Supplementary material

Highly Efficient Removal of Cr(VI) from Aqueous Solutions by a Polypyrrole/Monodisperse Latex Spheres

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**Text S1 Effect of the Py concentration**

PPy/MLS (25 mg, Py concentrations: 10–90 wt%) was added to a Cr(VI) solution (50 mL) at pH 2.0 with an initial concentration of 200 mg/L for 24 h at 25 °C, and then the mixture was filtered to analyze the content of Cr(VI) in the filtrate. The adsorption capacity of Cr(VI) was determined using Eq. 1. The composite prepared with optimum Py concentration was used as the adsorbent for the subsequent experiments.

\[
Q_e = \frac{(C_0 - C_e)}{m}V
\]

(1)

where \(Q_e\) is the adsorption capacity of the adsorbent per unit mass for Cr(VI) (mg/g), \(C_0\) is the initial concentration of Cr(VI) (mg/L), \(C_e\) is the Cr(VI) concentration after adsorption (mg/L), \(V\) is the volume of solution (mL), and \(m\) is the adsorbent mass (mg).

**Text S2 Effect of pH**

The adsorption properties of PPy, MLS and PPy/MLS for Cr(VI) at different pH values were studied. PPy/MLS (25 mg) were added to 25 mL of Cr(VI) solution with an initial concentration of 100 mg/L and different pH values (2.0–8.0), and the solution was adsorbed for 24 h at 25 °C and then filtered to analyze the content of Cr(VI) in the filtrate. The removal efficiency of Cr(VI) was determined by Eq. 2.

\[
\% \text{ Removal} = \frac{(C_0 - C_e)}{C_0}V \times 100
\]

(2)

**Text S3 Effect of adsorbent dosage**

The effect of the amount of PPy/MLS adsorbent on the adsorption performance of
Cr(VI) was studied. PPy/MLS (10-100 mg) was added to 25 mL of Cr(VI) solution (100 mg/L) at pH 2.0, and the solution was adsorbed for 24 h at 25 °C and then filtered to analyze the content of Cr(VI) in the filtrate. The removal rate and adsorption capacity of Cr(VI) were calculated according to Eqs. 1 and 2.

Text S4 Adsorption kinetics

Adsorption kinetics were used to analyze the adsorption process of Cr(VI). In a typical kinetic experiment, 30 mg of PPy/MLS was added to 200 mL of a Cr(VI) solution (25, 50, and 75 mg/L) at 25 °C and pH 2.0 at mixed at a speed of 400 rpm. Aliquots of the solutions were gathered and filtered at predetermined times. The concentrations of Cr(VI) in the filtrates of the aliquots were analyzed, and the adsorption capacity (Q_t) of Cr(VI) at time t was calculated according to Eq. 3. Finally, the data were fitted by pseudo-first order kinetics (Eq. 4), pseudo-second order kinetics (Eq. 5) and particle diffusion models (Eq. 6).

\[
Q_t = \frac{(C_0 - C_t)}{mV}
\]  
\[
\log(Q_e - Q_t) = \log Q_e - \frac{K_1 t}{2.303}
\]  
\[
\frac{t}{Q_t} = \frac{1}{K_2 Q_e^2} + \frac{t}{Q_e}
\]  
\[
Q_t = K_{ipt} t^{0.5} + C
\]

where Q_t is the adsorption capacity of adsorbent per unit mass for Cr(VI) (mg/g) at time t.
\( t, C_t \) is the Cr(VI) concentration after adsorption (mg/L) at time \( t \), \( K_1 \) is the pseudo-first-order kinetic adsorption rate constant (1/min), \( K_2 \) is the pseudo-second-order kinetic adsorption rate constant \((g\text{mg}\cdot\text{min}^{-1})\), \( K_{ip} \) is the particle diffusion model adsorption rate constant \((mg\text{g}^{-1/2}\text{min}^{-1})\), and \( C \) is the intercept related to the boundary layer thickness.

**Text S5 Adsorption isotherms**

The adsorption isotherms at 25, 35 and 45 °C were determined at pH 2.0 over 24 h with 50 mL of Cr(VI) solutions at 50–400 mg/L with 25 mg of adsorbent. The adsorption data were fitted by the Langmuir (Eq. 7) and Freundlich (Eq. 9) isothermal adsorption models.

\[
\frac{C_e}{Q_e} = \frac{C_e}{Q_m} + \frac{1}{bQ_m} \quad (7)
\]

\[
R_L = \frac{1}{1 + bC_0} \quad (8)
\]

\[
\ln Q_e = \ln K_F + \frac{1}{n} \ln C_e \quad (9)
\]

where \( b \) is the adsorption free energy constant \((mg^{-1})\), \( Q_m \) is the maximum adsorption capacity \((mg\cdot g^{-1})\), \( R_L \) is a nondimensional factor, the Freundlich constant \((K_F)\) indicates the relative adsorption capacity of the adsorbents \((mg\cdot g^{-1})\), and \( 1/n \) is the adsorption strength.

**Text S6 Thermodynamic investigations**
The thermodynamic parameters, such as the Gibbs free energy change ($\Delta G^0$), enthalpy change ($\Delta H^0$) and entropy change ($\Delta S^0$), were calculated by Eqs. 10-12.

\[
\ln K_c = \frac{\Delta S^0}{R} - \frac{\Delta H^0}{RT} \tag{10}
\]

\[
K_c = (C_0 - C_e) \frac{V}{mC_e} \tag{11}
\]

\[
\Delta G^0 = -RT\ln K_c \tag{12}
\]

where $R$ is the ideal gas constant (8.314 J/(mol$^{-1}$·K$^{-1}$)), and $T$ is the system temperature (K).

**Text S7 Regeneration analyses**

The cyclic adsorption properties of PPy/MLS for Cr(VI) were studied by adsorption-desorption experiments. The 45 mg portion of PPy/MLS was added to 30 mL of Cr(VI) solution (150 mg/L) at 25 °C. After adsorption, the solution was separated by centrifugal filtration. To recycle the adsorbent, the obtained solid was desorbed 3 times by using 30 mL of NaOH solution (0.5 mol/L) for 10.0 min and then washed 3 times with 30 mL of H$_2$O. Finally, the adsorbent was dried at 60 °C for 6 h, and the adsorption-desorption experiments were repeated 5 times.