Electronic Supplementary Information

Advanced catalyst design induced enhancement of multi-walled nanotube debundling and electrical conductivity of multi-walled nanotube/silicone composite

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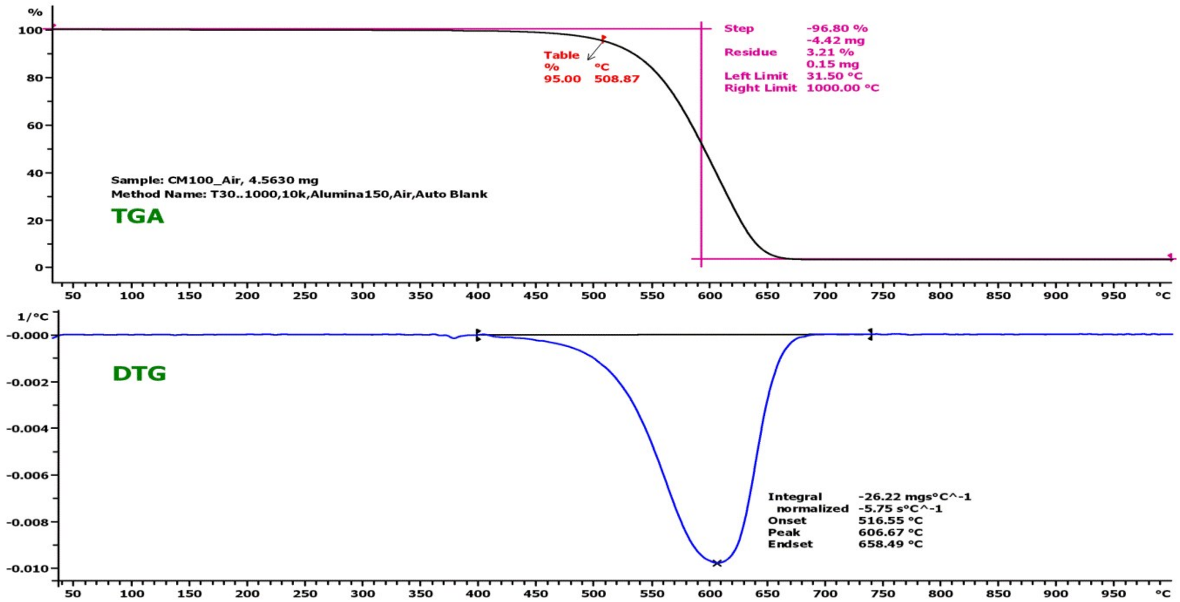
FS-MWNT



