Electronic Supplementary Information (ESI)

Tunable liquid sensing performance of conducting carbon nanotube-polyethylene composites with a porous segregated structure

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Experimental

The UHMWPE in powder, a product from Beijing No. 2 Auxiliary Agent Factory (Beijing, China), has the following features: density ρ=0.94g/cm^3, granule diameter D=210 μm and weight-average-molecular weight M_w=6×10^6 g/mol. The CNTs with diameters of 20–40 nm and lengths of 10–20 mm were kindly supplied by Chengdu Organic Chemicals Co. Ltd. (Chengdu, China). The nano-$CaCO_3$ particles with an average diameter of ~50 nm were were purchased from Inner Mongolia Mengxi Nano Material Co. Ltd. (Neimenggu, China). For the electrical conductivity measurements using a Keithley 4200SCS apparatus, silver paste was attached to the surface of each sample to ensure good contact of the sample surface with the electrode. In the liquid sensing test, the sample with dimensions of 0.5×10×35 mm^3 was quickly immersed into the good organic solvents at room temperature, and the volume resistivity of samples was real time recorded using a Keithley 4200SCS apparatus. For the long-term immersion-drying runs, the immersion was carried out in chloroform for 1800 s under controlled temperatures at 25 °C. For the drying procedure, the samples were lifted up and remaining solvent drops were wiped off at air and room temperature for 1200 s. The solvents (chloroform. heptane and toluene) were all purchased from Chengdu Kelong Chemical Reagent Factory (Chengdu, China) and were used as received. The scanning electron microscopy (SEM) specimens were frozen in liquid nitrogen for 10 min, and then quickly impact fractured. The freshly broken surfaces were sputter coated with gold and then observed in a field emission SEM (Inspect-F, FEI, Finland), with an accelerating voltage of 20 kV. For optical microscopy observations made using an Olympus BX51, the specimens were cut into films with a thickness of 15 μm, using a microtome.

Liquid sensing performance of pure CNT control samples

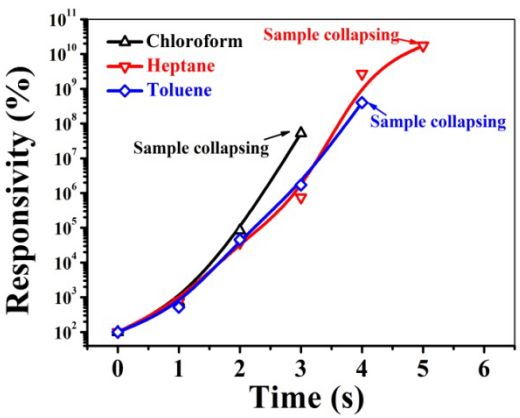

Fig. S1 Responsivity-time relationship of pure CNT control samples fabricated by powder pressing technology exposed to chloroform, heptane, and toluene liquids.

Fig. S1 shows the liquid sensing properties of the pure CNTs fabricated by powder pressing technology, as control samples. The responsivity of the pure CNT control samples for the detection of chloroform, heptane, and toluene liquids was 5.3×10^{7}%, 1.8×10^{10}%, and 4×10^{8}%, respectively. In spite of a high liquid sensing capacity with a relatively high electrical conductivity of ~420 S/m, the pure CNT control samples quickly collapsed in all the organic liquids within only 5 s, which limited their applications in detecting volatile organic liquids effectively.

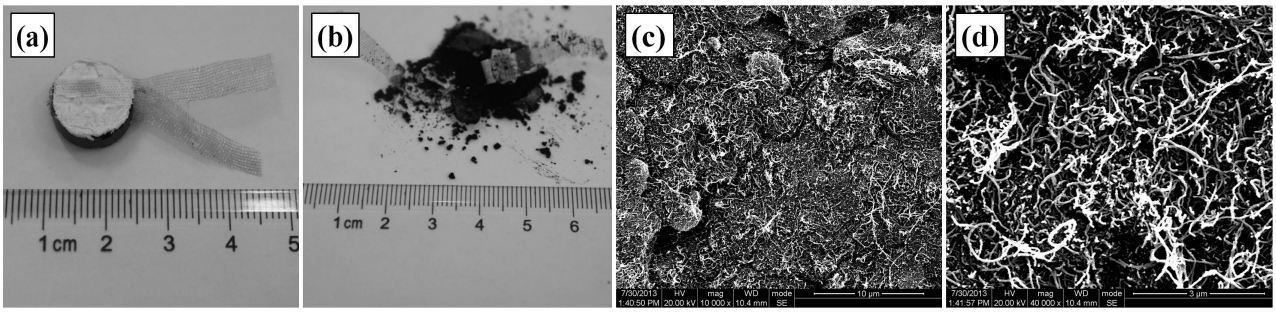

Fig. S2 Photographs of the pure CNT control samples before (a) and after (b) immersion in chloroform for only 5 s; SEM micrographs (c and d) of the fractured pure CNT control samples.

Fig. S2 exhibits the digital images of the pure CNT control samples before and after immersion in chloroform for only 5 s. Although the pure CNTs could be compression molded into wafer sheets with a diameter of 15 mm and a thickness of 3 mm, the dimensional stability of the pure CNT control samples was too weak to guarantee the stable signal output of the liquid sensing performance under the erosion of volatile organic liquids (Fig. S2b). This poor dimensional stability could be explained that the agglomeration of pure CNTs and relatively weak Van Waals' force between CNTs both weakened the adhesion interaction between CNT particles, as a result of a number of macro-voids (Fig. S2c and d). Thus, the pure CNT control samples easily collapsed in volatile organic liquids.