List of figures

Figure 1.1: (a) Potential excitation signal used for CV (b) Typical CV response for an electrochemically reversible system.
Figure 1.2: Excitation signals for pulse techniques and output I-E behaviors.
Figure 1.3: (a) Potential excitation signal used for amperometry (b) formation of concentration gradient (c) typical chronoamperogram.
Figure 1.4: Pathway of general electrode reaction.
Figure 2.1: Simplified scheme of an electrochemical system designed for electroanalysis.
Figure 2.2: Schematic representation of a common electrochemical cell.
Figure 2.3: (a) CVs of $6.0 \times 10^{-3}$ M K3[Fe(CN)6] in 1.0 M KCl at CPE using various scan rates. (b) Plot of variation of Ipa with a square root of scan rate at CPE.
Figure 2.4: Nyquist plot of an electrochemical system.
Figure 2.5: Randle's equivalent circuit diagram for Nyquist diagram.
Figure 3.1: Structure of dopamine.
Figure 3A.1: Structure of GO.
Figure 3A.2: (a) PXRD pattern and (b) IR spectrum of GO.
Figure 3A.3: Plot of Ipa of $1.0 \times 10^{-3}$ M DA with various quantities of GO in CPE matrix.
Figure 3A.4: CVs of $1.0 \times 10^{-3}$ M DA in 0.1 M KPBS of pH 7.0 at CPE (dashed line), MCPE/GO (solid line) and blank (dotted line). Scan rate: 50 mV s$^{-1}$.
Figure 3A.5: Plot of variation of Ipa with (a) concentrations of DA (b) square root of scan rate for DA at MCPE/GO.
Figure 3A.6: Plot of variation of (a) Ipa and (b) Epa of DA in 0.1 M KPBS of different pH at MCPE/GO. Scan rate: 50 mV s$^{-1}$.
Figure 3A.7: CVs of (a) $2.0 \times 10^{-3}$ M AA and (b) $1.0 \times 10^{-3}$ M UA in 0.1 M KPBS of pH 7.0 at CPE (dashed line) and MCPE/GO (solid line). Scan rate: 50 mV s$^{-1}$.
Figure 3A.8: Plot of variation of Ipa with concentrations of (a) AA and (b) UA at MCPE/GO in 0.1 M KPBS of pH 7.0. Scan rate: 50 mV s$^{-1}$.
Figure 3A.9: Plot of variation of Ipa with (a) square root of scan rate for AA (b) scan rate for UA at MCPE/GO in 0.1M KPBS of pH 7.0.
Figure 3A.10: (a) CVs of mixture of DA ($5.0 \times 10^{-3}$ M), AA ($2.0 \times 10^{-3}$ M) and UA ($1.0 \times 10^{-3}$ M) with a scan rate of 50 mV s$^{-1}$ at CPE (dashed line) and MCPE/GO (solid line). (b) CVs of mixture of DA, AA and UA (solid line) overlaid with individual CVs of AA (dashed line), DA (dotted line) and UA (dash dotted line) at MCPE/GO.
Figure 3A.11: Effects of variation of (a) pulse amplitude, (b) pulse width and (c) pulse interval on DPV peak current of $1.0 \times 10^{-4}$ M DA in 0.1 M KPBS of pH 7.0.

Figure 3A.12: (a) DPVs of various concentrations of DA at MCPE/GO in 0.1 M KPBS of pH 7.0. DA concentrations (in $\mu$M): 500, 300, 100, 70, 50, 20, 9, 7, 5, 3, 1, 0.7 and blank (a→m). Scan rate: 5 mV s$^{-1}$ and pulse amplitude: 50 mV. (b) Calibration plot of Ipa versus concentration of DA.

Figure 3A.13: (a) DPVs of solutions containing $5.0 \times 10^{-3}$ M AA, $1.0 \times 10^{-3}$ M UA and various DA concentrations (in $\mu$M): 100, 50, 30, 10, 7, 5, 3, 1, 0.8 and blank (a→j) at MCPE/GO. Scan rate: 5 mV s$^{-1}$ and Pulse amplitude: 50 mV. (b) Calibration plot of Ipa versus concentration of DA in the mixture containing AA and UA.

