Supporting Information

Carboxymethyl cellulose-assisted synthesis of carbon-confined leaf-like zeolite imidazolate framework-derived ZnS@N/C nanodots for enhanced multi-walled carbon nanotube dispersion and real-time neurotransmitter monitoring in PC-12 cells

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S1. Chemicals and reagents

Blanose® 7H4F carboxymethylcellulose (CMC, Ashland) has a molecular weight of about 725 kDa, a degree of substitution around 0.8, and a viscosity of 2500–4500 mPa.s in a 1% water solution at 25 °C. DA hydrochloride, zinc nitrate hexahydrate ($Zn(NO_3)_2.6H_2O$), 2-MIM, DEDTC, MWCNT, sodium hydroxide (NaOH), sodium chloride (NaCl), potassium hexacyanoferrate(II) ($K_4[Fe(CN)_6]$), potassium hexacyanoferrate(III) ($K_3[Fe(CN)_6]$), glucose ($C_6H_{12}O_6$), hydrogen peroxide (H_2O_2), nicotinamide adenine dinucleotide (NADH), indomethacin, sodium nitrite ($NaNO_3$), estradiol (E2), corticosterone (Cor), serotonin (SER), UA, and AA were purchased from Sigma Aldrich (USA). Potassium chloride, potassium dihydrogen phosphate, and ethanol (99.8%) were purchased from Baker (USA) and Honeywell (USA). A three-pole electrode (SPEs) was purchased from Zensor (USA) (model TE-100).

S2. Characterization techniques

The morphological features of the prepared samples were examined using field-emission scanning electron microscopy (FE-SEM, Regulus-8100, Hitachi, USA) and transmission electron microscopy (TEM, JEM 2100 F; JEOL Ltd., Tokyo, Japan). The elemental composition was determined using energy-dispersive X-ray analysis (EDX), and the crystalline structure and phase purity were assessed using X-ray powder diffraction (XRD; X'Pert3 Powder, Malvern Panalytical, UK). The functional groups and chemical bonds were qualitatively analyzed using Fourier-transform infrared spectroscopy (FTIR, Spotlight 200i Sp2 with AutoATR System, Perkin Elmer, USA), Raman spectroscopy (ACRON UniNanoTech Co., Ltd.), and X-ray photoelectron spectroscopy (XPS, JEOL Ltd., JPS-9030). The electrochemical experiments were conducted on a CHI6111E workstation (CH Instruments, USA) using a three-electrode system. A screen-printed electrode (SPCE, 0.071 cm^2 working area) and rotating ring disk electrode (RRDE, 0.21 cm^2 working area) acted as the working electrode, while silver/silver chloride (Ag/AgCl) and a platinum (Pt) filament functioned as the reference and counter electrodes, respectively. The electrochemical characteristics of the materials were evaluated using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and differential pulse voltammetry (DPV).

