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Efficient removal of tetracycline by reusable magnetic microspheres with a high surface area

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HIGHLIGHTS

- ▶ A novel magnetic resin Q100 is prepared with a high surface area.
- ▶ Q100 exhibited quite fast kinetics because of its small particle size.
- ▶ Q100 has efficient adsorption of tetracycline for its pore distribution.
- ▶ The effects of pH are important for tetracycline adsorption and desorption on resins.
- ▶ Q100 is a reusable adsorbent with excellent regeneration behavior.

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ABSTRACT

A novel hypercrosslinked magnetic resin Q100 with a high surface area of 1153.8 m^2/g was prepared and characterized. Another magnetic resin (Q80) and two non-magnetic commercial resins (NDA150 and XAD-4) were selected as adsorbents for comparison to investigate the adsorption behavior and predominant factors controlling the adsorption of tetracycline (TC) onto the adsorbents. The adsorption kinetics of TC onto all resins followed a pseudo-second-order equation. Q100 exhibited much faster kinetics ($k_2 = 0.18$) than the commercial resins XAD-4 ($k_2 = 0.031$) and NDA150 ($k_2 = 0.021$) because of the much smaller particle size of Q100. Moreover, Q100 also had the largest adsorption of the four resins due to its high surface area and abundant mesopore structure. For all of the adsorbents used in the present work, pH 5–6 was suitable for TC adsorption, whereas pH > 12 could be used for regeneration. An increased ionic concentration could enhance the adsorption of TC on the four resins for the salting out effect. The recyclabilities of the four resins were also evaluated, and Q100 was found to be more reusable for TC removal than the other three resins.

1. Introduction

Antibiotics are widely used in human medicine and the livestock industry. However, they are inevitably discharged in their original or metabolized forms into aquatic environments by domestic wastewater and pharmaceutical effluents [1]. Expelled antibiotics could accumulate in living beings along with food chain, causing drug-resistant gene spreading, biological poisoning and ecological imbalances [2]. Thus, it is very important to develop efficient treatment technologies for antibiotic removal.

Due to their large surface area and abundant pore structure, adsorbents such as carbon nanotubes, activated carbons, and porous resins have shown great potential in removing undesirable organic contaminants from aqueous solutions [3–6]. Among these sorbents, synthetic resins have drawn attention because of their much better regeneration performance than engineered carbons [7]. However, the resin-based adsorption technologies have not been widely used so far in full-scale applications for water treatment. The typically used fixed bed process of resin adsorption greatly limits the flux and increases the costs [8]. Recently, magnetic resins have been developed and are considered to be a promising sorbent for water treatment [8–10]. Owing to their convenient separation characteristics, magnetic resins have been used in a completely mixed contactor processes for wastewater treatment [9]. This process could significantly increase the amount of water treatment and decrease the costs compared to that of fixed beds, thus extending the application of resins for micropolluted water purification.

Studies addressing antibiotic adsorption by magnetic resins are still scarce. The most commonly used anion exchange magnetic resin, MIEX®, was found to be effective for removal of antibiotics with strong electronegativity. However, the removal performance of such antibiotics would greatly deteriorate due to competition

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