Figure 3B.1: Structure of Gly.

Figure 3B.2: Effects of (a) concentration of Gly (b) scan rate and (c) number of cycles on Ipa of $5.0 \times 10^{-4}$ M DA in 0.1 M KPBS of pH 7.0.

Figure 3B.3: Effect of MWCNT$_{SOX}$ loading on Ipa of $5.0 \times 10^{-4}$ M DA in 0.1 M KPBS of pH 7.0.

Figure 3B.4: CVs resulted for the electropolymerization of 0.04 M Gly in 0.2 M ABS of pH 5.0 at (a) CPE (b) MCPE/MWCNT$_{SOX}$.

Figure 3B.5: SEM images of (a) CPE, (b) MCPE/MWCNT$_{SOX}$, (c) MCPE/Gly and (d) MCPE/MWCNT$_{SOX}$/Gly.

Figure 3B.6: EDS analysis of (a) CPE, (b) MCPE/MWCNT$_{SOX}$, (c) MCPE/Gly and (d) MCPE/MWCNT$_{SOX}$/Gly.

Figure 3B.7: Nyquist plots of $5.0 \times 10^{-4}$ M DA in 0.1 M KPBS of pH 7.0 using different electrodes at Epa of DA.

Figure 3B.8: Equivalent circuit used for fitting impedance data.

Figure 3B.9: CVs of $5.0 \times 10^{-4}$ M DA in 0.1 M KPBS of pH 7.0 at CPE (dash dot line), MCPE/MWCNT$_{SOX}$ (dotted line), MCPE/Gly (dashed line) and MCPE/MWCNT/Gly (solid line). Scan rate: 50 mV s$^{-1}$.

Figure 3B.10: Plot of variation of Ipa with (a) concentrations of DA (b) scan rate for DA at MCPE/MWCNT$_{SOX}$/Gly in 0.1 M KPBS of pH 7.0.

Figure 3B.11: Plot of variation of (a) Epa and (b) Ipa of DA in 0.1 M KPBS of different pH at MCPE/MWCNT$_{SOX}$/Gly. Scan rate : 50 mV s$^{-1}$.

Figure 3B.12: CVs of $5.0 \times 10^{-4}$ M AA in 0.1 M KPBS of pH 7.0 at CPE (dash dot line), MCPE/MWCNT$_{SOX}$ (dotted line), MCPE/Gly (dashed line) and MCPE/MWCNT/Gly (solid line). Scan rate: 50 mV s$^{-1}$.
Figure 3B.13: Plot of variation of Ipa with (a) concentrations of AA (b) scan rate for AA at MCPE/MWCNTs<sub>OX</sub>/Gly in 0.1 M KPBS of pH 7.0.

Figure 3B.14: CVs of 5.0 × 10<sup>-4</sup> M UA in 0.1 M KPBS of pH 7.0 at CPE (dash dot line), MCPE/MWCNTs<sub>OX</sub> (dotted line), MCPE/Gly (dashed line) and MCPE/MWCNT/Gly (solid line). Scan rate: 50 mV s<sup>-1</sup>.

Figure 3B.15: Plot of variation of Ipa with (a) concentrations of UA (b) scan rate for UA at MCPE/MWCNTs<sub>OX</sub>/Gly in 0.1 M KPBS of pH 7.0.

Figure 3B.16: (a) CVs of mixture of 5.0 × 10<sup>-4</sup> M DA, AA and UA at CPE (dash dotted line), MCPE/MWCNTs<sub>OX</sub> (dotted line), MCPE/Gly (dashed line) and MCPE/MWCNTs<sub>OX</sub>/Gly (solid line) in 0.1 M KPBS of pH 7.0. Scan rate: 50 mV s<sup>-1</sup>. (b) CVs of mixture of DA, AA and UA (solid line) overlaid with individual CVs of AA (dashed line), DA (dotted line) and UA (dash dotted line) at MCPE/MWCNTs<sub>OX</sub>/Gly. Scan rate: 50 mV s<sup>-1</sup>.