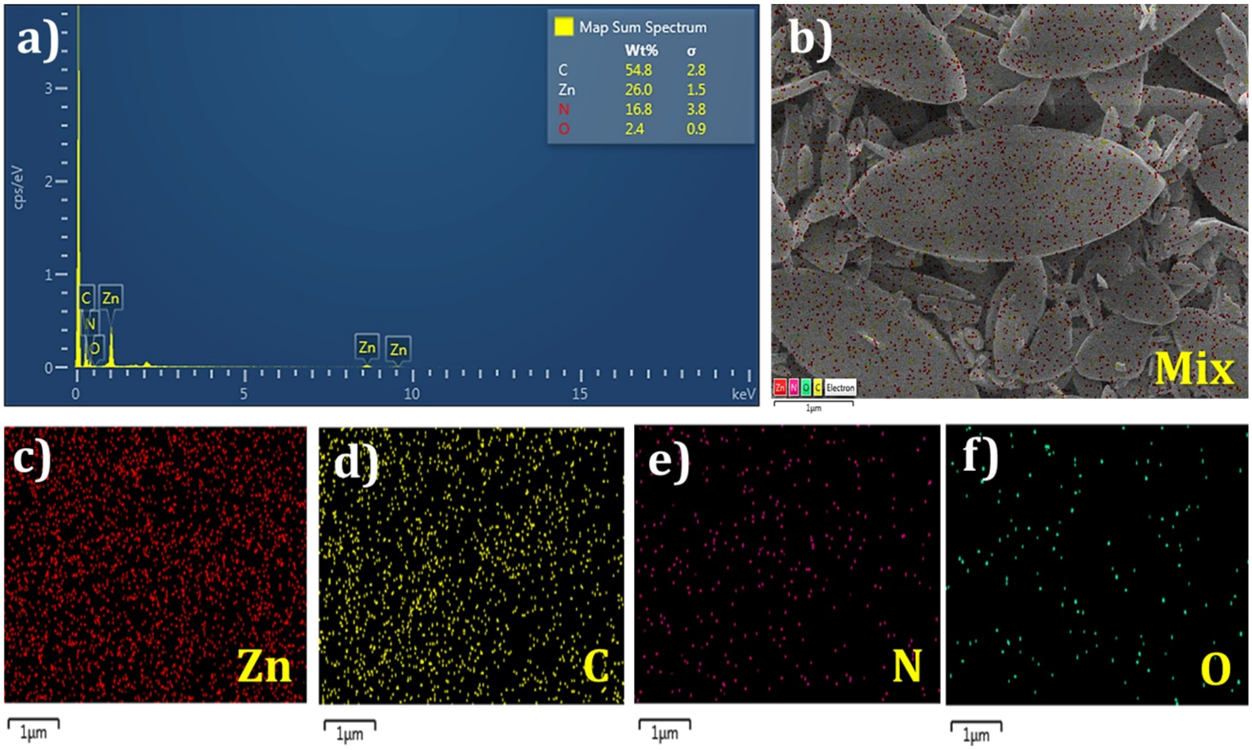

Fig. S1 (a) EDX and elemental mapping of ZIF-L (b) Mix, (c) Zn, (d) C, (e) N, and (f) O.

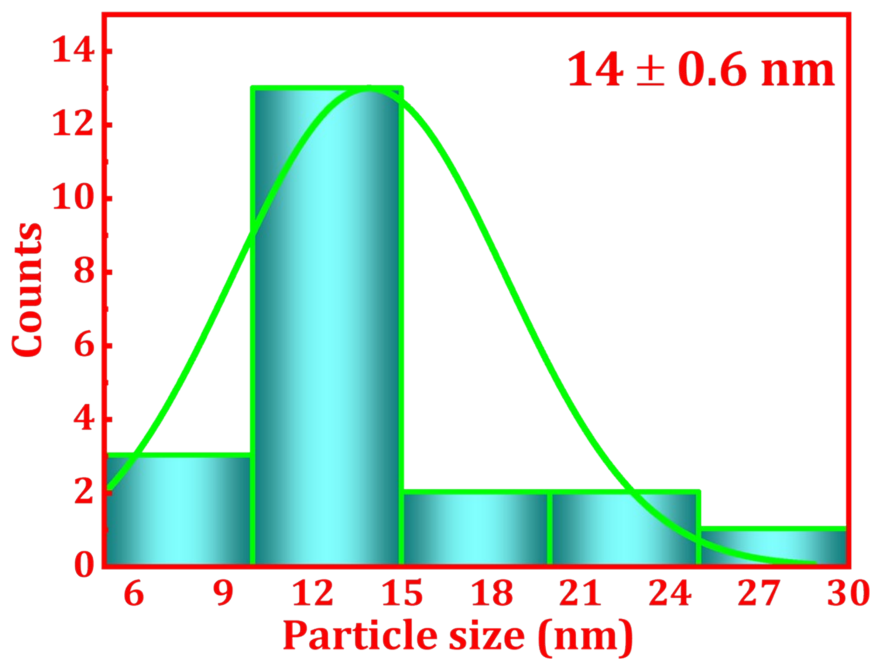

Fig. S2 Particle size distribution of ZnS@N/C nanodots.

