Fabrication and Application of Magnetite Coated N-doped Carbon Microtubes Hybrid Nanomaterials with Sandwich Structures

Min Zhang*, Liangfei Chen, Jing Zheng, Weizhen Li, Wenjun Gan*, Jingli Xu*†

College of Chemistry and Chemical Engineering, Shanghai University of Engineering Science, Shanghai 201620, PR China.

Synthesis of MnO$_2$@N-doped carbon@MnO$_2$ microtubes

20 mg N-doped carbon microtubes were dispersed into 30 mL of 0.01M KMnO$_4$ solution under high power ultrasonication for 1h. Then, the mixture was transferred to a Teflon-lined stainless steel autoclave (50 mL capacity) and heated at 180 °C for 3 h. The product was obtained by centrifugation and dried at 60 °C for 12 h.

Synthesis of MoS$_2$@N-doped carbon@MoS$_2$ microtubes

30 mg of N-doped carbon microtubes were dispersed in 30 mL dimethylformamide(DMF), and then 64 mg of (NH$_4$)$_2$MoS$_4$ was added. The mixture was sonicated at room temperature for approximately 60 mins until homogeneous. After that, 1mL NH$_3$·H$_2$O was added, and the obtained suspension was sonicated for another 60 min. The mixture was then transferred and sealed in an autoclave with a Teflon linear and was heated at 200 °C for 15 h to yield a dark brown precursor. The precursor was collected by centrifugation and washed with deionized (DI) water for at least 5 times to ensure a complete removal of DMF. The dried precursor was calcined under nitrogen atmosphere at 700 °C for 1 h, with a heating rate of 1 °C min$^{-1}$. 

Electronic Supplementary Material (ESI) for Dalton Transactions. This journal is © The Royal Society of Chemistry 2017
Fig. S1 Raman spectra for N-doped carbon microtubes.

Fig. S2 The optical images of N-doped carbon microtubes (a) and Fe₃O₄@N-doped carbon@Fe₃O₄ microtubes (b) dispersed in water for 30 seconds.
Fig. S3 The SEM and TEM imagines of Fe$_3$O$_4$@N-doped carbon@Fe$_3$O$_4$ microtubes with the different mass ratio of Fe(acac)$_3$ to N-doped carbon microtubes, (A,B,C), 0.5:1; (D,E,F), 2:1; (G,H,I), 4:1; (J,K,L), 10:1.

Fig. S4 The TEM images of Fe$_3$O$_4$@CNTs with the 60~100 diameter CNTs as the templates.
Fig. S5(A) The XPS spectra for the N-doped carbon microtubes (a) and Fe$_3$O$_4$@N-doped carbon@Fe$_3$O$_4$ microtubes (B) The N1s Spectra for the N-doped carbon microtubes (a) and Fe$_3$O$_4$@N-doped carbon@Fe$_3$O$_4$ microtubes (b).

Fig. S6 N$_2$ adsorption/desorption isotherm of N-doped carbon microtubes.

Fig. S7 X-Ray diffraction patterns of MoS$_2$@N-doped carbon@MoS$_2$ microtubes (a),...
Cu(Cu$_2$O)@N-doped carbon@Cu(Cu$_2$O) microtubes (b) and MnO$_2$@N-doped carbon@MnO$_2$ microtubes (c).