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Functionalized silica nanoparticles as adsorbents for removal of pollutants

Functionalized silica nanoparticles are potential adsorbents for the removal of pollutants from wastewater. This review article from the UAB Department of Chemistry contains an overview of different types of silica nanoparticles, their properties, the synthetic approaches and the mention of potential applications, focusing mainly in recent advances in the adsorption of different target substances (metal ions, dyes and other organics).

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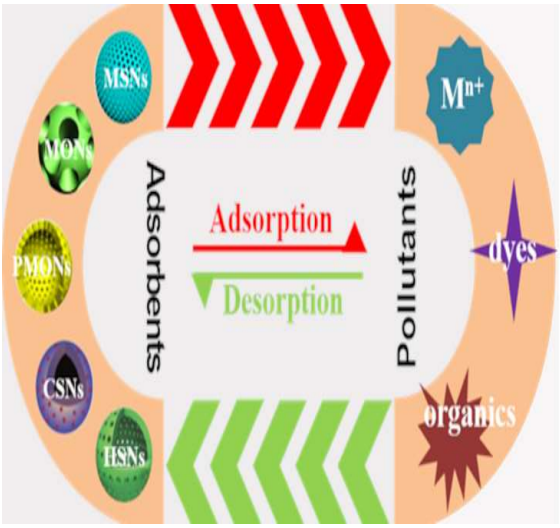
Adsorption is the process of transfer of the target substance (ions or molecules) from the liquid/gas phase of a system to the solid/liquid surface of the adsorbent. Adsorption is considered as an effective, economical, practical, selective, and environmentally friendly technology for water treatment. The most important factor in the adsorption process is the adsorption material, namely the adsorbent. A wide variety of classical adsorbents have been developed such as activated carbon, zeolites, activated alumina, lignite coke and bentonite. More recently, silica nanoparticles are considered very promising nanoadsorbents because of their unique characteristics such as low cost, simple synthesis, low environmental harm, a stable structure, a high specific surface area and porosity, adjustable pore size and volume. The adsorption mechanisms between silica nanoparticles and target molecules includes physical adsorption and chemisorption. The rich silanol group surface impart functionality to the silica nanoparticles, as hydroxyl groups can complex certain metal ions or compounds. Moreover, in order to enhance the adsorption capacity and selectivity, these silanol groups enable the decoration of silica nanoparticles with specific appropriate functional groups for a

selective chemical adsorption of target molecules based on chelation, electrostatic interaction or ion exchange.

This review article systematically introduces different types of silica nanoparticles, such as functionalized non-porous and mesoporous silica nanoparticles (MSNs), non-porous and mesoporous organosilica nanoparticles (MONs), periodic mesoporous organosilica nanoparticles (PMONs), core-shell silica nanoparticles (CSNs) and hollow silica nanoparticles (HSNs). It focuses on the preparation of the silica nanoparticles by sol-gel procedures, briefly describing the particularities of the synthesis of the different types of silica nanoparticles.

The article also mentions the potential applications in many fields, focusing mainly on the recent progress in the adsorption of metal ions, dyes and organics by the different types of functionalized silica nanoparticles. Despite the numerous interesting results presented, these nanoadsorbents are not yet applicable in real environments. Further investigation is needed to address some issues. The achievement of significant improvements in the physicochemical properties of organosilica nanoparticles remains a major challenge when complex organic moieties are present in the silylated monomers. Higher attention should be dedicated to their environmental risk assessment, and it is also important to develop a simple and low-cost synthesis process for large scale production.



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References

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