Rationally Designed Hierarchical nickel-enabled magnetic yolk-like nanospindles for enhanced catalyisis and protein adsorption

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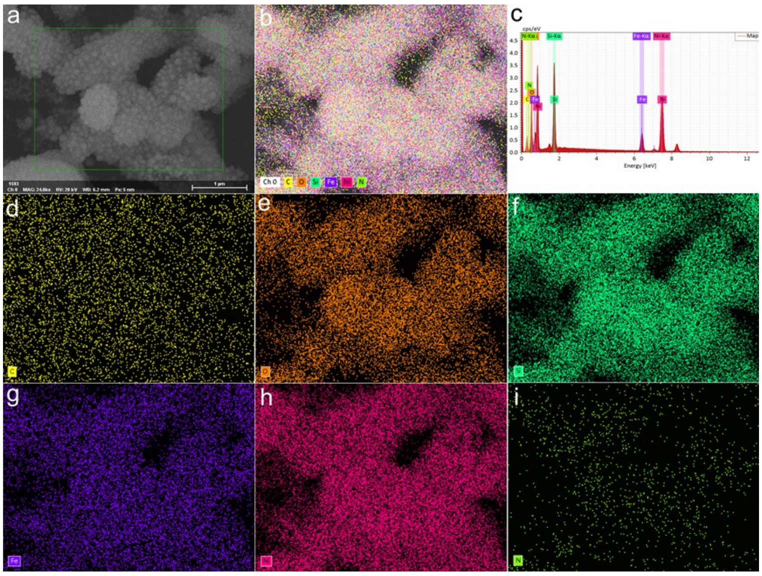

Fig. S1 Energy-disperse X-ray spectrum (EDS) mapping imagines and EDX spectrum of FeOx@SiO_2@C-Ni/900(c). (d) C, (e) O,(f) Si, (g) Fe, (h) Ni, (i) N

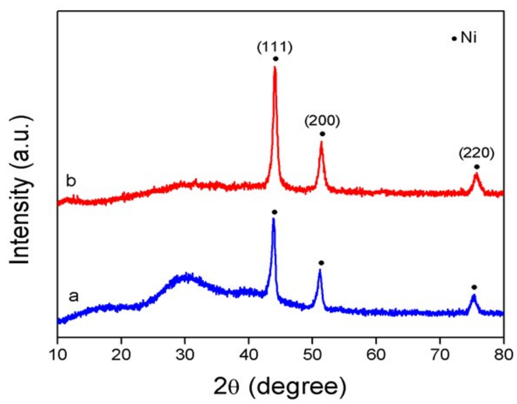

Fig. S2 The XRD Pattern of Fe_2O_3@NS@PDA calcinated in nitrogen environment at 700 ^{o}C (a), and 900 ^{o}C (b).

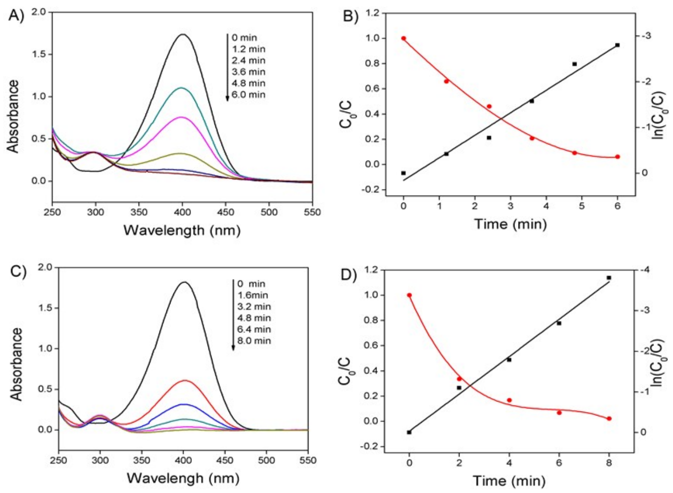

Fig. S3 (A) successive reduction of 4-NP using $FeO_x@SiO_2@C$-Ni/700 as catalysts; (B) C/C_0 and $\ln(C/C_0)$ versus time for the reduction of 4-NP over 1 mg $FeO_x@SiO_2@C$-Ni/700 catalysts; (C) successive reduction of 4-NP using $FeO_x@SiO_2@C$-Ni/900 as catalysts; (D) C/C_0 and $\ln(C/C_0)$ *versus* time for the reduction of 4-NP over 1 mg $FeO_x@SiO_2@C$-Ni/900 catalysts.

