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# *Electrochemical sensor based on amine and thiol modified multi-walled carbon nanotubes for sensitive and selective determination of uranyl ions in real water samples*

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## Supporting Information

### S1. Materials

All chemical reagents were of analytical grade and were used without further purification. Multi-walled carbon nanotubes (MWCNTs) Multi-walled carbon nanotubes (MWCNTs) (>98% carbon basis, O.D. × L (6-13 nm × 2.5-20 μm), size (10 μm , average length, TEM), surface area (~220 $m^2/g$)), graphite powder (particle size < 20 μm, density 2.26 $g/cm^3$), melamine, uranyl acetate, potassium chloride (KCl), dicyclohexyl carbodiimide (DCC), amino thiazole (AT), dimethylformamide (DMF), hydrochloric acid, paraffin oil, nitric acid, and potassium ferrocyanide were purchased from Sigma Aldrich. Nickel chloride, copper chloride, mercury chloride, barium chloride, lead nitrate, cadmium sulfate, absolute ethanol, methanol, sodium chloride, potassium thiocyanate, sodium acetate, hexamine, sodium hydroxide, and acetic acid (AcOH) were obtained from Merck (Germany). Ultra-purified water (18 MΩ, Milli-Q system, Millipore, Bedford, MA, U.S.A.) was used to prepare the different solutions.

### S2. Instruments

The chemical modification of MWCNTs with AT, modified MWCNTs with MT ligand, MWCNTs, and oxidized MWCNTs was investigated using an FT-IR spectrometer (Nicolet iS10, Thermo Scientific USA), in the wavenumber range from 4000 $cm^{-1}$ to 400 $cm^{-1}$. Furthermore, the surface morphology of the prepared samples was elaborated by SEM (JSM 6510 LV, Jeol, Japan), XRD (Bruker Co, D8 Discover, Cu target, 40kv 40 mA, Germany), and XPS (Themo Fisher Scientific, USA). All electrochemical measurements, including cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and differential pulse stripping voltammetry (DPSV), were performed using a Gamry potentiostat (Interface 5000E/ potentiostat /galvanostat /ZRA) with a three-electrode system: modified CPE (working electrode), saturated calomel electrode (reference electrode), and a platinum wire (auxiliary electrode).

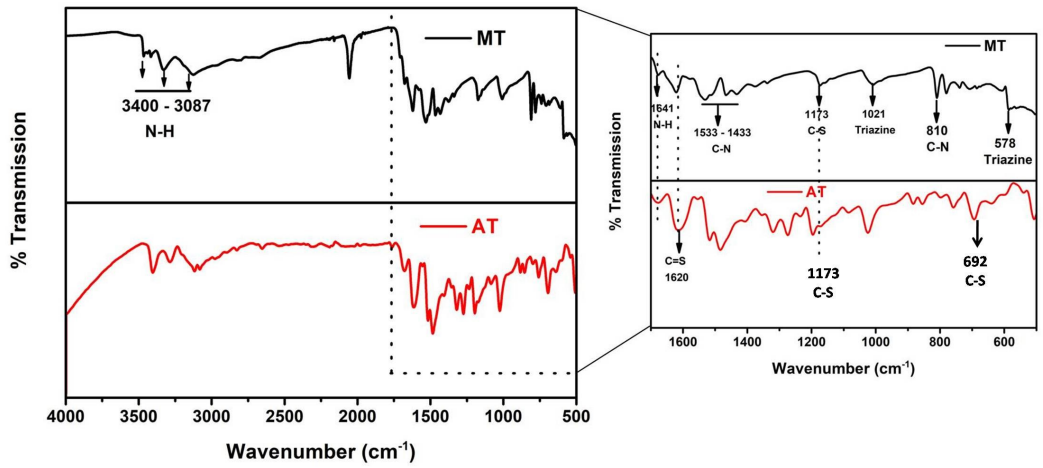



Figure S1: FTIR spectra of melamine thiourea (MT) and 2-aminothiazole ligands (AT).

