Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Nitrogen doped carbon nanotubes for sensitive and selective determination of heavy metals

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Physical Characterization

The morphology of the synthesized material (N-CNT 200, N-CNT 400, N-CNT 600 & O-CNT) was characterized using scanning electron microscope (SEM, JEOL, JSM-66101 V) which suggests tubular appearance of the synthesized N-CNT.

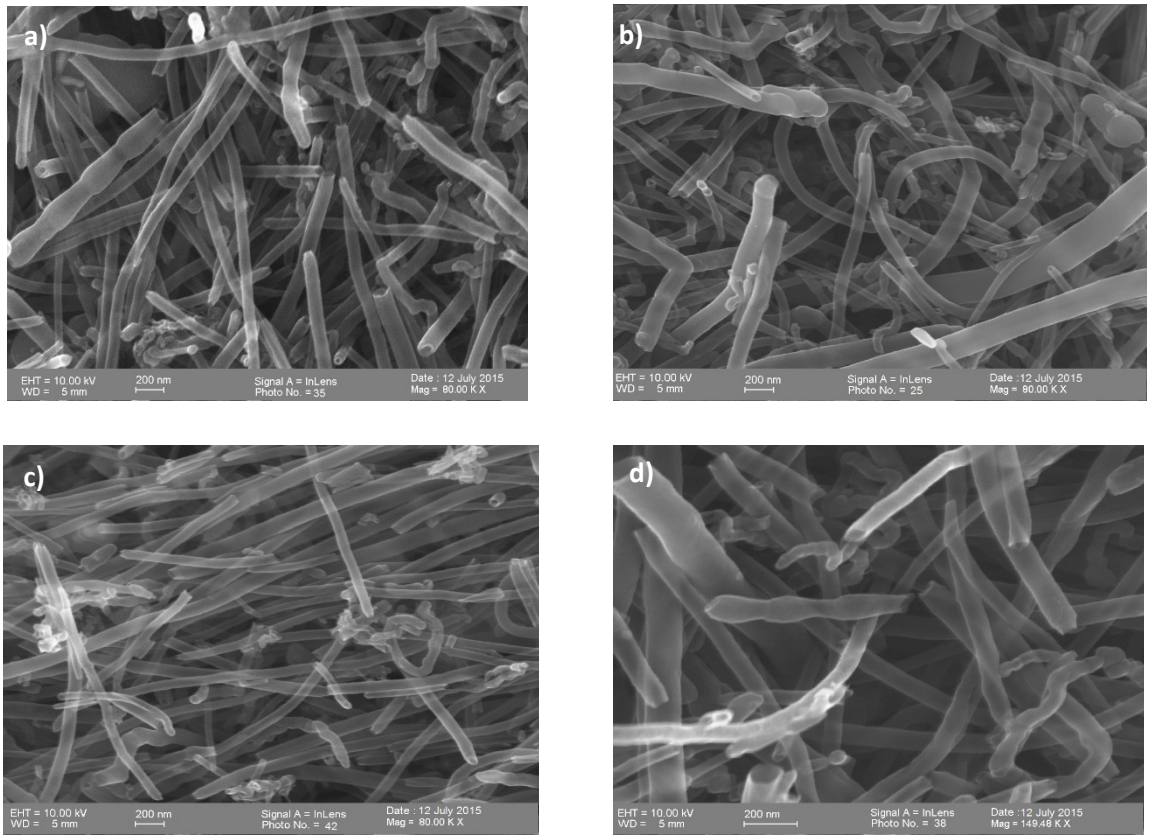

Fig. S1 : Scanning electron microscope images of synthesized a) N-CNT 200 b) N-CNT 400 c) N-CNT 600 d) N-CNT 800.

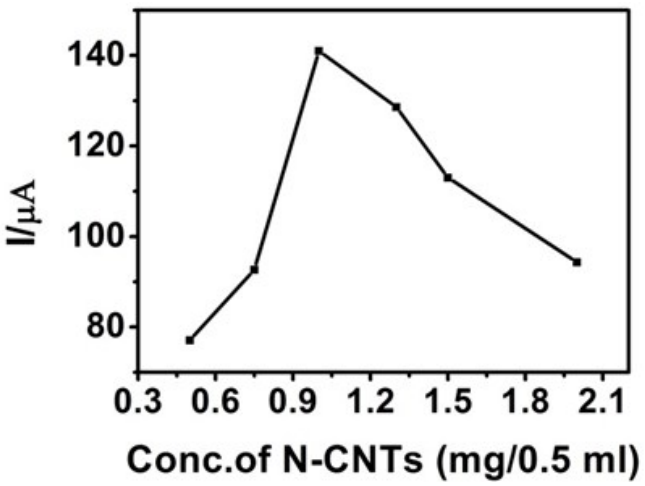

Fig. S2: Effect of concentration of the N-CNT 600 on the oxidation current in a solution containing 5 μM $Pb(NO_3)_2$ in 0.05 M sulphuric acid (pH 4.0) at a frequency of 15 Hz, step potential 0.3 mV, pulse amplitude 25 mV, scan rate 4.5 mVs^{-1}, CE: Pt wire, RE: Ag/AgCl/3M KCl

Fabrication of Bi modified glassy carbon electrode (Bi/GCE)

Bismuth modified GCE was fabricated using a previously reported literature.[1] Briefly, the solution were prepared by mixing tartaric acid (D+) and HNO_3 to make sufficiently acidic solution with subsequent addition of KNO_3 and glycerol (10 %) for proper dissolving of bismuth nitrate. Bismuth nanoparticles were deposited onto GCE using triple pulse voltage technique[2] employing Autolab potentiostat/galvanostat in a three electrode assembly. All potentials were referenced using Ag/AgCl/3M KCl. Deposition of metal particles was accomplished by step-edge oxidation at 0·18 V for 5 s. After that, the nucleation density at the step edges was increased by applying a very short (5 ms) nucleation pulse to initiate the nanoparticle growth. Thirdly, after this nucleation pulse is applied, subsequent growth is carried out at a potential of –0·075 V for 50 sec.