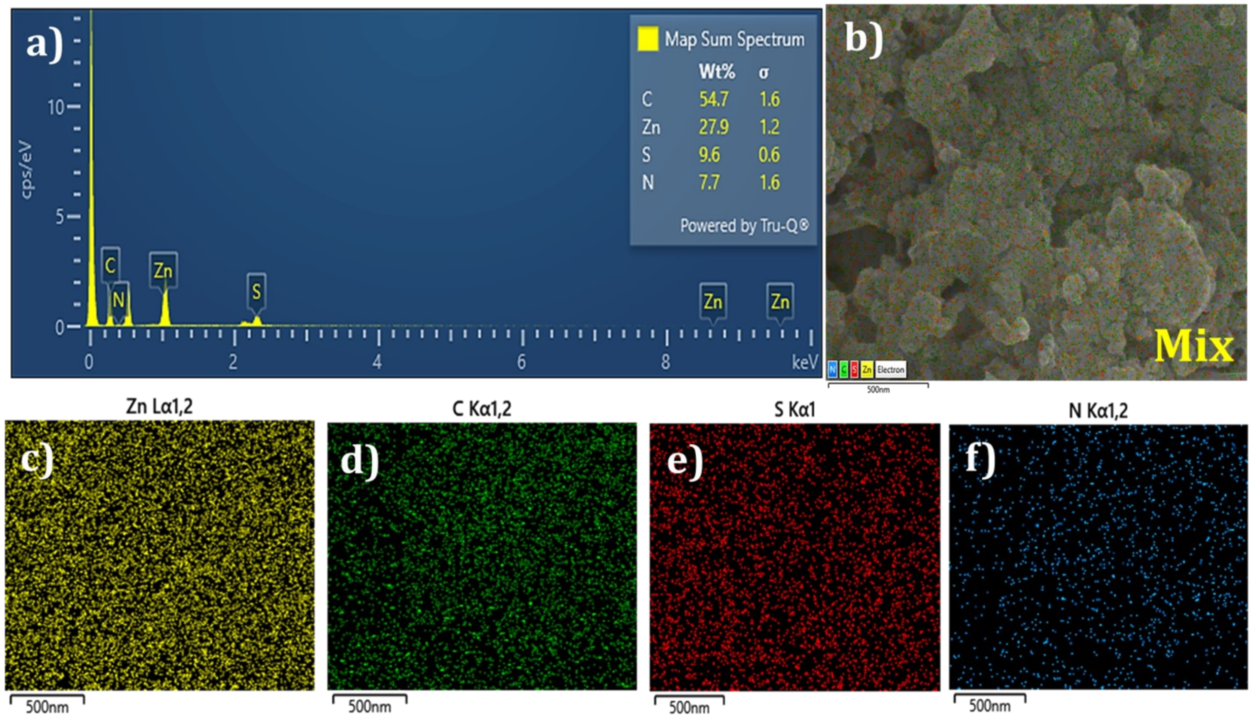

Fig. S3 (a) EDX and elemental mapping of ZnS@N/C nanodots (b) Mix, (c) Zn, (d) C, (e) S, and (f) N.

