Supporting Information

Constructing Fe_2O_3 Nanoparticles in Nitrogen-Doped Carbon Materials to Enhance the Electrochemical Sensing Performance of Pb^{2+} and Cd^{2+}

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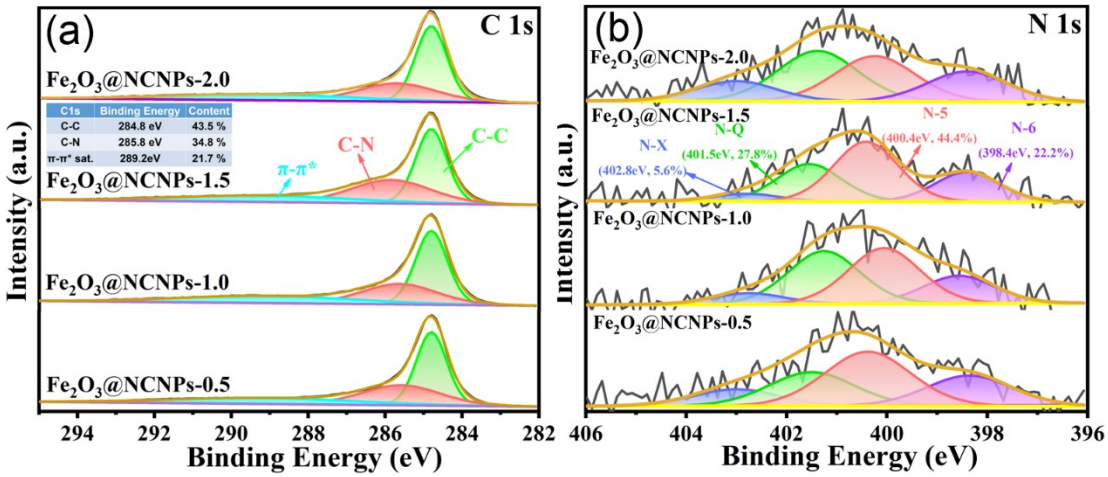

Fig. S1 High resolution (**a**) C 1*s* and (**b**) N 1*s* XPS spectrum of Fe_2O_3@NCNPs-x.

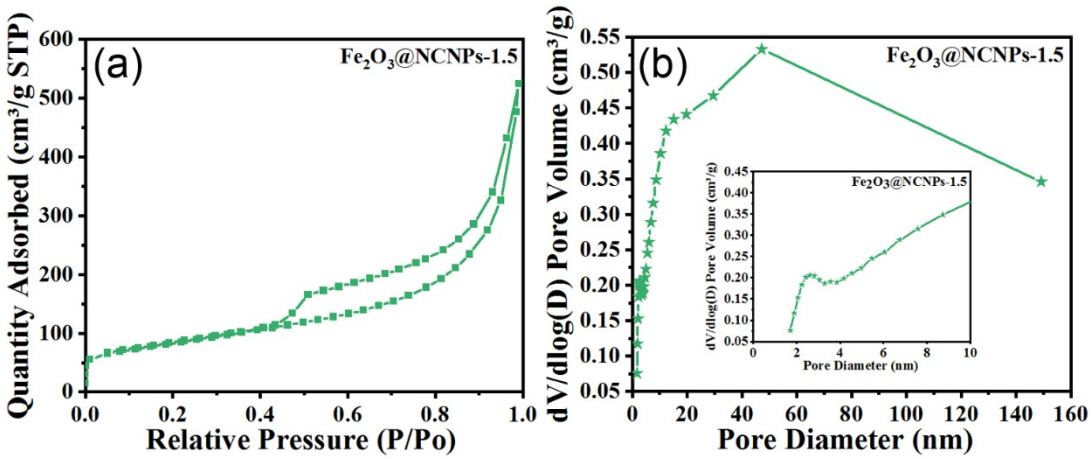

Fig. S2 (**a**) the N_2 adsorption/desorption isotherm and (**b**) the pore-size distribution of Fe_2O_3@NCNPs-1.5 nanomaterial.

