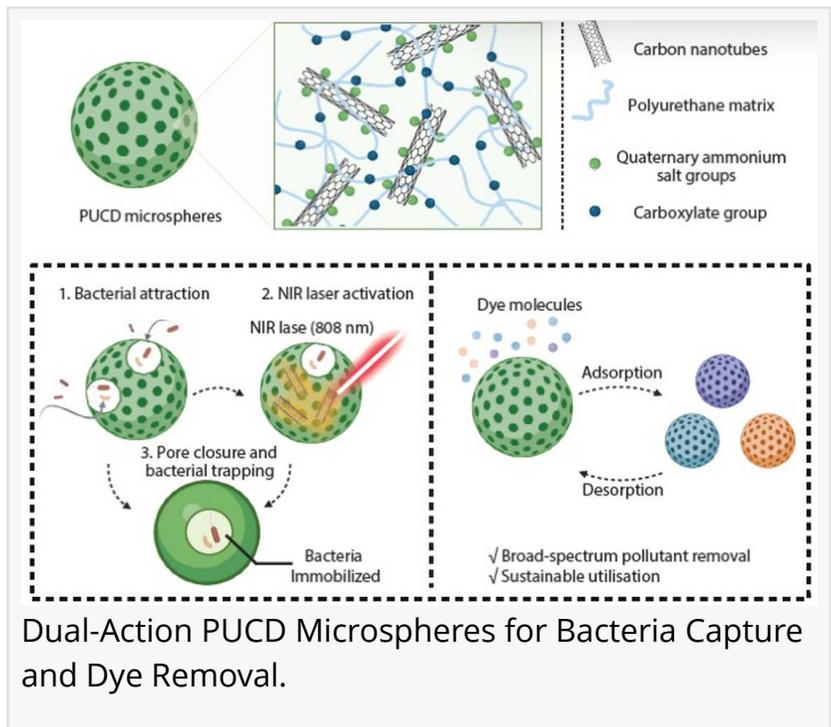


Smart microspheres clean hospital wastewater on two fronts

GA, UNITED STATES, March 18, 2026 /EINPresswire.com/ -- Hospital wastewater is difficult to clean because it often carries two very different threats at once: [chemical](#) dye residues and harmful bacteria. Researchers have now developed a polyurethane microsphere that can tackle both in a single step. The material combines positively and negatively charged adsorption sites with a near-infrared-responsive structure that changes under light. This allows it to remove dye molecules efficiently while also capturing bacteria and locking them in place. The result is a multifunctional adsorbent designed not only to improve purification efficiency, but also to reduce the risk of bacterial re-release and toxin leakage during treatment.



Treating hospital wastewater remains a major environmental and public-health challenge. Conventional methods such as membrane separation, oxidation, biological treatment, and chemical disinfection each solve part of the problem, but rarely all of it. Some are energy-intensive or costly, while others fail to remove dyes effectively. Disinfection can also rupture bacterial cells, releasing toxins and potentially spreading antibiotic resistance genes into the environment. Traditional adsorbents face another limitation: many rely on only one type of surface charge, making them poorly suited for the mixed pollutants found in real hospital effluents. Based on these challenges, there is a need for deeper research into integrated materials that can remove multiple contaminants safely and efficiently.

A team from Sichuan University, the Sichuan Institute of Atomic Energy, and the Med-X Center for Materials reported (DOI: [10.1007/s10118-025-3536-y](https://doi.org/10.1007/s10118-025-3536-y)) this advance in the Chinese Journal of Polymer Science. Published online on January 22, 2026, the study describes PUCD microspheres, a light-responsive polyurethane system doped with modified carbon nanotubes. The researchers

designed the material to combine broad-spectrum dye adsorption with in situ bacterial capture, aiming to create a safer and more practical platform for hospital wastewater purification.

The microspheres were engineered with a clever division of labor. Carboxyl groups in the polyurethane backbone provided negative charges, while cationic polymer-grafted carbon nanotubes supplied positive charges, giving the material “bipolar” adsorption sites. The team also created micrometer-scale pores sized to interact with bacterial cells. Under near-infrared light, the carbon nanotubes generated heat, triggering a phase transition in the polyurethane and shrinking the pores into what the researchers describe as a polymer trap. In tests, the system removed up to 98.3% of dyes, maintained strong performance across a broad pH range, and retained 83.3% efficiency for rhodamine B after five reuse cycles. For both *Staphylococcus aureus* and *Escherichia coli*, bacterial capture exceeded 99%. Unlike conventional bactericidal approaches that destroy cells and release harmful components, this system largely immobilized live bacteria intact, sharply reducing desorption and lowering toxin release compared with common disinfectants. It also performed well under continuous-flow conditions and in mixed dye solutions, suggesting promise beyond idealized lab tests.

According to the researchers, the most important advance is not simply stronger pollutant removal, but safer removal. Their results suggest that PUCD shifts wastewater treatment away from a kill-and-release model toward one based on capture, confinement, and controlled separation. In that sense, the material functions as both a chemical adsorbent and a physical pathogen trap. The team argues that this dual mechanism could reduce secondary risks in treated water while simplifying treatment design into a more compact, single-stage process.

The implications extend beyond one polymer system. Hospital effluents are increasingly complex, and future treatment technologies will need to handle mixed contamination without creating new hazards. A material that can remove dyes, sequester pathogens, operate across variable pH, and remain reusable offers a practical blueprint for next-generation wastewater treatment. With further scaling and validation in real effluents, such responsive adsorbents could help hospitals, laboratories, and other medical facilities reduce ecological pollution and improve downstream water safety.

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