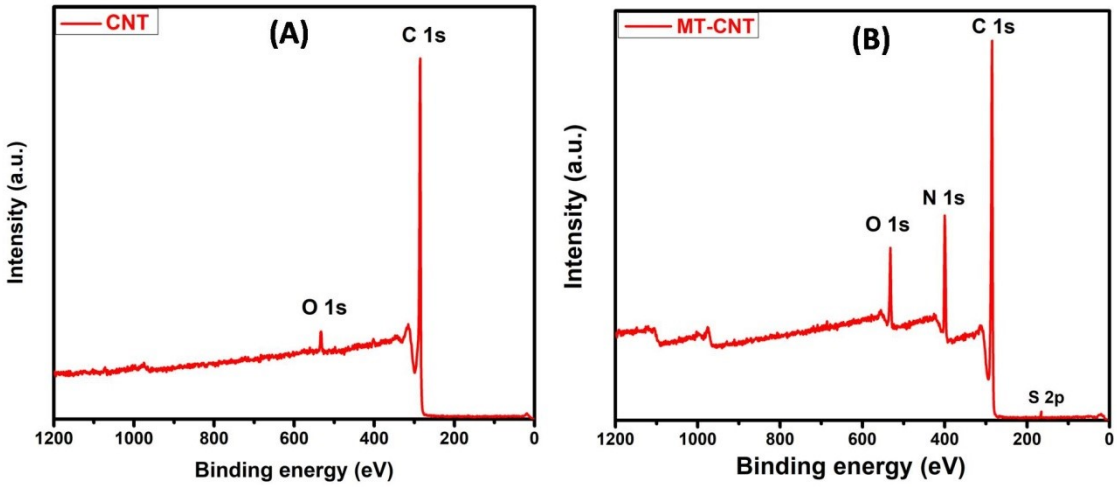



Figure S2 .XPS survey spectra of MWCNT(A), and MT-MWCNT(B)

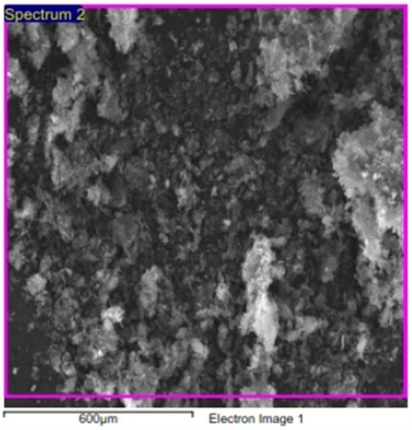
# (A)

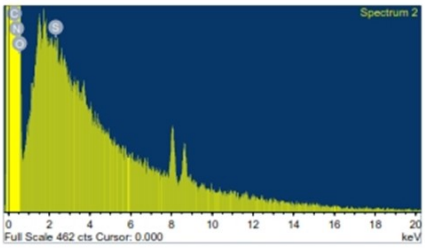
Spectrum processing :
Peaks possibly omitted : 1.492, 1.751, 8.047, 8.621 keV

Processing option : All elements analyzed (Normalised)
Number of iterations = 6

Standard :
C CaCO3 1-Jun-1999 12:00 AM
N Not defined 1-Jun-1999 12:00 AM
O SiO2 1-Jun-1999 12:00 AM
S FeS2 1-Jun-1999 12:00 AM

| Elem... | Weight% | Atomic% |
|---|---|---|
| C K | 72.54 | 77.23 |
| N K | 14.90 | 13.11 |
| O K | 11.51 | 9.26 |
| S K | 1.05 | 0.40 |
| Totals | 100.00 | |



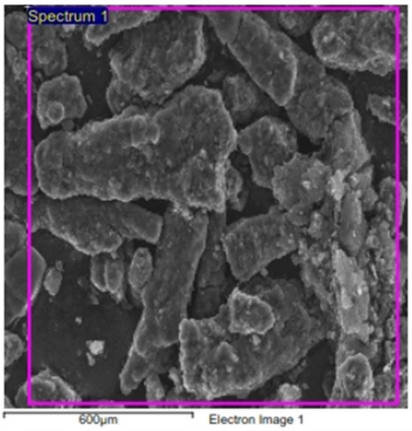

# (B)

Spectrum processing :
Peaks possibly omitted : 1.470, 3.697, 6.408, 8.050, 8.631 keV

Processing option : All elements analyzed (Normalised)
Number of iterations = 6

Standard :
C CaCO3 1-Jun-1999 12:00 AM
N Not defined 1-Jun-1999 12:00 AM
O SiO2 1-Jun-1999 12:00 AM
S FeS2 1-Jun-1999 12:00 AM

| Elem... | Weight% | Atomic% |
|---|---|---|
| C K | 67.95 | 73.06 |
| N K | 18.75 | 17.45 |
| O K | 10.72 | 8.46 |
| S K | 2.58 | 1.03 |
| Totals | 100.00 | |



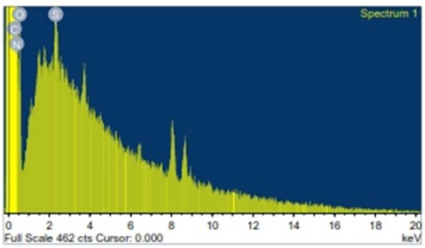



Figure S3 .EDX analysis of AT/MWCNT(A), and MT/MWCNT(B)

