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Recent advancements in smart materials for the removal of organic, inorganic and microbial pollutants in water treatment: A review

Abstract

As the expeditious urban and industrial expansion, a substantial portion of wastewater is produced annually, posing a significant threat to environmental contamination and dwindling the availability of clean water resources. Water contaminants are generally categorized into organic, inorganic, and microbial pollutants. This escalating water pollution crisis has initiated the research community to innovate novel, effective and economical cost methods for water treatment applications. Among the approaches, adsorption has been marked by its importance in water treatment. Recent advancements in the field have focused on developing smart adsorbent materials capable of modifying their physicochemical properties in response to various external stimuli (light and magnetic field) and internal stimuli (thermal and pH fluctuation). The exploration of smart materials has captivated the interest of researchers worldwide and opened up exciting avenue for more efficient water treatment outcomes towards removing different types of pollutants. Notably, these smart materials demonstrate high pollutant uptake and release efficacy when responding to specific stimuli changes, ensuring efficient removal of contaminants and exerting self-cleaning properties. Such materials offer an environmentally benign advantage by eliminating the need for toxic organic solvents during regeneration. The review compiles and highlights the characteristics and performance of several stimuli-responsive smart materials, including thermal, light, magnetic and pH regarding organic, inorganic and microbial pollutants removal efficiencies. A particular focus is given to multi-stimuli responsive materials in environmental applications that represent the modern era and transformation of water treatment methodologies, followed by a discussion on the challenges and prospects of this particular research area.

Keywords

Multi-stimuli-responsive; Organic, inorganic, and microbial pollutants; Single-stimulus-responsive; Smart materials; Water treatment