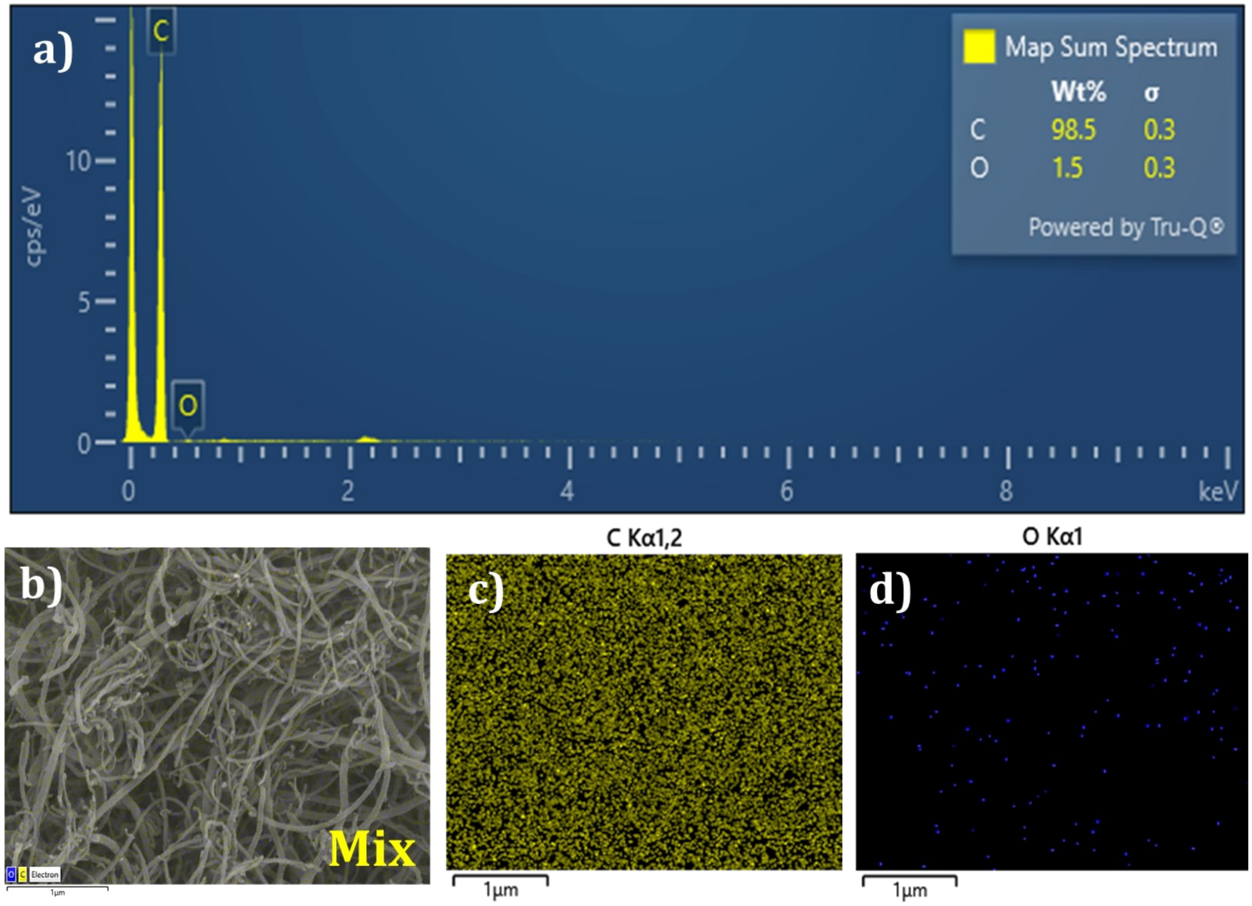

Fig. S4 (a) EDX and elemental mapping of pristine MWCNT, (b) Mix, (c) C, and (d) O.