Figure 3B.17: Effects of (a) Pulse amplitude, (b) Pulse width and (c) Pulse interval on DPV peak current 1.0 × 10<sup>-4</sup> M DA.

Figure 3B.18: (a) DPVs of various concentrations of DA at MCPE/MWCNTs<sub>OX</sub>/Gly in 0.1 M KPBS of pH 7.0. DA concentration (in mM): (a) 0.5, (b) 0.25, (c) 0.1, (d) 0.07, (e) 0.04, (f) 0.01, (g) 0.008, (h) 0.006, (i) 0.004, (j) 0.002, (k) 0.0009, (l) 0.0007, (m) 0.0005 and (n) blank. Scan rate: 5 mV s<sup>-1</sup>. (b) Calibration plot of Ipa versus concentration of DA.

Figure 3B.19: (a) DPVs of solutions containing 1.0 × 10<sup>-4</sup> M AA, 5.0 × 10<sup>-4</sup> M UA and various DA concentrations; 0.1, 0.07, 0.04, 0.01, 0.008, 0.006, 0.004, 0.002, 0.0009, 0.0007, 0.0005 mM and blank (a→l) at MCPE/MWCNTs<sub>OX</sub>/Gly in 0.1 M KPBS of pH 7.0. Scan rate: 5 mV s<sup>-1</sup>. (b) Calibration plot of Ipa versus concentration of DA in ternary mixture.

Figure 4.1: Structure of epinephrine.

Figure 4.2: Structure of SDS.

Figure 4.3: FE–SEM images of (a) CPE, (b) MCPE/pMWCNTs, (c) MCPE/SDS and (d) MCPE/pMWCNTs/SDS.

Figure 4.4: EDX analyses of (a) CPE, (b) MCPE/pMWCNTs, (c) MCPE/SDS and (d) MCPE/pMWCNTs/SDS.

Figure 4.5: Nyquist plots of 5.0 × 10<sup>-4</sup> M EP in 0.1 M KPBS of pH 7.0 at different electrodes.

Figure 4.6: The equivalent circuit used for the analysis.
Figure 4.7: CVs of $5.0 \times 10^{-4}$ M EP in 0.1 M KPBS of pH 7.0 at CPE (dotted line), MCPE/pMWCNTs (short dashed line), MCPE/SDS (dash dotted line), MCPE/pMWCNTs/SDS (solid) and blank (long dashed line). Scan rate: 50 mV s$^{-1}$.

Figure 4.8: CVs of $5.0 \times 10^{-4}$ M EP in 0.1 M KPBS of pH 7.0 at MCPE/pMWCNTs (short dashed line), MCPE/pMWCNTs/SDS (solid), MCPE/MWCNT$_{OX}$ (dotted line) and MCPE/MWCNT$_{OX}$/SDS (dash dotted line). Scan rate: 50 mV s$^{-1}$.

Figure 4.9: Plot of variation of $I_{pa}$ with square root of scan rate for $5.0 \times 10^{-4}$ M EP at MCPE/pMWCNTs/SDS.

Figure 4.10: Plot of variation of (a) $I_{pa}$ and (b) $E_{pa}$ of $5.0 \times 10^{-4}$ M EP in 0.1 M KPBS of different pH at MCPE/pMWCNTs/SDS. Scan rate: 50 mV s$^{-1}$.

Figure 4.11: (a) Chronoamperograms of different concentrations of EP at MCPE/pMWCNTs/SDS, (b) plot of $I_{pa}$ vs. $t^{-1/2}$ and (c) plot of slope against concentrations of EP.

Figure 4.12: Plot of variation of $I_{pa}$ of $5.0 \times 10^{-4}$ M EP with different quantities of pMWCNTs.

Figure 4.13: Plot of variation of $I_{pa}$ of $5.0 \times 10^{-4}$ M EP with different concentrations of SDS.

Figure 4.14: (a) Amperometric current response of different concentrations of EP at MCPE/pMWCNTs/SDS in 0.1 M KPBS of pH 7.0 under hydrodynamic conditions. Applied potential: 215.0 mV. (b) Calibration plot of $I_{pa}$ vs. concentration of EP at MCPE/pMWCNTs/SDS.

