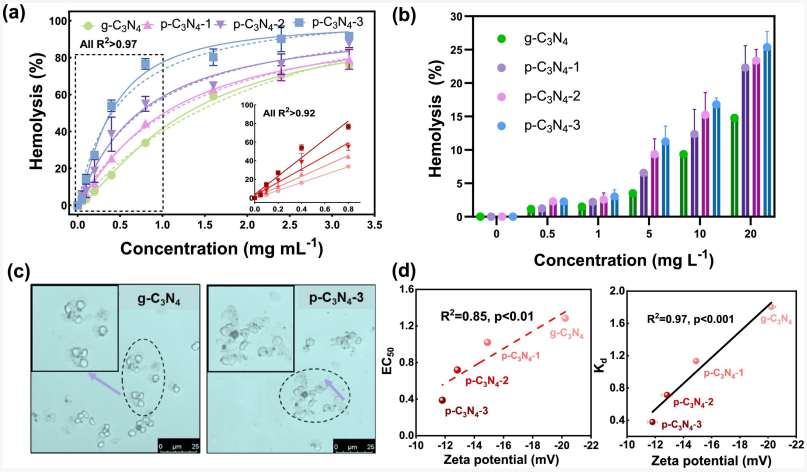
Surface protonation amplifies carbon nitride nanosheet-induced phospholipid extraction

GA, UNITED STATES, July 18, 2025 /EINPresswire.com/ -- This study systematically investigates the cytotoxicity evolution of protonated carbon nitride toward red blood cells and elucidates its underlying mechanisms, revealing that surface protonation amplifies carbon nitride nanosheet-induced phospholipid extraction and enhances cytotoxicity.



Hemolysis toxicity of g-C3N4 and p-C3N4.

Graphitic carbon nitride (g-C3N4), an engineered carbon nanomaterial with tunable electronic structure, chemical stability, and biocompatibility, has promising applications in photocatalytic therapy, targeted drug delivery, and pollutant degradation. However, its transformations in biological and environmental systems (e.g., chemical protonation) can alter surface chemistry, charge distribution, and nanoscale topology, thereby affecting its biological interactions and toxicity.

In a study published in the KeAi journal Environmental Chemistry and Ecotoxicology, a group of researchers from the Guangdong University of Technology, China, investigated the cytotoxicity evolution of protonated carbon nitride (p-C3N4) toward red blood cells and elucidated its underlying mechanisms.

“Hemolysis assays showed that p-C3N4 exhibits enhanced phospholipid membrane-rupturing capabilities compared to pristine g-C3N4, with no significant lipid peroxidation detected,” shares lead and co-corresponding author Yiping Feng. “Surface characterization revealed that protonation reduces the net negative charge of carbon nitride, increasing its affinity with phospholipid membranes.”

Through molecular docking simulations, the researchers observed that interactions between p-C3N4 and phospholipid molecules were governed by electrostatic and hydrophobic forces, as well as hydrogen bonding with oxygen-containing functional groups.

“Molecular dynamics simulations further revealed that larger oxygen-bearing macropores on p-C3N4 allow for tight and specific binding with phospholipid headgroups, facilitating efficient lipid extraction and intensifying membrane disruption,” adds Feng.

The team’s findings provide critical insights into the cytotoxic changes that carbon nitride materials may undergo during transformations. They also highlight opportunities to mitigate associated risks or use surface protonation for enhanced functionality in carbon nitride-based technologies.

References
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