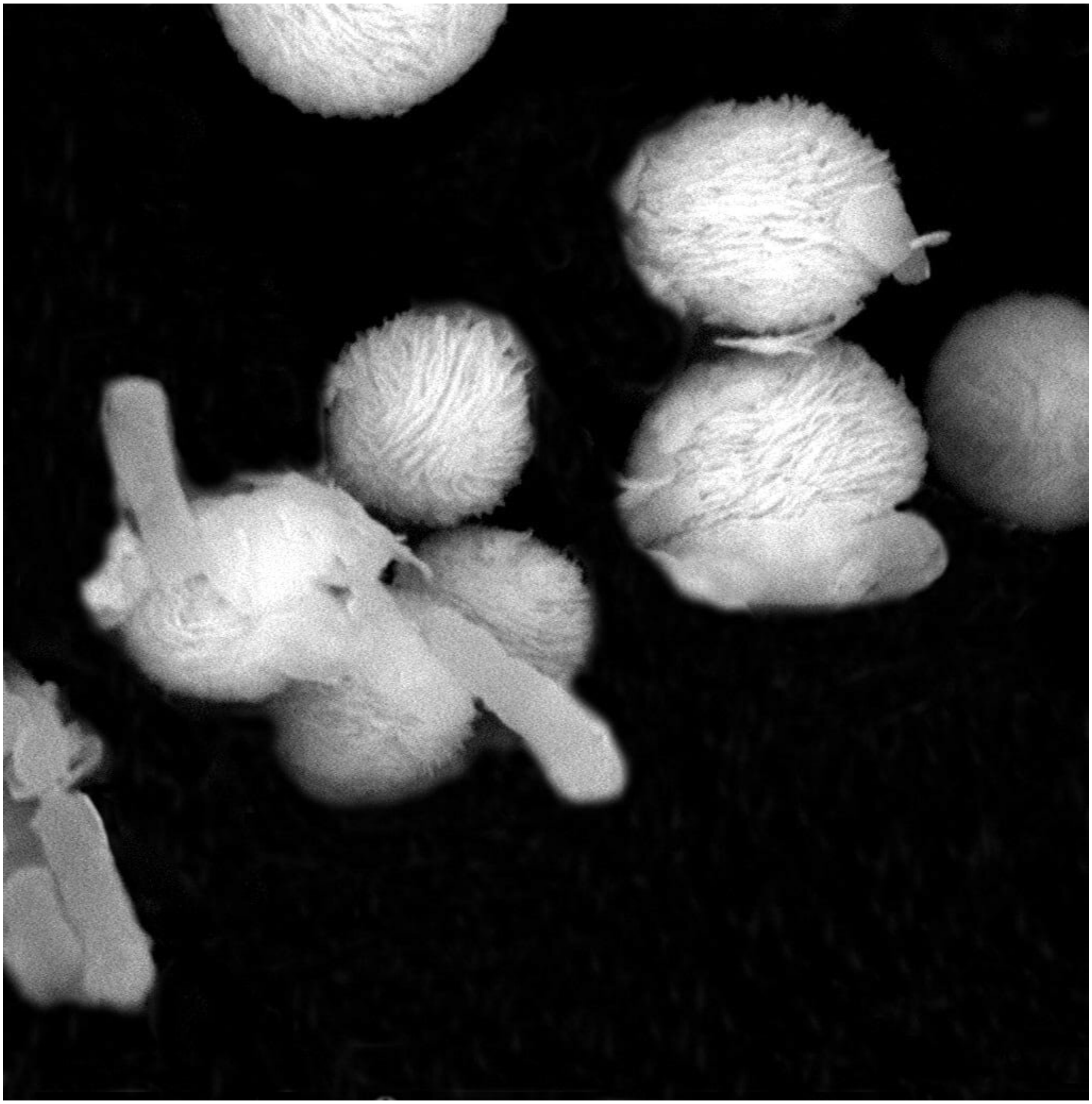
A scanning electron microscope image shows a graphene oxide shell around the layered nanoplates that make up the core of a particle that traps and zaps antibiotic-resistant bacteria and the resistance genes they release. The wrapped spheres developed at Rice and Tongji universities proved three times better able to disinfect secondary effluent from wastewater plants than the spheres without the nitrogen-doped graphene oxide. Credit: Deyi Li/Tongji University

The Rice lab showed its spheres—cores of bismuth, oxygen and carbon wrapped with nitrogen-doped graphene oxide—inactivated multidrug-resistant Escherichia coli bacteria and degraded plasmid-encoded antibiotic-resistant genes in secondary wastewater effluent.

The graphene-wrapped spheres kill nasties in effluent by producing three times the amount of reactive oxygen species (ROS) as compared to the spheres alone.

The spheres themselves are photocatalysts that produce ROS when exposed to light. Lab tests showed that wrapping the spheres minimized the ability of ROS scavengers to curtail their ability to disinfect the solution.

The researchers said nitrogen-doping the shells increases their ability to capture bacteria, giving the catalytic spheres more time to kill them. The enhanced particles then immediately capture and degrade the resistant genes released by the dead bacteria before they contaminate the effluent.



An electron microscope image shows E. coli bacteria trapped by wrapped microspheres developed at Rice and Tongji universities. The spheres were created to disinfect secondary effluent from wastewater treatment plants, a breeding ground for antibiotic resistant bacteria and antibiotic resistance genes. Credit: Deyi Li/Tongji University

"Wrapping improved bacterial affinity for the microspheres through enhanced hydrophobic interaction between the bacterial surface and the shell," said co-lead author Pingfeng Yu, a postdoctoral research associate at Rice's Brown School of Engineering. "This mitigated ROS dilution and scavenging by background constituents and facilitated immediate capture and degradation of the released ARGs."

Because the wrapped spheres are large enough to be filtered out of the disinfected effluent, they can be reused, Yu said. Tests showed the photocatalytic activity of the spheres was relatively stable, with no significant decrease in activity after 10 cycles. That was significantly better than the cycle lifetime of the same spheres minus the wrap.

More information: Deyi Li et al, Hierarchical Bi2O2CO3 wrapped with modified graphene oxide for adsorption-enhanced photocatalytic inactivation of antibiotic resistant bacteria and resistance genes, *Water Research* (2020). DOI: 10.1016/j.watres.2020.116157

Provided by Rice University