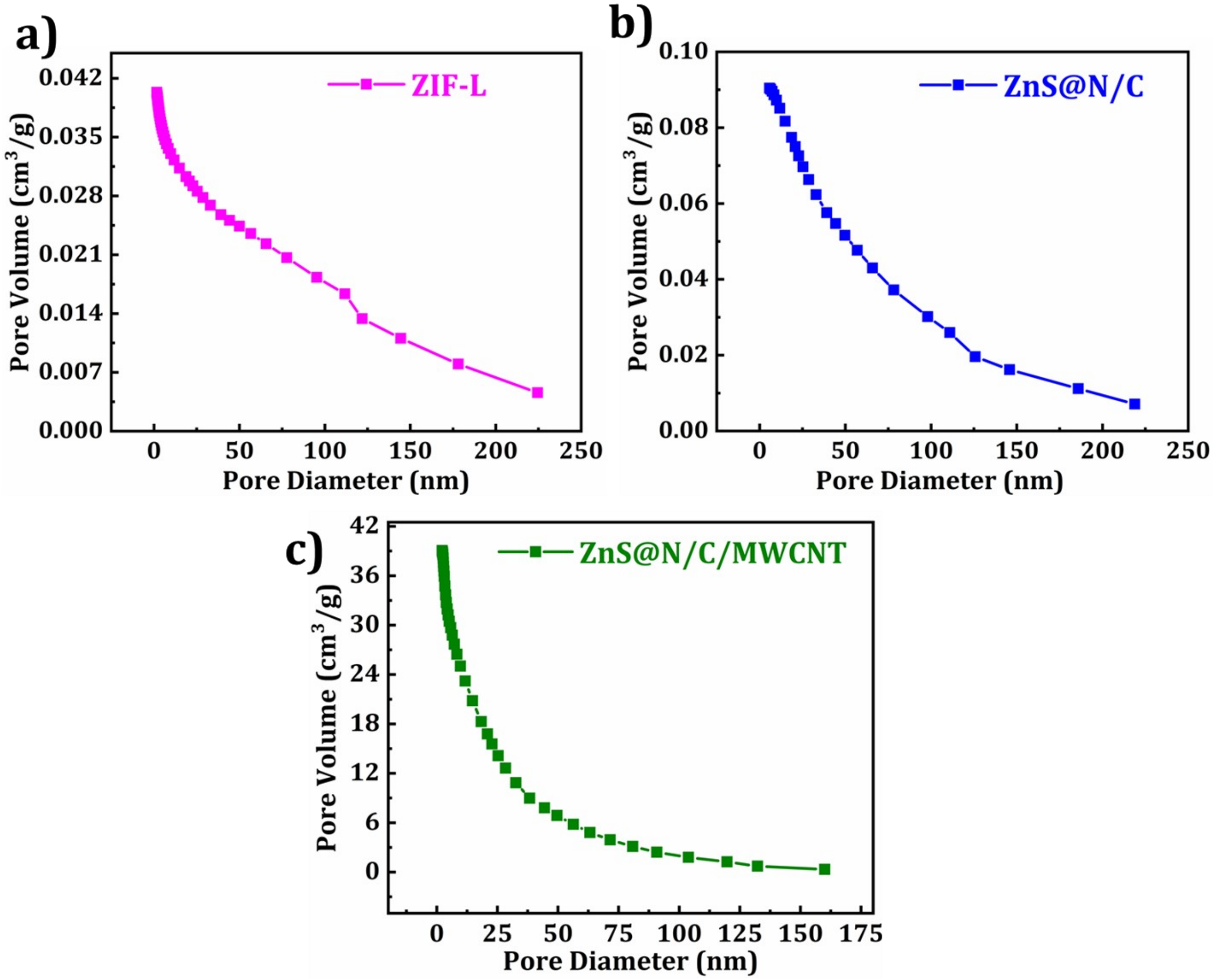

Fig. S5 Barrett–Joyner–Halenda (BJH) pore size distribution curves of (a) ZIF-L, (b) ZnS@N/C, and (c) ZnS@N/C/MWCNT.

