Formation of Fe$_3$O$_4$@SiO$_2$@C/Ni Hybrids with Enhanced Catalytic Activity and Histidine-rich Protein Separation

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Figure S1. Energy-disperse X-ray spectrum (EDS) of Fe₃O₄@SiO₂@C/Ni-1 composites

Figure S2. (A) FTIR spectra of Fe₃O₄ (a), Fe₃O₄@SiO₂ (b), Fe₃O₄@SiO₂@PDA-Ni²⁺-1 (c) and Fe₃O₄@SiO₂@C/Ni-1 (d). (B) TGA test of Fe₃O₄@SiO₂ (a), Fe₃O₄@SiO₂@PDA-Ni²⁺-1 (b), Fe₃O₄@SiO₂@PDA-Ni²⁺-2 (c).
**Figure S3.** FESEM images of products obtained by annealing Fe$_3$O$_4$@SiO$_2$@PDA-Ni$^{2+}$-1 under N$_2$ atmosphere at 350 °C (A), 600 °C (C); FESEM images of core-shell structured Fe$_3$O$_4$@SiO$_2$@C/Ni composites obtained by annealing Fe$_3$O$_4$@SiO$_2$@PDA-Ni$^{2+}$-2 under N$_2$ atmosphere at 350°C (B), 600°C (D). Scale bars: 500 nm (A-D).

**Figure S4.** XRD patterns of Fe$_3$O$_4$ (a), Fe$_3$O$_4$@PDA/Ni$^{2+}$ (b), Fe$_3$O$_4$@C/Ni(c) ((M$_{dopamine:nickel}$ of 1:2, 37.6 mg nickel salt and 15 mg dopamine, carbonization at 500°C)
Figure S5. FESEM of Fe$_3$O$_4$@SiO$_2$@C/Ni with different thickness of SiO$_2$ by adjusting the different amount of TEOS from 50 μL (a), 150 μL (b), 300 μL (c), 500 μL (d) while keeping the other parameters fixed. Scale bars: 500 nm (A, C) and 250 nm (B, D).

Figure S6. Magnetic hysteresis curves of Fe$_3$O$_4$@SiO$_2$@PDA-Ni$^{2+}$-1 (A), Fe$_3$O$_4$@SiO$_2$@C/Ni-1 (B) measured at room temperature. (the inset is the digital picture showing that Fe$_3$O$_4$@SiO$_2$@C/-1 can be isolated from the solution by magnet.)
Figure S7. SEM and TEM images of $\alpha$-Fe$_2$O$_3$ (a-d) and SiO$_2$@Fe$_3$O$_4$ (e-h).

Figure S8. XRD patterns of $\alpha$-Fe$_2$O$_3$@PDA/Ni$^{2+}$ (a), Fe$_3$O$_4$@C/Ni (b), $\alpha$-Fe$_2$O$_3$@SiO$_2$@PDA/Ni$^{2+}$ (c) and $\alpha$-Fe$_2$O$_3$@SiO$_2$@C/Ni (d).
Figure S9. Recyclability of Fe$_3$O$_4$@SiO$_2$@C-Ni-1 as Catalysts for the reduction of 4-nitrophenol.

Figure S10. Linear fitting of adsorption isotherms plots based on Freundlich model.
**Table S1** the estimate of Langmuir model and Freundlich model

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<td>$b$</td>
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**Figure S11.** Reusability of Fe$_3$O$_4$@SiO$_2$@C/Ni-1 through the adsorption–regeneration cycle.
Figure S12. (A) Curve a is UV-vis spectra of initial BHb (A), BHb/BSA binary solution (B), BHb/Lysozyme binary solution (C), BHb/BSA/Lysozyme ternary solution(D). Curve b is UV-vis spectra of supernatant of BHb (A), BHb/BSA binary solution (B), BHb/Lysozyme binary solution (C), BHb/BSA/Lysozyme ternary solution (D) after adsorbed by Fe₃O₄@SiO₂@C/Ni-1 Curve c is UV-vis spectra of desorption solution of Fe₃O₄@SiO₂@C/Ni-1 in BHb (A), BHb/BSA binary solution (B), BHb/Lysozyme binary solution (C), BHb/BSA/Lysozyme ternary solution (D) with 0.2 g mL⁻¹ imidazole solution as the eluent.
Figure S13. SDS-PAGE analysis of adsorption by Fe$_3$O$_4$@SiO$_2$@C/Ni-1 from solution. Lane 1, marker; lane 2, initial human blood diluted 60-fold as the control; lane 3, residual human blood solution after adsorption by Fe$_3$O$_4$@SiO$_2$@C/Ni-1; lane 4, the eluted human blood from Fe$_3$O$_4$@SiO$_2$@C/Ni-1 by 0.2 g ml$^{-1}$ imidazole solution.