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Mesoporous silica modified for phosphate ion adsorption

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Eutrophication is a process that leads to the uncontrolled growth of algae and other aquatic plants, being one of the main environmental challenges faced in contaminated water bodies worldwide. This phenomenon is caused by the excessive accumulation of nutrients, including phosphate, in aquatic environments. Common sources of phosphate contamination include runoff from agricultural activities, industrial and domestic wastewater, as well as fertilizers and detergents.[1] An alternative to the eutrophication problem could be the development of porous materials capable of adsorbing phosphate ions from water. Mesoporous silicas can provide a large surface area for adsorption; however, their surface is relatively inert, lacking highly reactive or selective functional groups. Iron-impregnated silica can serve as an efficient adsorbent for the removal of inorganic and organic pollutants from wastewater and soils. The presence of iron in this material can enhance its adsorption capacity for a wide range of contaminants.[2] Thus, modifying the surface of porous silica with Fe(III) may increase the affinity of phosphate ions for the adsorbent. Surface modification with iron is a promising strategy for various applications, especially in catalysis and environmental remediation. Our research group has been working with mesoporous silicas modified with Fe(III) to adsorb phosphate ions from wastewater.

For this work, the impregnation method of Fe(III) ions into silica was chosen. The method involves suspending silica in a solution containing Fe(III) ions under agitation. The concentration of Fe(III) ions in the solution during the reaction was determined using a reagent, thiocyanate (SCN^-), which forms a blood-red complex $[Fe(SCN)6]^{3-}$, allowing the determination of iron concentration via UV-Vis spectrophotometry.

The modification of porous silica with Fe(III) ions is a process where these ions interact strongly with the active centers of silica, the silanol groups (Si-OH). After surface modification, the textural characterization of the material was performed by N^2 physisorption, confirming an increase in the surface area of the synthesized material. The initial mesoporous silica had a surface area of 726 m2/g, which increased to 785 m2/g after modification. According to the adsorption-desorption isotherms, both silicas are characterized as mesoporous with pore diameters around 5.8 nm.

The increase in surface area could be related to cluster formation. These clusters could action as new active centers, significantly increasing the density of available sites for phosphate ion adsorption. Consequently, modifying mesoporous silica with iron ions could result in superior efficiency in phosphate ion adsorption. Initial adsorption tests showed that the modified material is promising as an adsorbent for contaminant ions. In conclusion, the modified material exhibits important textural properties for use as an adsorbent. However, further characterization and additional adsorption tests are necessary to fully explore the adsorptive potential of the material.

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References

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