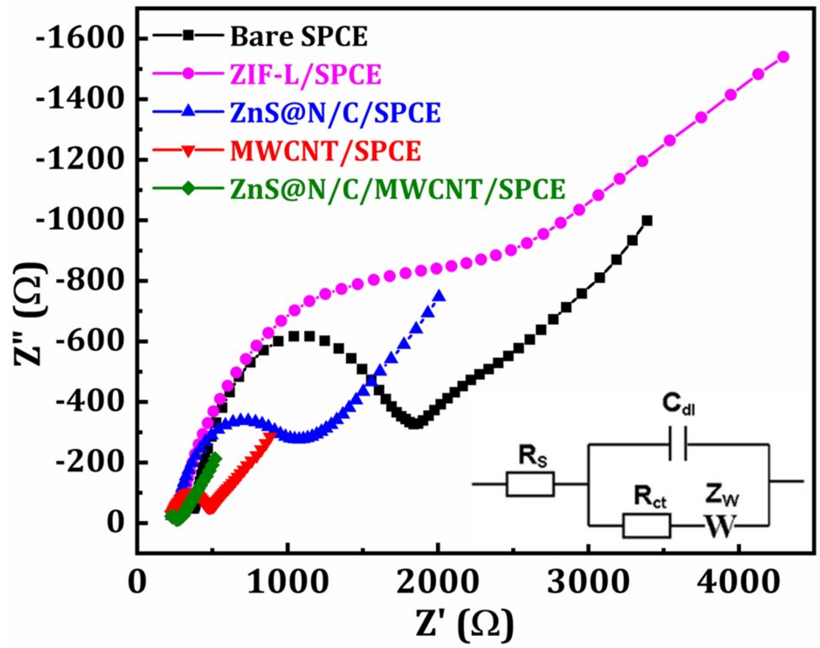

Fig. S6 EIS results of Bare SPCE, ZIF-L, ZnS@N/C, MWCNT, ZnS@N/C/MWCNT modified SPCEs in a 0.1 M KCl + 5 mM $[Fe(CN)_6]^{3-/4-}$ solution with a scan rate of 0.05 V/s.

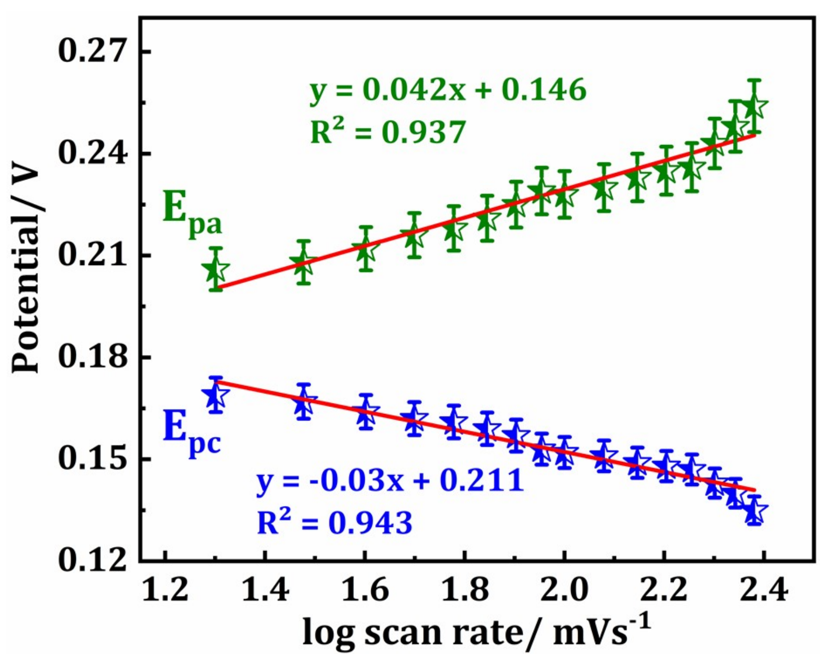

Fig. S7 Calibration plot of logarithmic scan rate versus peak potentials (E_{pa} and E_{pc}).