Table S1. The ICP data of the resultant products with different calcination temperature before and after catalytic reaction.

Catalysts	Ni ($\mu g.mg^{-1}$)
$FeO_x@SiO_2@C$-Ni/500	256.67
$SiO_2@C$-Ni/700	394.69
$SiO_2@C$-Ni/900	474.32

Table S2. A full comparison of $FeO_x@SiO_2@C$-Ni nanospindles catalysis activity and test condition with other nickel and noble metal catalysts.

Catalyst	Type	$K(\times10^{-3}s^{-1})$	$\kappa(g^{-1}s^{-1})$	Ref.
$FeO_x@SiO_2@C$-Ni/500	nanospindles	46	179.22	This work
$SiO_2@C$-Ni/700	nanospindles	8.21	20.85	This work
$SiO_2@C$-Ni/900	nanospindles	7.66	16.15	This work
Au nanoparticles	nanoparticles	0.06	0.72	S1
Pd nanocatalysts	nanoparticles	0.73	0.36	S2
$Fe_3O_4@SiO_2$-Au@$mSiO_2$	Core-shell	7.0	105	S3
Au@meso-SiO_2	Hollow spheres	0.08	2.51	S4
Ni/SiO_2	Core-shell	2.8	0.94	S5
Cu_2O@Ag	Core-shell	0.44	1.09	S6

RGO-Ni	Nanosheets	0.25	0.04	S7
C-Ni/600	Nanoparticles	18.6	449	S8
Ni/SNTs	Nanotube	84	91	S9
Fe_3O_4@SiO_2-Ag	nanospheres	7.67	7.67	S10
Ni (modified)	Nanoparticles	2.4	0.80	S11
Ni/MC-550	Bottle-neck	1.51	338	S12

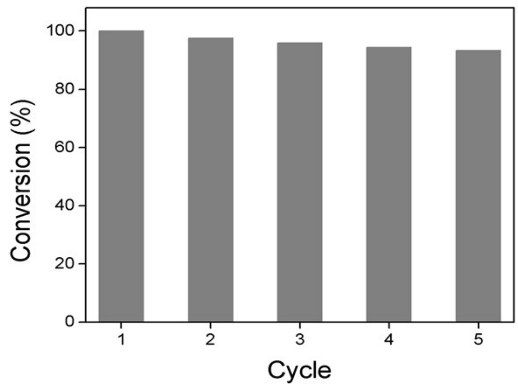

Fig. S4 The reusability of FeO_x@SiO_2@C-Ni/500 as the catalyst for the reduction of 4-NP with $NaBH_4$.

Table S3. Properties of different adsorbents for His-rich proteins capture.

Adsorbent	Type	Capacity (mg g^{-1})	Ref.
FeO_x@SiO_2@C-Ni/500	nanospindles	1893.0	This work
FeO_x@SiO_2@C-Ni/700	nanospindles	952.4	This work
FeO_x@SiO_2@C-Ni/900	nanospindles	724.6	This work
CNTs/Fe_3O_4@Cu Silicate	nanotubes	302.3	S13
Cu-IDA-silica-coated Fe_3O_4	microspheres	418.6	S14
Magnetic HCNTs	nanotubes	2200	S15
Fe_3O_4@PVBC@IDA-Ni	core-shell	1988	S16
Fe_3O_4/Cys	nanospheres	53.2	S17
Fe_3O_4@SiO_2@LDH	Microspheres	239	S18
$MnFe_2O_4$@SiO_2@NH_2@2AB-Ni	nanoparticles	220	S19
Fe_3O_4@$NiSiO_3$	Yolk-shell	220	S20
Fe_3O_4@SiO_2-IDA-Cu	nanoparticles	38.2	S21
P(PEGDMA-VI)@ECA	microspheres	22.0	S22
Fe_3O_4@SiO_2@C/Ni	nanoparticles	409.8	S23