Figure 4.15: Amperometric response of $3.0 \times 10^{-7}$ M DA, $1.0 \times 10^{-6}$ M AA, $1.0 \times 10^{-5}$ M 5-HT, AAP, FA, UA, Trp, Tyr, Cys and $5.0 \times 10^{-6}$ M EP at MCPE/pMWCNTs/SDS. Applied potential: 215.0 mV.

Figure 4.16: Amperometric response of $1.0 \times 10^{-4}$ M EP at MCPE/pMWCNTs/SDS for 30.0 minutes in 0.1 M KPBS of pH 7.0. Applied potential: 215.0 mV.

Figure 5.1: Structure of Trp.

Figure 5.2: FE-SEM images of (a) CPE and (b) MCPE/MWCNT$_{OX}$.

Figure 5.3: Nyquist plots of $5.0 \times 10^{-4}$ M Trp in 0.1 M KPBS of pH 7.0 using different electrodes at the $E_{pa}$ Trp.

Figure 5.4: The equivalent circuit used for fitting the Nyquist plot.

Figure 5.5: CVs of $5.0 \times 10^{-4}$ M Trp in 0.1 M KPBS of pH 7.0 at CPE (dashed line) and MCPE/MWCNT$_{OX}$ (solid line). Scan rate: 50 mV s$^{-1}$. 

Figure 5.6: (a) Plot of variation of Ipa with scan rate for 5.0 \times 10^{-4} \text{ M Trp in 0.1 M KPBS of pH 7.0 at MCPE/MWCNTsOXC.} (b) Plot of variation of Ipa with concentration of Trp at MCPE/MWCNTsOXC in KPBS of pH 7.0. Scan rate: 50 \text{ mV s}^{-1}.

Figure 5.7: Plot of Ipa of 1.0 \times 10^{-3} \text{ M Trp with different quantities of MWCNTsOXC.}

Figure 5.8: Plot of variation of (a) Ipa and (b) Epa of 5.0 \times 10^{-4} \text{ M Trp in 0.1 M KPBS of different pH at MCPE/MWCNTsOXC. Scan rate: 50 mV s}^{-1}.

Figure 5.9: (a) Amperometric current response of different concentrations of Trp at MCPE/MWCNTsOXC in 0.1 M KPBS of pH 7.0 under hydrodynamic conditions. Applied potential: 645.0 \text{ mV}. (b) Calibration plot of Ipa versus concentration of Trp at MCPE/MWCNTsOXC.

Figure 5.11: Amperometric response of 1.0 \times 10^{-4} \text{ M Trp at MCPE/MWCNTsOXC for 30.0 min in 0.1 M KPBS of pH 7.0. Applied potential: 645.0 mV.}

Figure 6.1: Structure of AAP.

Figure 6.2: Structure of PR reagent.

Figure 6.3: SEM images of (a) CPE and (b) MCPE/PR.

Figure 6.4: Effects of (a) concentration of PR (b) scan rate and (c) number of cycles on Ipa of 5.0 \times 10^{-4} \text{ M AAP in 0.1 M ABS of pH 5.0.}

Figure 6.5: Ten consecutive CVs of 1.0 \times 10^{-5} \text{ M PR reagent in 0.1 M KPBS of pH 8.0 at (a) CPE and (b) MCPE/MWCNTsOXC for the formation of poly(PR reagent). Scan rate: 50 mV s}^{-1}.

Figure 6.6: Nyquist plots of 5.0 \times 10^{-4} \text{ M AAP in 0.1M ABS of pH 5.0 using different electrodes at their oxidation peak potential.}

Figure 6.7: Equivalent circuit used for the fitting of impedance data.

Figure 6.8: CVs of 5.0 \times 10^{-4} \text{ M AAP in 0.1 M ABS of pH 5.0 at CPE (dashed line), MCPE/MWCNTsOXC (short dashed line), MCPE/MWCNTsOXC/PR (dotted line), MCPE/PR (solid line) and blank (dash dot line) at MCPE/PR. Scan rate: 50 mV s}^{-1}.

