Supplementary Information for

Steaming multiwalled carbon nanotubes via acid vapor for controllable nanoengineerings and the fabrication of carbon nanoflutes

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Materials

The multiwalled carbon nanotubes (MWCNTs) (length 5-15 μm, diameter 40-60 nm, purity >98%) were purchased from Shenzhen Nanotech Port Co., Ltd. The concentrated HNO_3 (65~68 wt.%) and HCl (36~38 wt.%) were purchased from Sinopharm Chemical Reagent Beijing Co. Ltd and used directly without any dilution. A sample of MWCNTs@amorphous carbon (50.68 wt.%) & metal (M = Fe, Ni, Co, total 16.97 wt.%) (Fig. S3A), synthesized by coating MWCNTs with a layer of amorphous carbon[S1] and loading the metal nanoparticles (Fe, Co, Ni)[S2], was used to examine the capability of the present steaming strategy in removing the impurities of metal and/or amorphous carbon.

Experimental procedure

A typical steaming procedure for surface functionalization of MWCNTs is as follows: 0.3 g pristine MWCNTs (p-MWCNTs) were loaded on the porous SiO_2 griddle of glass steamer (Fig. S1A) and then placed into a 50 mL Teflon-vessel (Fig. S1B), at the bottom of which 0.15-3 mL HNO_3 was added previously. Subsequently, the Teflon vessel was sealed in the autoclave and then moved to the oven for steaming at the temperature of 120-200 ^{o}C within 5 h (Fig. S1, C to E). After the steaming treatment, cooled down the autoclave to the room temperature and took the steamer out of the Teflon vessel into a clean beaker, in which washed the functionalized MWCNTs (f-MWCNTs) with distilled water and ethanol by *in-situ* filtration (Fig. S1F). Finally, the steamer was transferred to the oven for drying (60 ^{o}C) and the formed solid black cakes (f-MWCNTs, inset of Fig. S1F) could be collected easily and completely.

Normal surface functionalization, short-cut, end-open, production of carbon nanoflutes, removal of amorphous carbon and some metal catalysts that could not react with HCl, should be treated by HNO_3. Alternatively, the HCl was used for removing most transitional metal impurities or catalysts.

References:

s1 Y. Wan, Y. L. Min and S. H. Yu, *Langmuir* 2008, **24**, 5024-5028.

s2 X. Meng, H. Cheng, Y. Akiyama, Y. Hao, W. Qiao, Y. Yu, F. Zhao, S. Fujita and M. Arai, *J. Catal.* 2009, **264**, 1-10.

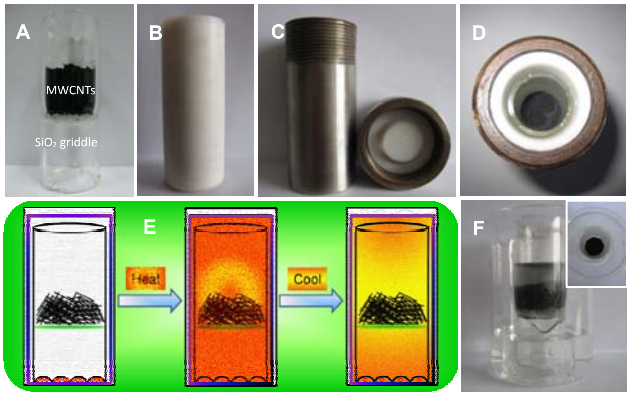

Fig. S1 (A) The photograph of glass steamer and the placement of MWCNTs. (B) The Teflon vessel (50 mL). (C) The stainless steel autoclave with a cover padded by Teflon. (D) The situation of equipments (E) The schematic procedure of the steaming process. (F) The washing and separation of f-MWCNTs through filtration *in-situ* in the glass steamer.

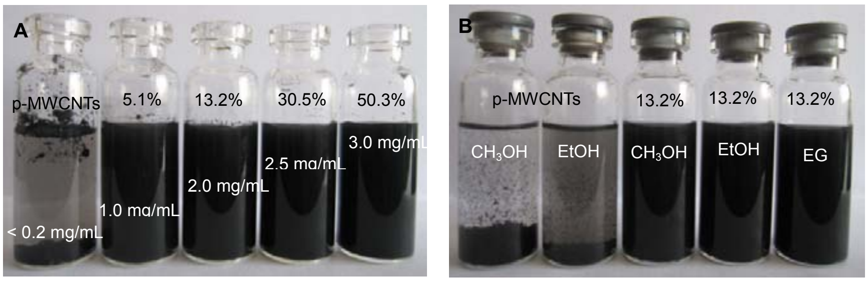

Fig. S2 The dispersion ability of p-MWCNTs and f-MWCNTs with different weight losses in water (A) and in organic solvents (B), ethylene glycol (EG).

