Supporting information

One-step room-temperature synthesis of bimetallic nanoscale zero-valent FeCo by hydrazine reduction: effect of metals salts and application in contaminated water treatment

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Adsorption data analysis

The removal performance of the alloy at any time \( t \) was determined by either the amount of Cu\( ^{2+} \) and RB5 adsorbed onto one gram of the alloy \( (q_t, \text{Eq S1}) \) or the removal percentage \( (R\%, \text{ Eq. S2}) \).

\[
q_t = (C_i - C_t) \frac{V}{m} \quad \text{(S1)}
\]

\[
R\% = \left(\frac{C_i - C_e}{C_i}\right) \times 100 \quad \text{(S2)}
\]

where \( C_i \) and \( C_t \) (mg/L) are the concentration of Cu\( ^{2+} \) or RB5 at time 0 and \( t \), respectively, \( V \) (L) is the volume of Cu\( ^{2+} \) or RB5 solution, and \( m \) (g) is the used mass of the alloy.

Adsorption kinetic models

**Pseudo-first-order model**

The rate constant of adsorption is determined from the pseudo-first-order equation given by Lagergren and Svenska \(^1\) as follow:

\[
q_t = q_e (1 - e^{-kt}) \quad \text{(S3)}
\]

where \( q_e \) (mg/g) is the adsorption capacity at equilibrium, \( q_t \) (mg/g) is the amount of solute adsorbed on the adsorbent at time \( t \), \( k_1 \) (min\(^{-1}\)) is the pseudo-first order rate constant and \( t \) (min) the time.

**Pseudo-second-order model**

The pseudo-second-order equation \(^2\) based on equilibrium adsorption is expressed as:

\[
q_t = \frac{k_2q_e^2t}{1 + k_2q_e^2t} \quad \text{(S4)}
\]

where \( k_2 \) (g/mg min) is the rate constant of the second-order adsorption.

**Elovich model**

This model is one of the equations that best describes the activated chemical adsorption. It is suitable in systems that have heterogeneous adsorbing surfaces \(^3\).

\[
q_t = \frac{1}{\beta} \ln (1 + \alpha \beta t) \quad \text{(S5)}
\]
where \( q_t \) (mg/g) is the amount of adsorption at time \( t = t \), \( \beta \) is Elovich constant (g/mg), \( \alpha \) is initial adsorption rate (mg/(g min))

**Adsorption isotherm models**

**Freundlich model**
This empirical model can be used to describe non-ideal distribution of heat of adsorption and affinities on a heterogeneous surface, it is not restricted to the formation of monolayer \(^4\). The non-linear form can be presented by Eq. S7.

\[
q_e = k_F C_e^{1/n}
\]  

(S6)

where \( k_F \) is Freundlich constant (mg\(^{(1-1/n)}\)L\(^{1/n}\)/g) related to adsorption capacity, and \( n \) (–) adsorption intensity

**Langmuir model**
Adsortion isotherm of single adsorptive was analyzed with the Langmuir model, which is used to describe a monolayer adsorption onto the surface of an adsorbent with finite number of identical adsorption sites \(^5\), it can be written in non-linear form as:

\[
q_e = \frac{q_L k_L C_e}{1 + k_L C_e}
\]  

(S7)

where \( k_L \) (L/mg) is the Langmuir constant and \( q_L \) (mg/g) is the monolayer adsorption capacity of the adsorbent.

**Temkin model**
Temkin model assumes that adsorption is a multi-layer process, and neglects the extremely low and high concentrations \(^6\). Eq. S8 gives the non-linear form of this model.

\[
q_e = \frac{(RT)}{b_T} \ln A_T C_e
\]  

(S8)

where \( A_T \) (L/g) is Temkin equilibrium binding constant, \( b_T \) (J/mol) is Temkin constants, R is the universal gas constant (8.314 J/mol K), and \( T \) is the absolute temperature (K).

**Error analysis**
The error functions have been designed to evaluate the reliability of the models and identify the best model that describe and foresee the adsorption process \(^7\). Three error functions were applied
in this study, specifically, coefficient of determination ($R^2$, Eq. S9), nonlinear chi-square ($\chi^2$, Eq. S10), and root mean square error (RMSE, Eq. S11).

$$R^2 = \frac{\sum (q_{e,cal} - \bar{q}_{e,exp})^2}{\sum (q_{e,cal} - \bar{q}_{e,exp})^2 - \sum (q_{e,cal} - q_{e,exp})^2}$$  \hspace{1cm} (S9)

$$\chi^2 = \sum_{i=1}^{N} \left[ \frac{(q_{e,exp} - q_{e,cal})^2}{q_{e,cal}} \right]$$  \hspace{1cm} (S10)

$$RMSE = \sqrt{\frac{1}{N - M} \sum_{i=1}^{N} (q_{e,measured} - q_{e,model})^2}$$  \hspace{1cm} (S11)

where $q_{e,exp}$ is the experimental adsorption capacity at equilibrium, $q_{e,cal}$ is the calculated adsorption capacity at equilibrium, $N$ is the number of experimental data, $\bar{q}_{e,exp}$ is the average experimental capacity at equilibrium, and $M$ is the number of variables of the model.
Figures

Figure S1. (a) structure and selected properties, (b) visible spectra of different concentrations, and (c) calibration curve of RB5 dye.
Figure S2. Adsorption kinetics and fitted models for the adsorption of (a) Cu$^{2+}$ ($C_i$ 10 mg/L, pH$_o$ 5.3, dosage 0.10 g/L), and (b) RB5 ($C_i$ 10 mg/L, pH$_o$ 7, dosage 1.00 g/L) onto FeCo alloy prepared at room temperature.
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