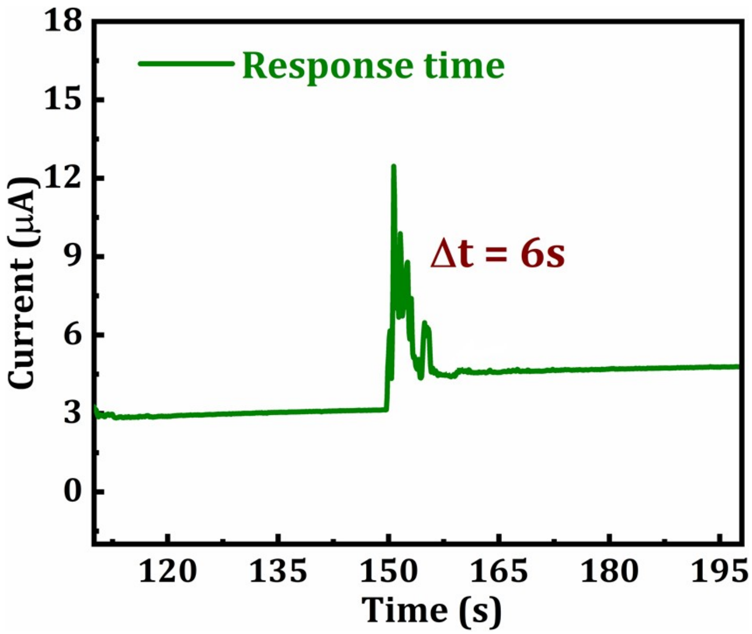

Fig. S8 Response time for steady-state current measured by amperometry technique.

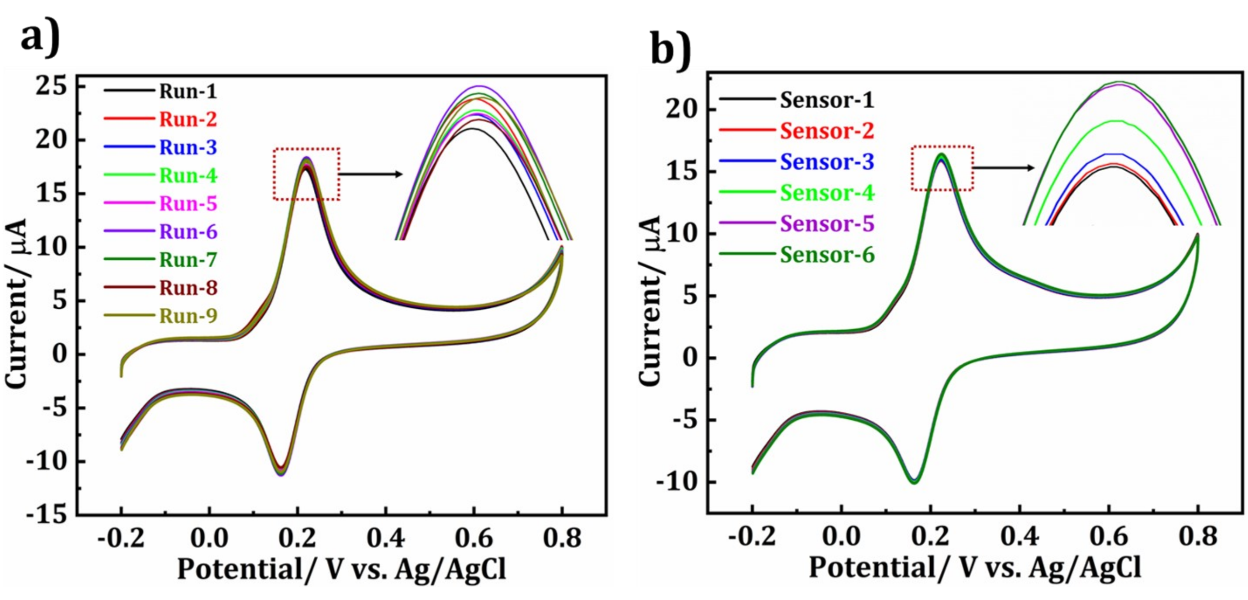

Fig. S9 (a) Repeatability test and (b) reproducibility test of DA sensor (electrolyte conditions: 0.1 M PBS (pH=7.0) +100 μM DA, scan rate: 0.05 Vs^{-1}).