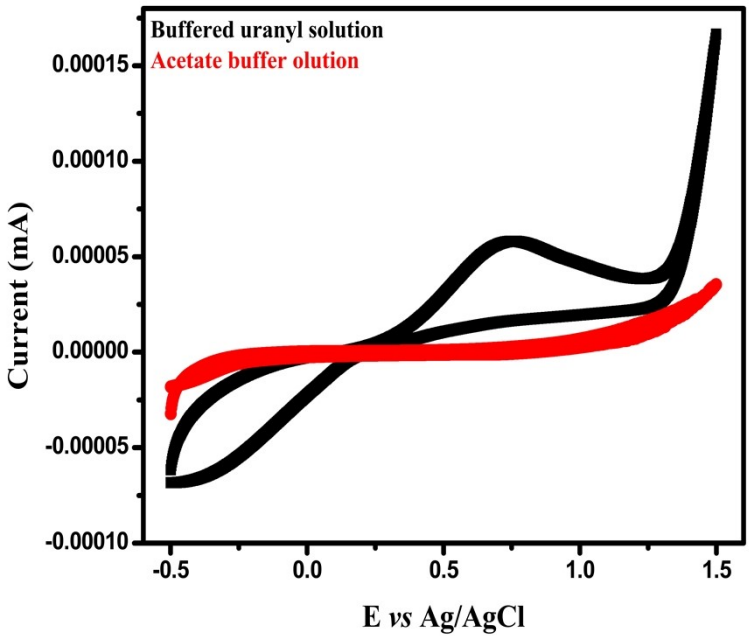



Figure S4. Cyclic voltammograms of buffered uranyl solution and acetate buffer (pH 2) only on CPE at scan rate 100 mVs.

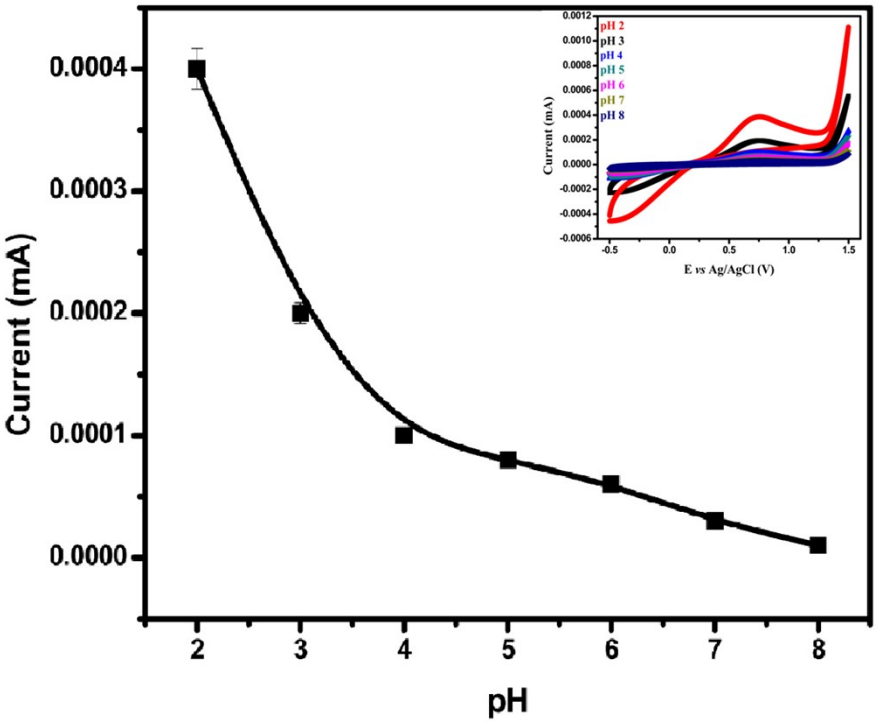



Figure S5. Effect of pH on the peak current of $UO_2^{+2}$ (5 x $10^{-3}$ mol $L^{-1}$)

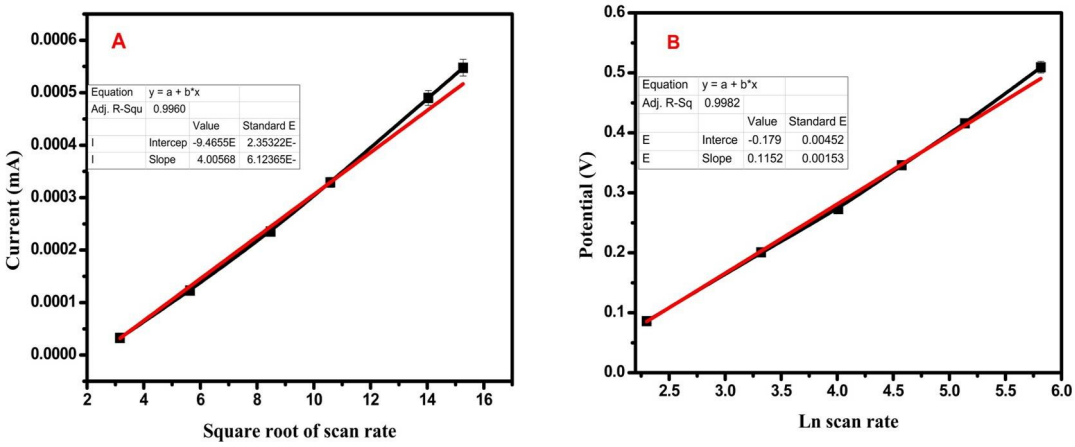



Figure S6**.** Effect of scan rate on the current (A) and on the peak potential (B) using MT-MWCNT@CPE.

**Table S1. The elemental composition of CNT and MT/MCNT from XPS analysis.**

| Sample | C 1s | O 1s | N 1s | S 2p |
|---|---|---|---|---|
| **CNT** | **95.91** | **3.69** | **0.2** | **0.2** |
| **MT/MCNT** | **79.12** | **6.17** | **13.51** | **1.2** |