$Fe_3O_4@SiO_2@IL$	microspheres	2150	S24

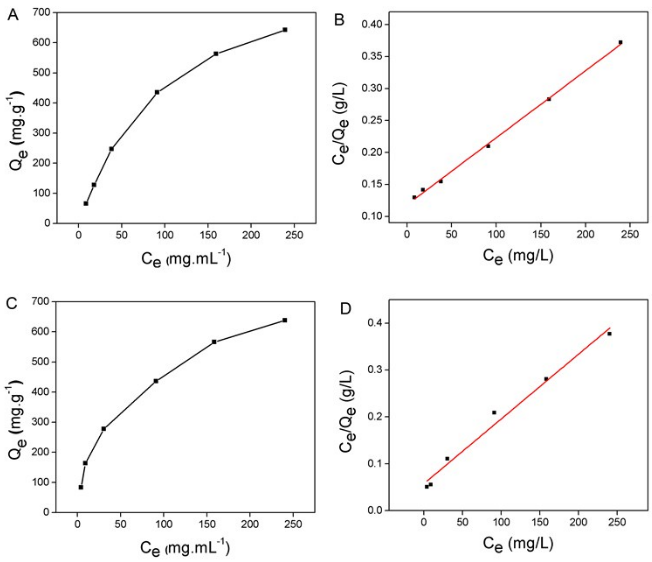

Fig. S5 Adsorption isotherms of protein BHb and Linear fitting of adsorption isotherms plots based on Langmuir model for $FeO_x@SiO_2@C$-Ni/700 (A,B), $FeO_x@SiO_2@C$-Ni/900 (C,D).

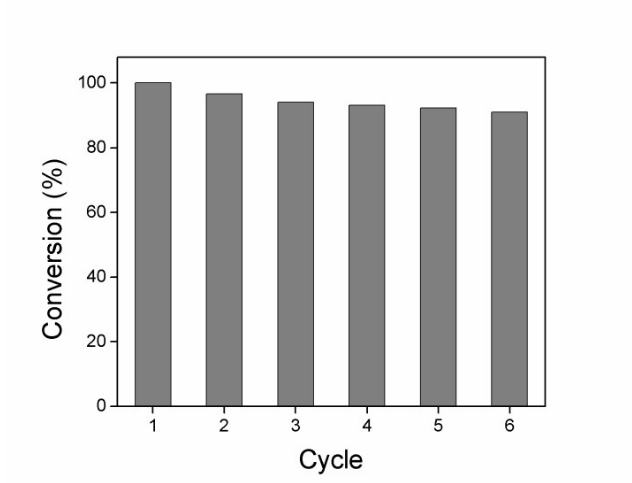

Fig. S6 The reusability of $FeO_x@SiO_2@C$-Ni/500.

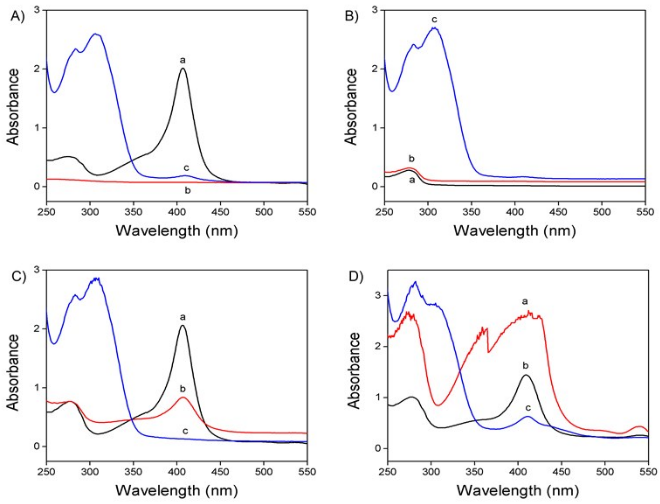

Fig. S7 Curve a is UV-vis spectra of 0.4 mg mL^{-1} of the BHb (A), BSA (B), BHb and BSA mixture (C), and 500-fold diluted bovine blood (D) before adsorbed by $FeO_x@SiO_2@C$-Ni/500 adsorbents. Curve b is the UV-vis spectra of the supernatant of the above BHb (A), BSA (B), BHb and BSA mixture (C), and 100-fold diluted bovine blood (D) after adsorption by adsorbents. Curve c is the UV-vis spectra of desorption solution of the adsorbed protein by adsorbents in BHb (A), BSA (B), BHb and BSA mixture (C) and 100-fold diluted bovine blood (D) using a concentration of 0.2 g.mL^{-1} of imidazole solution as the eluent.

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