Figure 6.9: (a) Plot of variation of Ipa with concentration of AAP at MCPE/PR in 0.1 M ABS of pH 5.0. Scan rate: 50 \text{ mV s}^{-1}. (b) Plot of variation of Ipa with scan rate for AAP at MCPE/PR in 0.1 M ABS of pH 5.0.

Figure 6.10: Plots of variation of (a) Ipa and (b) Epa of AAP with ABS of different pH at MCPE/PR. Scan rate: 50 \text{ mV s}^{-1}.

Figure 6.11: Effects of variation of (a) pulse amplitude, (b) pulse width (c) pulse interval on DPV peak current 1.0 \times 10^{-4} \text{ M AAP in 0.1 M ABS of pH 5.0.}
Figure 6.12: (a) DPVs of various concentrations of AAP at MCPE/PR in 0.1 M ABS of pH 5.0. AAP concentration (in μM): 100, 70, 40, 10, 8, 6, 4, 2, 0.9, 0.7 and blank (a→j). Scan rate: 5 mV s$^{-1}$ and Pulse amplitude: 100 mV. (b) Calibration plot of Ipa versus concentration of AAP.

Figure 6.13: (a) DPVs of solutions containing 100 μM 4-AP and various AAP concentrations: 100, 70, 40, 10, 7, 4, 2, 0.9 and 0.7 μM (a→i) at MCPE/PR. Scan rate: 5 mV s$^{-1}$ and pulse amplitude: 100 mV. (b) Calibration plot of Ipa versus concentration of AAP in binary mixture.

Figure 7.1: Effects of variation of (a) concentration of CM (b) scan rate and (c) number of cycles on Ipa of 1.0 × 10$^{-3}$ M Hg$^{2+}$ in 0.1 M KCl.

Figure 7.2: Effect of MWCNT$_{SOX}$ loading on Ipa of 1.0 × 10$^{-3}$ M Hg$^{2+}$ in 0.1 M KCl.

Figure 7.3: CVs resulted for the electropolymerization of 1.0 × 10$^{-5}$ M CM in 0.5 M KPBS of pH 8.0 at (a) CPE (b) MCPE/MWCNT$_{SOX}$.

Figure 7.4: Effect of supporting electrolytes on Ipa of 1.0 × 10$^{-3}$ M Hg$^{2+}$.

Figure 7.5: Nyquist plots of 1.0 × 10$^{-3}$ M Hg$^{2+}$ in 0.1 M KCl solution using different electrodes at Epa of Hg$^{2+}$.

Figure 7.6: Equivalent circuit used for fitting impedance data.

Figure 7.7: CVs of 1.0 × 10$^{-3}$ M Hg$^{2+}$ in CPE (red), MCPE/MWCNT$_{SOX}$ (magenta), MCPE/CM (blue), MCPE/MWCNT$_{SOX}$/CM (black) and blank (green) in 0.1 M KCl solution. Scan rate: 50 mV s$^{-1}$.

Figure 7.8: Effect of variation of stripping peak current with (a) deposition potential and (b) deposition time for 1.0 × 10$^{-4}$ M Hg$^{2+}$ in 0.1 M KCl using DPSV. Scan rate: 5 mV s$^{-1}$.

Figure 7.9: Effects of (a) pulse amplitude, (b) pulse width and (c) pulse interval on stripping peak current of 1.0 × 10$^{-4}$ M Hg$^{2+}$ in 0.1 M KCl.

Figure 7.10: DPSVs of various concentrations of Hg$^{2+}$ in MCPE/MWCNT$_{SOX}$/CM in 0.1 M KCl solution. Hg$^{2+}$ concentrations (in μM): 100, 80, 60, 40, 20, 10, 8, 6, 4, 2, 1 and blank (a→l). Scan rate: 5 mV s$^{-1}$. (b) Calibration plot of Ipa versus concentration of Hg$^{2+}$.

Figure 7.11: Amperometric response of 1.0 × 10$^{-4}$ M Hg$^{2+}$ at MCPE/MWCNT$_{SOX}$/CM for 30.0 min in 0.1 M KCl solution. Applied potential: 50.0 mV.