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Efficient co-adsorption of multiple types of coexisting pollutants from water using a chitosan-based magnetic composite adsorbent

Contaminants in real water are typically very complicated, and various types of contaminants usually coexist. For example, in the textile industries, the discharged dyeing effluents also contain numerous kinds of other pollutants besides residual dyes, such as scouring auxiliaries and fixing, leveling, and dispersing agents. The coexisting pollutants obviously cause further deterioration of water pollution and significantly increase the difficulty of treatment. Adsorption is one of the most commonly applied techniques in water treatment due to its high efficiency, versatility and reasonable cost. However, adsorption also faces several challenges in applications, such as efficient co-removal of multiple types of coexisting pollutants, rapid and efficient separation after saturated adsorption, selective recovery of valuable pollutants, and effective reuse.

Obviously, the development of high-performance absorbent materials is the key to solving the aforementioned problems. Natural polymers have been recently received much more attention due to their characteristics of environmental friendliness, low cost, and wide source. Among them, chitosan, poly-*β*-(1→4)-2-amino-2-deoxy-D-glucose, is one of the high-performance natural polymers, deacetylation of chitin (the second most abundant natural polymer). Besides excellent chelating effects, chitosan presents abundant free amino groups along the chain backbone that are cationically charged in a wide range of physiological pHs, and show prominent affinities to contaminants containing negative charges. Moreover, it is a significant strategy to give some chemical modifications like etherification, esterification, or grafting reactions for further enduing chitosan with superior adsorption properties on the basis of the characteristics of target pollutants and structure-activity relationship. Many extra functional groups could be introduced onto chitosan which greatly improve its adsorption performance.

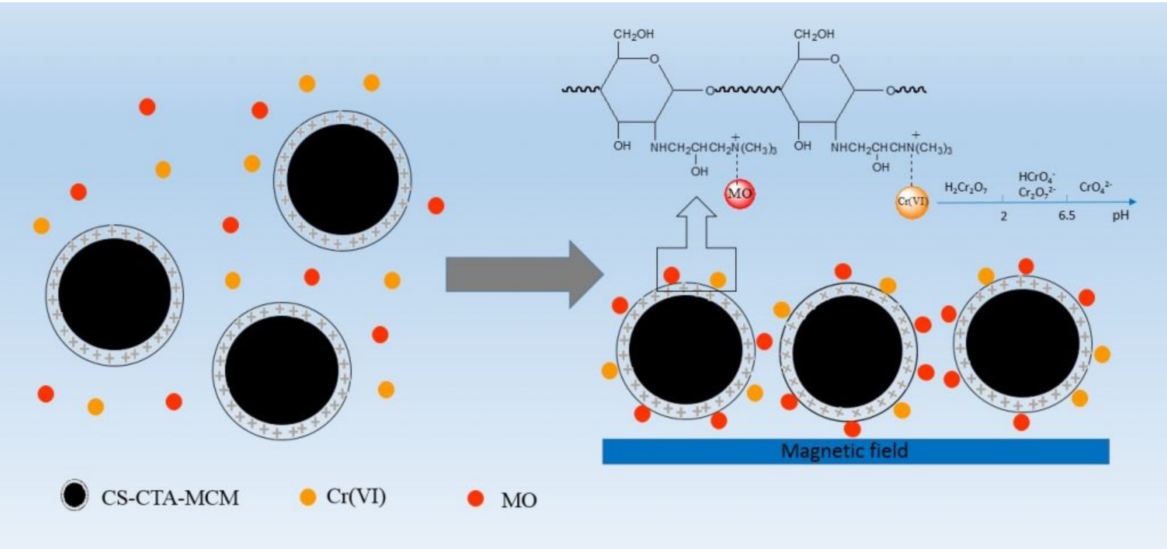

Fig. 1. Co-adsorption of Cr(VI) and methyl orange (MO) using a chitosan-based adsorbent.

However, efficient separation of the adsorbents from water, prior to the recycle of both the sorbates and adsorbents, is an indispensable step in water treatment. But it would be very difficult to separate if the adsorbent was made into a very small size for improvement of the adsorption efficiency by increase of the surface area. Rapid separability of the adsorbents having small size is very important. Recently, magnetic separation technologies is gaining growing attension. With the aid of magnetic force, magnetic matters can be separated from the water efficiently regardless of its size. As for many nonmagnetic adsorbents, magnetic nanoparticles could be embedded into adsorbent matrix to obtain the magnetic composites, having the so-called core-shell microsphere structure, magnetic matters, such as Fe and Fe_3O_4, as core and nonmagnetic materials as shell, to achieve the rapid separation.

Methyl orange (MO) is a normal anionic dye and Cr(VI) as a component of dyeing and finishing auxiliaries usually coexists in dyeing effluents. In this work, 3-chloro-2-hydroxypropyl trimethyl ammonium (CTA), a low toxic quaternary ammonium salt reagent with strong positive charges, was selected to modify chitosan for improvement of its adsorption affinity to aforementioned two anionic pollutants. Moreover, for fast separation from water after its saturated adsorption, magnetic Fe_3O_4 nanoparticles were embedded into chitosan. Thus a novel CTA modified chitosan magnetic composite adsorbent (CS-CTA-MCM) was obtained. Based on Figure 1, CS-CTA-MCM has preferential adsorption of MO over Cr(VI) in their aqueous mixtures at neutral and weak basic conditions, which is due to the fact that CS-CTA-MCM shows higher affinity to dye than to metal ions. Thus Cr(VI) and MO could be roughly separated and selectively adsorbed by this composite adsorbent at suitable pH conditions. While, the simultaneous removal of aforementioned two pollutants could be accomplished at weak acidic conditions ascribed to more efficient Cr(VI) forms for effective adsorption. Furthermore, this magnetic adsorbent after saturated adsorption could be rapidly separated from water under an external magnetic field and easily regenerated using dilute NaOH aqueous solutions then virtually reused with little adsorption capacity loss.

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Publication

Efficient adsorption of both methyl orange and chromium from their aqueous mixtures using a quaternary ammonium salt modified chitosan magnetic composite adsorbent.
Li K, Li P, Cai J, Xiao S, Yang H, Li A
Chemosphere. 2016 Jul