Supporting Information

Hexavalent chromium ion and methyl orange dye uptake via a silk protein sericin-chitosan conjugate

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S1. Kinetics:

S1.1 Pseudo-first-order

\[
\log (q_e - q_t) = \log q_e - k_{ad} \frac{t}{2.303}
\]  

(S1)

where \( q_e \) and \( q_t \) is the adsorption capacity (mg.g\(^{-1}\)) at equilibrium and at time \( t \) (min), respectively for the CS, \( k_{ad} \) is the equilibrium rate constant of the pseudo-first-order sorption (min\(^{-1}\)).

S1.2 Pseudo-second-order

\[
\frac{t}{q_t} = \frac{1}{h} + \frac{t}{q_e}
\]  

(S2)

where \( q_t = (q_e^2 kt)/(1+q_e kt) \) is the amount of metal ions adsorbed on the surface of the CS at any time, \( t \) (mg g\(^{-1}\)), \( k \) is the pseudo-second-order rate constant (g.mg\(^{-1}\).min\(^{-1}\)), and the initial sorption rate, \( h = k q_e^2 \) (mg.g\(^{-1}\).min\(^{-1}\)).

S1.3 Intraparticle kinetic model

\[
q_t = k_i t^{1/2} + C
\]  

(S3)

where \( k_i \) (mg.g\(^{-1}\).min\(^{-0.5}\)) is the intraparticle diffusion rate constant and \( C \) is the thickness of the boundary layer.

S2. Isotherms:

S2.1 Langmuir isotherm

\[
\frac{C_e}{q_e} = \frac{1}{Q^0 b} + \frac{C_e}{Q^0}
\]  

(S4)

where \( q_e \) is the amount of adsorbate adsorbed per unit weight of the adsorbent (mg.g\(^{-1}\)), \( C_e \) is the equilibrium concentration of adsorbate in solution (mg.L\(^{-1}\)), \( Q^0 \) is the amount of adsorbate at complete monolayer coverage (mg.g\(^{-1}\)) and gives the Langmuir maximum sorption capacity of adsorbent, \( b \) (L.mg\(^{-1}\)) is Langmuir isotherm constant that relates to the energy of adsorption. The
essential characteristics of the Langmuir isotherm can be expressed in terms of the dimensionless constant separation factor or equilibrium parameter, 

\[ R_L = \frac{1}{1 + bC_0} \]

where \( b \) (L.mg\(^{-1}\)) is Langmuir isotherm constant.

**S2.2 Freundlich isotherm**

\[ \log q_e = \log k_F + \frac{1}{n} \log C_e \]  \hspace{1cm} (S5)

\( k_F \) is the measure of adsorption capacity (mg.g\(^{-1}\)) \((\text{L.mg}\(^{-1}\))^{1/n}\) and \(1/n\) is the adsorption intensity. The Freundlich maximum adsorption capacity \((q_{max})\) was determined using

\[ K_F = \frac{q_{max}}{C_0^{1/n}}. \]

**S2.3 D-R isotherm**

\[ \ln q_e = \ln X_m - k_{DR} \varepsilon^2 \]  \hspace{1cm} (S6)

\( X_m \) is the adsorption capacity (mg.g\(^{-1}\)) and \( k_{DR} \) is the constant related to adsorption energy \((\text{mol}^2.\text{kJ}^{-2})\). \( \varepsilon \) is Polanyi potential and can be calculated by the equation

\[ \varepsilon = RT \ln \left( 1 + \frac{1}{C_e} \right) \]

where, \( T \) is the temperature (K) and \( R \) is the gas constant (8.314 J.mol\(^{-1}\)K\(^{-1}\)). The value of \( k \) is used to calculate the mean of free energy \( E \) (kJ.mol\(^{-1}\)) of the sorption, \( E = -(2k)^{-0.5} \).

**S.3 Thermodynamic parameters:**

The value of thermodynamic parameters was determined using the Eqs (6) and (7);

\[ \Delta G^0 = -RT \ln K^0 \]  \hspace{1cm} (S7)

\[ \ln K^0 = \frac{\Delta S^0}{R} - \frac{\Delta H^0}{RT} \]  \hspace{1cm} (S8)

where, \( \Delta G^0, \Delta H^0 \) and \( \Delta S^0 \) are the standard free energy change (kJ.mol\(^{-1}\)), standard enthalpy change (kJ.mol\(^{-1}\)) and standard entropy change (kJ.mol\(^{-1}\)K\(^{-1}\)), respectively. \( K^0 \) is the adsorption
distribution coefficient, $T$ is the temperature (K), $R$ is the universal gas constant (8.314 J.mol$^{-1}$K$^{-1}$).

**Fig. S1.** pH$_{ZPC}$ determination of the CS using salt addition method.
Fig. S2. Reusability analysis on MO dye and Cr(VI) ions removal using CS.

Fig. S3. EDX analysis of (A) CS and (B) Cr(VI) ions adsorbed CS.
Fig. S4. Influence of pH on the coadsorption of Cr(VI) ions and MO dye using CS

Fig. S5. Possible interactions between the CS and MO dye and Cr(VI) ions, and reduction of Cr(VI) to Cr(III). Hydrophobic interactions represented by “·”, electrostatic” represented by green dashed line.