Architecting neonicotinoid-scavenging nanocomposite hydrogels for environmental remediation

ABSTRACT

The ubiquitous presence of neonicotinoid insecticides in the environment poses potential health concerns across all biomes, aquatic systems, and food chains. This global environmental challenge requires robust, advanced materials to efficiently scavenge and remove these harmful neonicotinoids. In this work, we engineered nanocomposite hydrogels based on sustainable cellulose acetate for water treatment. The nanocomposite hydrogels were incorporated with small quantities of polymers of intrinsic microporosity (PIM-1) and graphene oxide (GO). We prepared the hydrogels using green solvents such as Cyrene and MeTHF via simple dropwise phase inversion. High adsorption capacity and fast kinetic behavior toward acetamiprid, clothianidin, dinotefuran, imidacloprid, and thiamethoxam were observed. We also developed a rapid and sustainable ultrasound-assisted regeneration method for the hydrogels. Molecular dynamics of the complex quaternary system revealed the synergistic effects of the components, and the presence of PIM-1 was found to increase the GO surface area available for neonicotinoid scavenging. We demonstrated the robustness and practicality of the nanocomposites in continuous environmental remediation by using the hydrogels to treat contaminated groundwater from the Adyar river in India. The presented methodology is adaptable to other contaminants in both aqueous environments and organic media.

Keyword: Neonicotinoids; Water purification; Green solvents; Polymers of intrinsic microporosity; Graphene