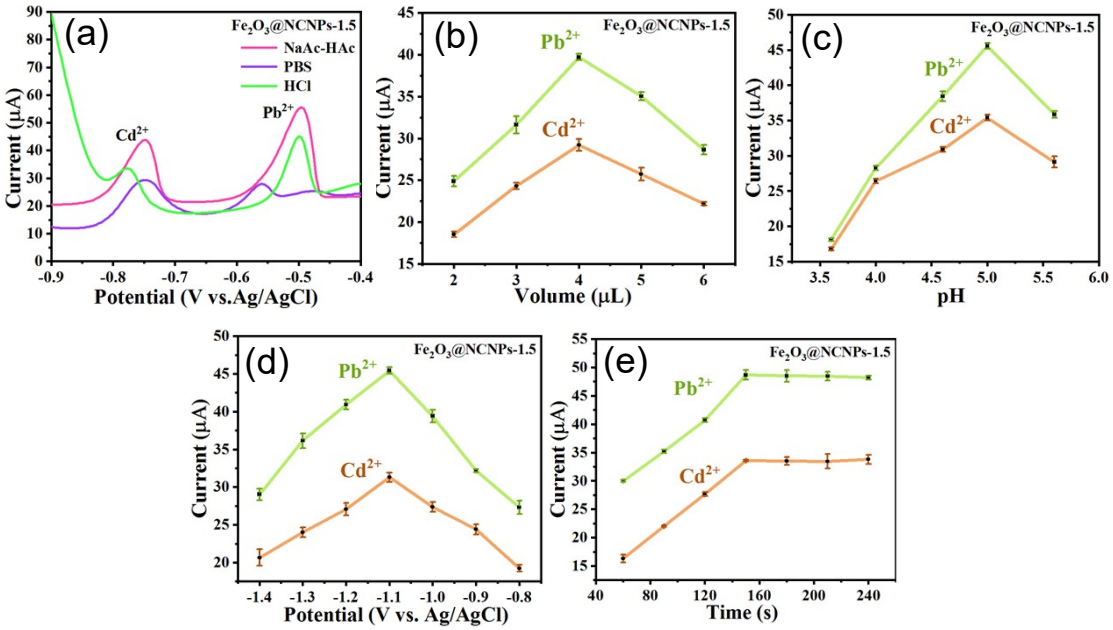

Fig. S3 Investigation of ptimal experimental conditions: the influence of (**a**) supporting electrolytes, (**b**) modified volume, (**c**) pH values, (**d**) deposition potential, and (**e**) deposition time on the current response of the Fe_2O_3@NCNPs-1.5/GCE. The error bars represented the standard deviations of triple measurements.

Table S1 The curve fitting information of **C 1*s*** for Fe_2O_3@NCNPs-n.

	C-C		
Sample	Binding Energy (eV)	FWHM	%Area
Fe_2O_3@NCNPs-0.5	284.8	0.9	45.5
Fe_2O_3@NCNPs-1.0	284.8	0.9	45.5
Fe_2O_3@NCNPs-1.5	284.8	0.9	43.5
Fe_2O_3@NCNPs-2.0	284.8	0.9	48.1
	C-N		
Sample	Binding Energy (eV)	FWHM	%Area
Fe_2O_3@NCNPs-0.5	285.6	2.4	31.8
Fe_2O_3@NCNPs-1.0	285.6	2.3	29.5
Fe_2O_3@NCNPs-1.5	285.8	2.4	34.8
Fe_2O_3@NCNPs-2.0	285.7	2.4	28.8
	π-π* satellite		
Sample	Binding Energy (eV)	FWHM	%Area
Fe_2O_3@NCNPs-0.5	289.2	5.5	22.7
Fe_2O_3@NCNPs-1.0	289.1	5.4	25.0
Fe_2O_3@NCNPs-1.5	289.2	5.5	21.7
Fe_2O_3@NCNPs-2.0	289.2	5.5	23.1

Table S2 The curve fitting information of **N 1*s*** for Fe_2O_3@NCNPs-n.

	N-6		
Sample	Binding Energy	FWHM	%Area
Fe_2O_3@NCNPs-0.5	398.4	1.9	22.5
Fe_2O_3@NCNPs-1.0	398.6	1.7	18.9
Fe_2O_3@NCNPs-1.5	398.4	1.6	22.2
Fe_2O_3@NCNPs-2.0	398.4	1.9	20.7
	N-5		
Sample	Binding Energy	FWHM	%Area
Fe_2O_3@NCNPs-0.5	400.4	1.9	40.0
Fe_2O_3@NCNPs-1.0	400.1	1.7	37.7
Fe_2O_3@NCNPs-1.5	400.4	1.6	44.4
Fe_2O_3@NCNPs-2.0	400.2	1.9	31.0
	N-Q		
Sample	Binding Energy	FWHM	%Area
Fe_2O_3@NCNPs-0.5	401.5	1.9	25.0
Fe_2O_3@NCNPs-1.0	401.3	1.7	35.9
Fe_2O_3@NCNPs-1.5	401.5	1.6	27.8
Fe_2O_3@NCNPs-2.0	401.4	1.9	34.5
	N-X		
Sample	Binding Energy	FWHM	%Area
Fe_2O_3@NCNPs-0.5	403.0	1.9	12.5
Fe_2O_3@NCNPs-1.0	402.8	1.7	7.5
Fe_2O_3@NCNPs-1.5	402.8	1.6	5.6
Fe_2O_3@NCNPs-2.0	403.0	1.9	13.8

Table S3 The curve fitting information of **O 1*s*** for Fe_2O_3@NCNPs-n.

