Tetracycline adsorption onto ferric activated sludge-based adsorbent derived from biological sludge

Xin Yang*, Jiadong Zhang*, Guoren Xu*

* State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology, Harbin, China (E-mail: *xgr@hit.edu.cn)*

Abstract
Ferric activation was novelly used to produce sludge-based adsorbent (SBA) from biological sludge through pyrolysis, and the adsorbents were applied to remove tetracycline from aqueous solution. The adsorption kinetics and isotherms and influences of solution pH on the tetracycline adsorption were conducted in batch experiments. It was found that ferric activation could promote the porous structure development of adsorbents. The adsorption was pH-dependent, and the maximum adsorption capacity was achieved at pH 4.0-8.0. The Freundlich isotherm model best described the adsorption process, and the adsorption kinetics fitted the Pseudo-second-order model well. Ferric-activated SBA had higher adsorption capacity for tetracycline than non-activated SBA, which was due to that the enhanced mesoporous structure favored the diffusion of tetracycline into the pores. The results indicated that ferric activation could be an effective approach for preparing adsorbents from biological sludge to remove tetracycline, providing a potential option for waste resource recovery.

Keywords
Biological sludge; ferric activation; sludge-based adsorbent; adsorption; tetracycline antibiotics

INTRODUCTION

Tetracycline (TC, $C_{22}H_{24}N_2O_8$) is an important antibiotic, but its presence in aquatic environments increases the potential for antibiotic resistance among microorganisms (Liu et al., 2013). Sludge-based adsorbent (SBA), a charcoal derived from sludge thermal pyrolysis, can be used to remove organic contaminants. Chemical activation treatment is able to enhance the adsorption capability of the adsorbents (Smith et al., 2009).

MATERIAL AND METHODS

The sludge was collected from an urban treatment plant in Beijing, China. Raw sludge with mass ratio (activator/dried sludge) of 0.5 were heated at 750 °C in a tubular furnace under an oxygen-deficient atmosphere for 2 h. The adsorbents prepared with and without activator were referred to as ferric-activated SBA and non-activated SBA. The tetracycline concentration was determined by an ultraviolet-visible spectrometer at 356 nm.

RESULTS AND DISCUSSION

Table 1 shows the textural properties of raw sludge and adsorbents. It was evident that the ferric-activated SBA had a large BET surface area and high pore volume relative to the starting material. The ferric activation of sludge caused near fiftyfold and tenfold increases in the BET surface area and mesopore volume, respectively.

As shown in Figure 1, the adsorption of tetracycline onto ferric-activated SBA was strongly dependent on pH values and tetracycline could be effectively removed in a wide range of pH 4.0-8.0. The Freundlich isotherm model best described the adsorption process (Figure 2). Ferric activation treatment could promote tetracycline adsorption, and adsorption mechanism was probably pore-filling effect and hydrogen bonding effect.

CONCLUSIONS

Biological sludge was employed as a lowcost source to prepare adsorbents through ferric activation

for the removal of tetracycline. The results showed that ferric-activated SBA exhibited a better development of a porous structure. The increased surface area and mesoporous structure of ferric-activated SBA can promote the absorption of tetracycline. The adsorption mechanism was probably pore-filling effect and hydrogen bonding effect. Ferric-activated SBA prepared from wastewater treatment plant sludge could be used to remove tetracycline from water, and it was a better resourceful disposal of sludge.

Table 1. Surface area and porosity of raw sludge and adsorbents.

Sample	BET surface area (m^2/g)	V_t (cm^3/g)	V_{mic} (cm^3/g)	D_p (nm)
Non-activated SBA	2.33	0.0095	0.00006	8.54
Ferric-activated SBA	126.86	0.15518	0.01918	4.44

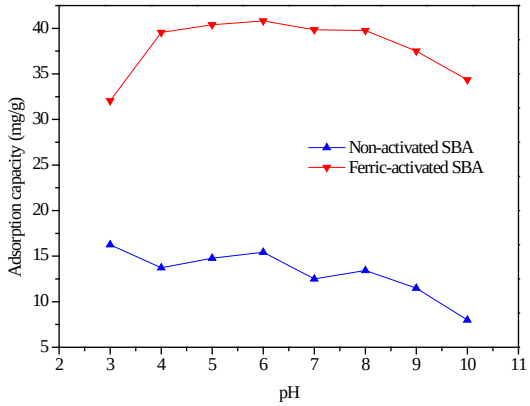

Figure 1. Effect of initial pH on the adsorption of tetracycline.

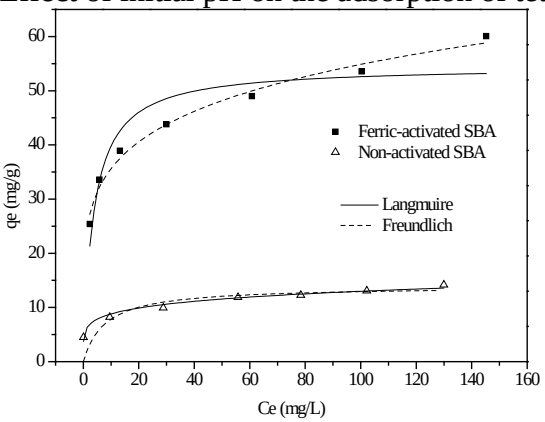

Figure 2. Adsorption isotherms of tetracycline on the adsorbents.

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