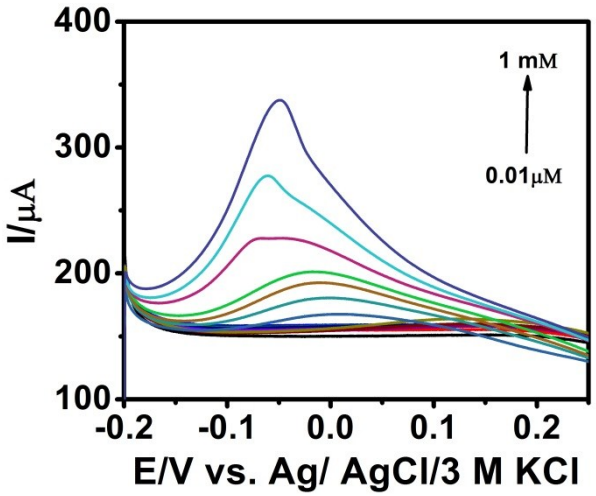

Fig. S3: Square wave voltammograms at N-CNT 600 modified GCE in 0.05 M H_2SO_4 (pH 4.0) at various concentration of Cu metal ions ranging from 0.001 μM – 1 mM at a frequency of 15 Hz, step potential 0.3 mV, pulse amplitude 25 mV, scan rate 4.5 mVs^{-1}, CE: Pt wire, RE: Ag/AgCl/3M KCl .

Table S1: Surface composition of O-CNTs and N-CNTs derived from C H N analysis.

Sample	C (%)	H(%)	N(%)
O-CNT	80.6	19.4	0
N-CNT 200	88.8	2.4	8.8
N-CNT 400	89.9	1.9	8.2
N-CNT 600	91.7	1.5	6.8
N-CNT 800	94.6	0.9	4.5

Table S2: Analytical parameters for simultaneous determination of Pb metal ions in presence of Cd metal ions using various CNTs

Sample	Regression Equation	Linear Range (µM)	R^2	Sensitivity (µA $µM^{-1}$ cm^{-2})
N-CNT 200	1.70x+112.63	0.01-70	0.98	24.062
N-CNT 400	5.57x+46.95	0.01-70	0.98	78.83
N-CNT 600	8.35x+67.60	0.01-70	0.98	118.18
O-CNT	3.34x+480.12	0.01-70	0.97	47.27

Table S3: Analytical parameters for simultaneous determination of Cd metal ions in presence of Pb metal ions using various CNTs

Sample	Regression Equation	Linear Range (µM)	R^2	Sensitivity (µA $µM^{-1}$ cm^{-2})
N-CNT 200	1.85x+23.47	0.1-100	0.97	26.18
N-CNT 400	2.28x+42.08	0.1-100	0.98	32.27
N-CNT 600	2.61x+71.48	0.1-100	0.99	37.15
O-CNT	1.76x+39.70	0.1-100	0.99	24.91

Table S4: Surface composition of O-CNTs and N-CNTs derived from XPS experiments[3 -4]

Sample	C %	O %	N %				
			N_{total}	N1	N2	N3	N4
OCNT	80.6	19.4	0	--	--	----	
N-CNT 200	84.5	9.5	6.0	1.7	4.3	----	----
N-CNT 400	89.5	4.8	5.7	3.5	1.8	0.4	----
N-CNT 600	93.3	2.4	4.3	2.2	1.4	0.5	0.2
N-CNT 800	95.5	1.6	2.9	1.2	0.8	0.7	0.2

Table S5: Analytical results of N-CNT 600 modified GCE towards determination of Pb and Cd metal ions from natural water resources (n=5)

Sample	Analyte	Concentration (Added) µM	Concentration (found) µM	Recovery (%)

Tap water (IIT Ropar)	**Cd**	**5**	**4.8**	**96**
	Pb	**2**	**2.1**	**105**
Groundwater	**Cd**	**1**	**1.1**	**110**
	Pb	**5**	**5.2**	**104**

References:

1. C. Pharamani, H. Thejaswini and S. Sampath, *Bulletin of Materials Science*, 2008, **31**, 207-212.
2. E. C. Walter, M. P. Zach, F. Favier, B. J. Murray, K. Inazu, J. C. Hemminger and R. M. Penner, *ChemPhysChem*, 2003, **4**, 131-138.
3. T. C. Nagaiah, S. Kundu, M. Bron, M. Muhler and W. Schuhmann, *Electrochemistry Communications*, 2010, **12**, 338-341.
4. S. Kundu, W. Xia, W. Busser, M. Becker, D. A. Schmidt, M. Havenith and M. Muhler, *Physical Chemistry Chemical Physics*, 2010, **12**, 4351-4359.