	Fe-O		
Sample	Binding Energy (eV)	FWHM	%Area
Fe_2O_3@NCNPs-0.5	530.5	1.3	34.2
Fe_2O_3@NCNPs-1.0	530.6	1.3	31.3
Fe_2O_3@NCNPs-1.5	530.3	1.5	33.3
Fe_2O_3@NCNPs-2.0	530.6	1.4	33.3
	OVs		
Sample	Binding Energy (eV)	FWHM	%Area
Fe_2O_3@NCNPs-0.5	531.9	1.6	37.5
Fe_2O_3@NCNPs-1.0	531.8	1.7	34.4
Fe_2O_3@NCNPs-1.5	532.2	1.8	41.7
Fe_2O_3@NCNPs-2.0	531.9	1.7	30.0
	O_2		
Sample	Binding Energy (eV)	FWHM	%Area
Fe_2O_3@NCNPs-0.5	533.1	1.3	19.8
Fe_2O_3@NCNPs-1.0	533.0	1.3	25.0
Fe_2O_3@NCNPs-1.5	533.0	1.5	20.8
Fe_2O_3@NCNPs-2.0	533.0	1.4	26.7
	H-O-H		
Sample	Binding Energy (eV)	FWHM	%Area
Fe_2O_3@NCNPs-0.5	534.4	1.4	8.5
Fe_2O_3@NCNPs-1.0	534.4	1.4	9.3
Fe_2O_3@NCNPs-1.5	534.8	1.5	4.2
Fe_2O_3@NCNPs-2.0	534.3	1.4	10.0

Table S4 The curve fitting information of **Fe 2*p*** for Fe_2O_3@NCNPs-n.

Sample	Fe 2*p*3/2-Fe^{2+} Binding Energy	FWHM	%Area
Fe_2O_3@NCNPs-0.5	710.6	1.5	22.1
Fe_2O_3@NCNPs-1.0	710.5	1.5	19.2
Fe_2O_3@NCNPs-1.5	710.4	1.5	21.7
Fe_2O_3@NCNPs-2.0	710.5	1.6	14.3
Sample	Fe 2*p*3/2-Fe^{3+} Binding Energy	FWHM	%Area
Fe_2O_3@NCNPs-0.5	712.6	1.7	26.5
Fe_2O_3@NCNPs-1.0	712.4	1.7	28.9
Fe_2O_3@NCNPs-1.5	712.4	1.7	18.1
Fe_2O_3@NCNPs-2.0	712.1	1.8	32.9
Sample	Fe 2*p*1/2-Fe^{2+} Binding Energy	FWHM	%Area
Fe_2O_3@NCNPs-0.5	724.1	1.7	16.2
Fe_2O_3@NCNPs-1.0	723.9	1.7	11.5
Fe_2O_3@NCNPs-1.5	724.2	1.7	13.3
Fe_2O_3@NCNPs-2.0	723.9	1.8	9.6
Sample	Fe 2*p*1/2-Fe^{3+} Binding Energy	FWHM	%Area
Fe_2O_3@NCNPs-0.5	727.0	1.9	12.9
Fe_2O_3@NCNPs-1.0	726.9	1.8	16.6
Fe_2O_3@NCNPs-1.5	726.8	1.8	10.2
Fe_2O_3@NCNPs-2.0	726.9	1.8	18.3

Table S5 The pore structure parameters of Fe_2O_3@NCNPs-1.5 nanomaterial.

Fe_2O_3@NCNPs-1.5	
S_{BET} [a] (m^2/g)	292
S_{micro} [b] (m^2/g)	30
V_{total} [c] (cm^3/g)	0.505
V_{micro} [d] (cm^3/g)	0.014
P [e] (nm)	6.92

a. The surface area (S_{BET}) calculated by the Brunauer-Emmett-Teller (BET) method.

b and **d**. The surface area (S_{micro}) and volume (V_{micro}) of micropore calculated by the t-plot equation.

c. The total pore volume calculated by the N_2 adsorption/desorption isotherm at P/P_0=0.95.

e. The main pore size.

Table S6 The LOD and LOQ value of individual detection and simultaneous detection of Pb^{2+} and Cd^{2+} on Fe_2O_3@NCNPs-1.5/GCE.

Analyte		LOD (nM)	LOQ (nM)
Individual	Pb^{2+}	27.45	94.47
detection	Cd^{2+}	38.20	118.88
Simultaneous	Pb^{2+}	4.92	15.15
detection	Cd^{2+}	18.79	61.75

Table S7 Comparison of the electrochemical performance of individual detection and simultaneous detection of Pb^{2+} and Cd^{2+} on Fe_2O_3@NCNPs-1.5/GCE and Fe_2O_3 NPs/GCE at the same testing conditions.

		Analyte	Fe_2O_3 NPs/GCE	Fe_2O_3@NCNPs-1.5/GCE
Simultaneous determination	LOD (nM)	Pb^{2+}	10.99	4.92
		Cd^{2+}	41.09	18.79
Individual determination	LOD (nM)	Pb^{2+}	9.48	27.45
		Cd^{2+}	38.31	38.20