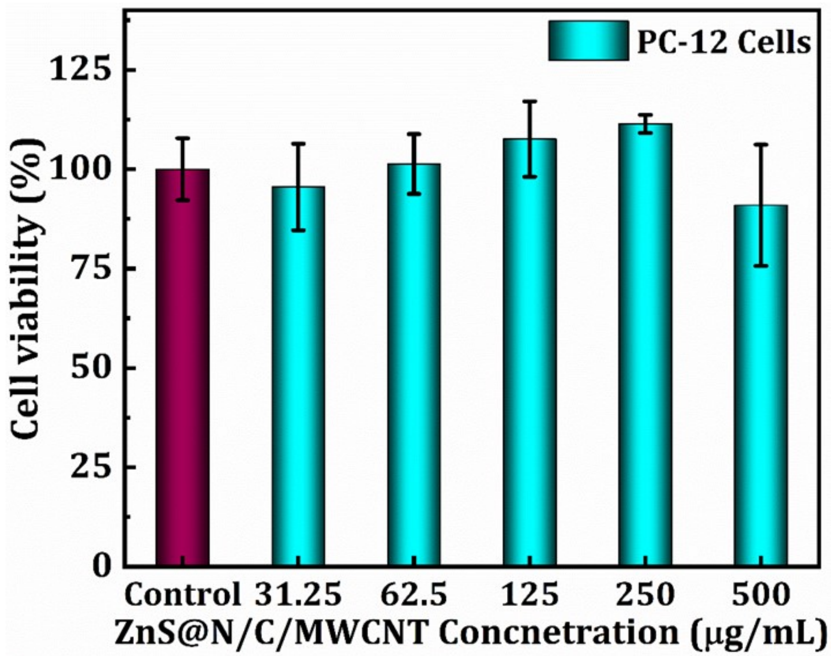

Fig. S10 Cell viability test of ZnS@N/C/MWCNT with PC-12 cells.

Table S1 Electroanalytical characteristics of the ZnS@N/C/MWCNT modified electrode compared with previously reported methods for electrochemical detection of dopamine.

Modified electrode	Detection method	LOD (μM)	Linear range (μM)	Ref.
AuNPs@$MoSe_2$/SPCE	LSV	0.21	3-20	1
MWCNT-BPVCM-e/GCE	CV	2.3	5-1000	2
$MnFe_2O_4$/MoS_2/SPCE	DPV	0.41	1-100	3
GR/β-CD/GCE	DPV	0.011	0.1-58.5	4
Pt-Ag/GR/GCE	DPV	0.012	0.1-60	5
rGO-SPCE	CV	0.1	0.20-500	6
rGO-PEDOT: PSS/GCE	DPV	0.4	3-33	7
AgNPs-GO/ ITO	CV, Amperometry	0.2	0.1-100	8
$CuCrO_2$-TiO_2/SPCE	DPV	0.14	1-230	9
CoFe-LDH/GCE	DPV	0.08	2-900	10
ZnS-Sb_2S_3/C/GCE	Amperometry	0.6	0.21-710	11
Au@Pt/GO/GCE	Amperometry	0.11	0.5-177.5	12
VS_2-SnS_2/f- MWCNT/GCE	Amperometry	0.008	0.025–1017	13
Ga_2O_3·ZnO@SWCNT/GCE	Amperometry	0.052	1-2056	14
ZnS@NC/MWCNT/SPCE	**Amperometry**	**0.00397**	**0.0125-1774**	**This work**

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