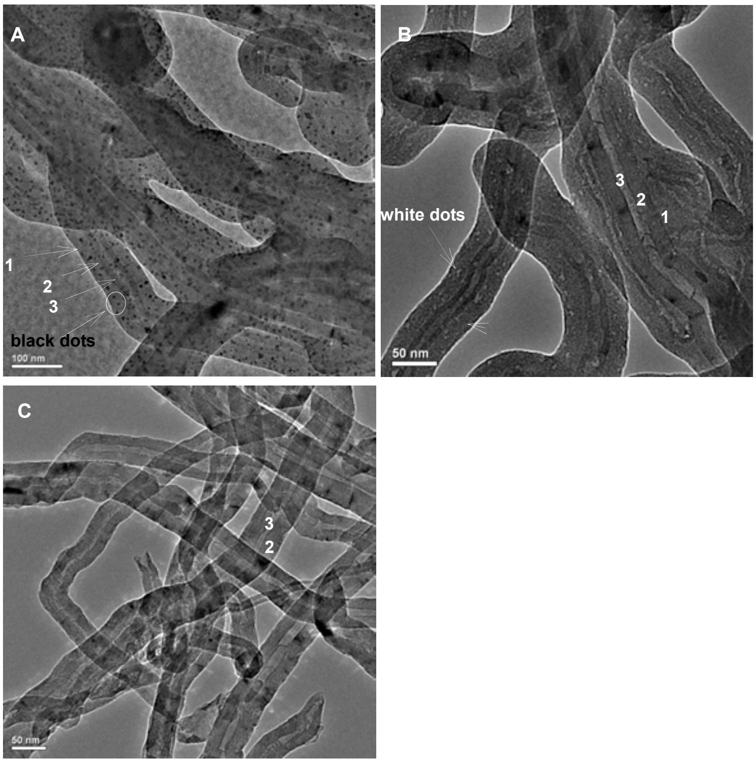

Fig. S3 (A) MWCNTs@amorphous carbon (50.68 wt.%) & metal (M = Fe, Ni, Co, total 16.97 wt.%), (B) MWCNTs@amorphous carbon obtained after selectively removed the metal impurities by steaming with HCl, (C) MWCNTs obtained after simultaneously removed the metal impurities and amorphous carbon by streaming with HNO_3. 1-amorphous carbon, 2-the multi-walls of MWCNTs, 3-the hollow tubes of CNTs.

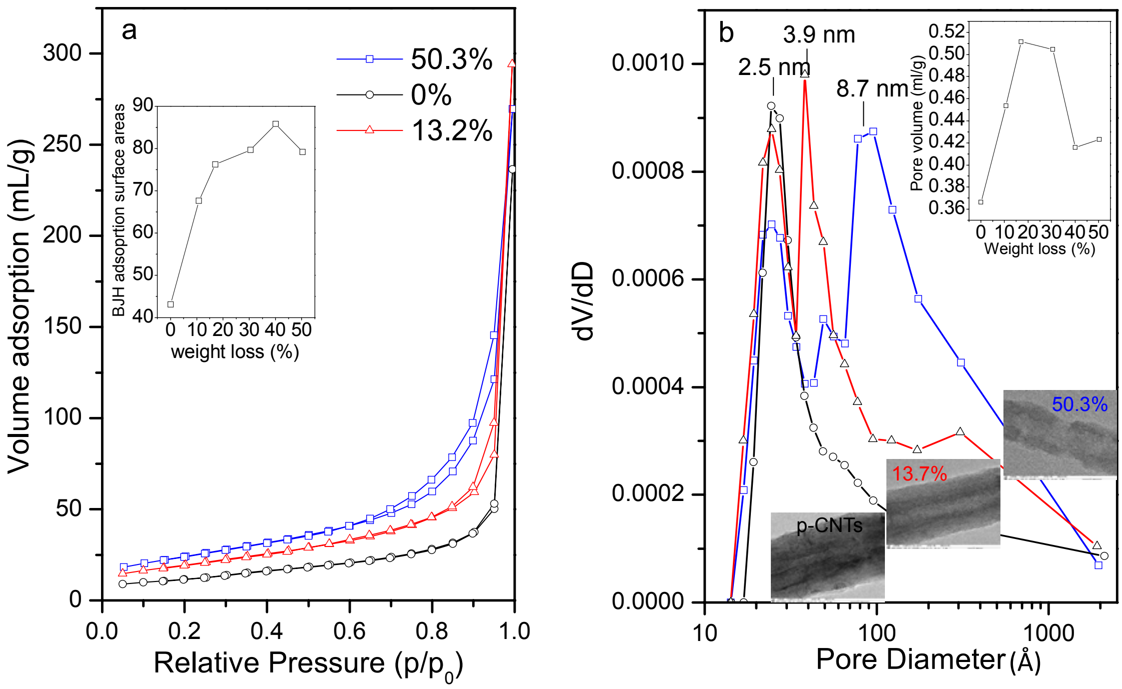

Fig. S4 (a) Nitrogen adsorption isotherms of the p-MWCNTs and f-MWCNTs with different weight losses. Inset figure is the changing relations between the weight losses and the specific surface area of f-MWCNTs. (b) The pore size distribution of p-MWCNTs and f-MWCNTs. Upper inset figure is the changing relations between the weight loss and the pore volume of f-MWCNTs, below inset figures are TEM mages of p-MWCNTs and f-MWCNTs with varied weight losses.