STD-MWNT

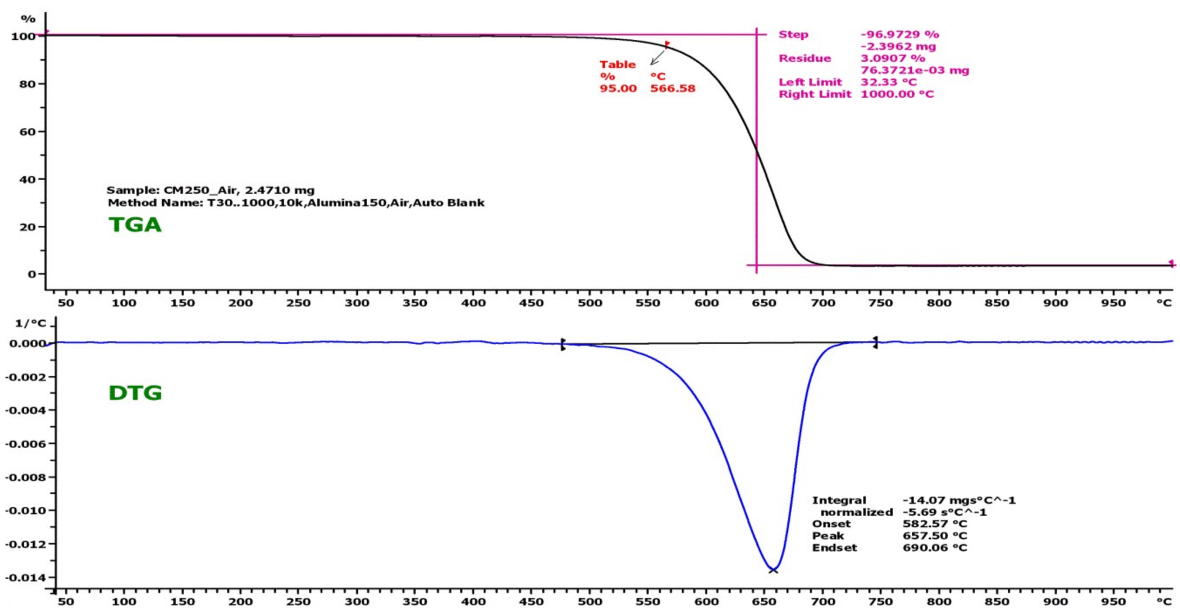


Figure S1. TGA analysis of FS-MWNT and STD-MWNT.

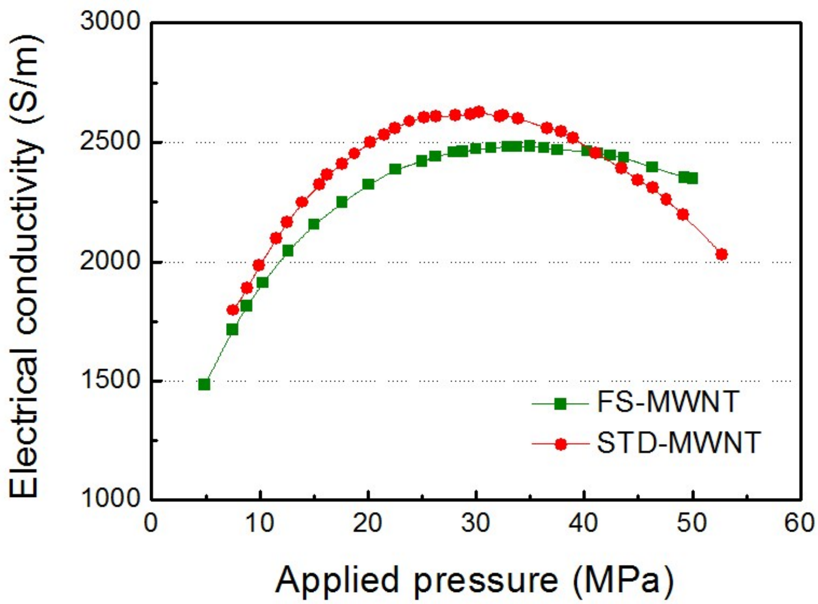


Figure S2. Electrical conductivity of CVD grown MWNT powders.

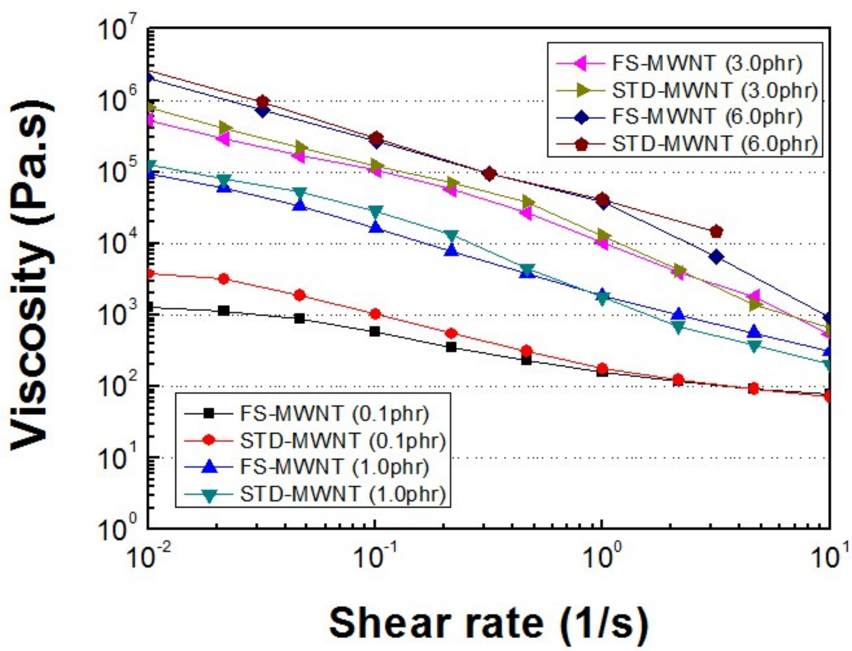


Figure S3. Viscosity of MWNT/silicone composites.

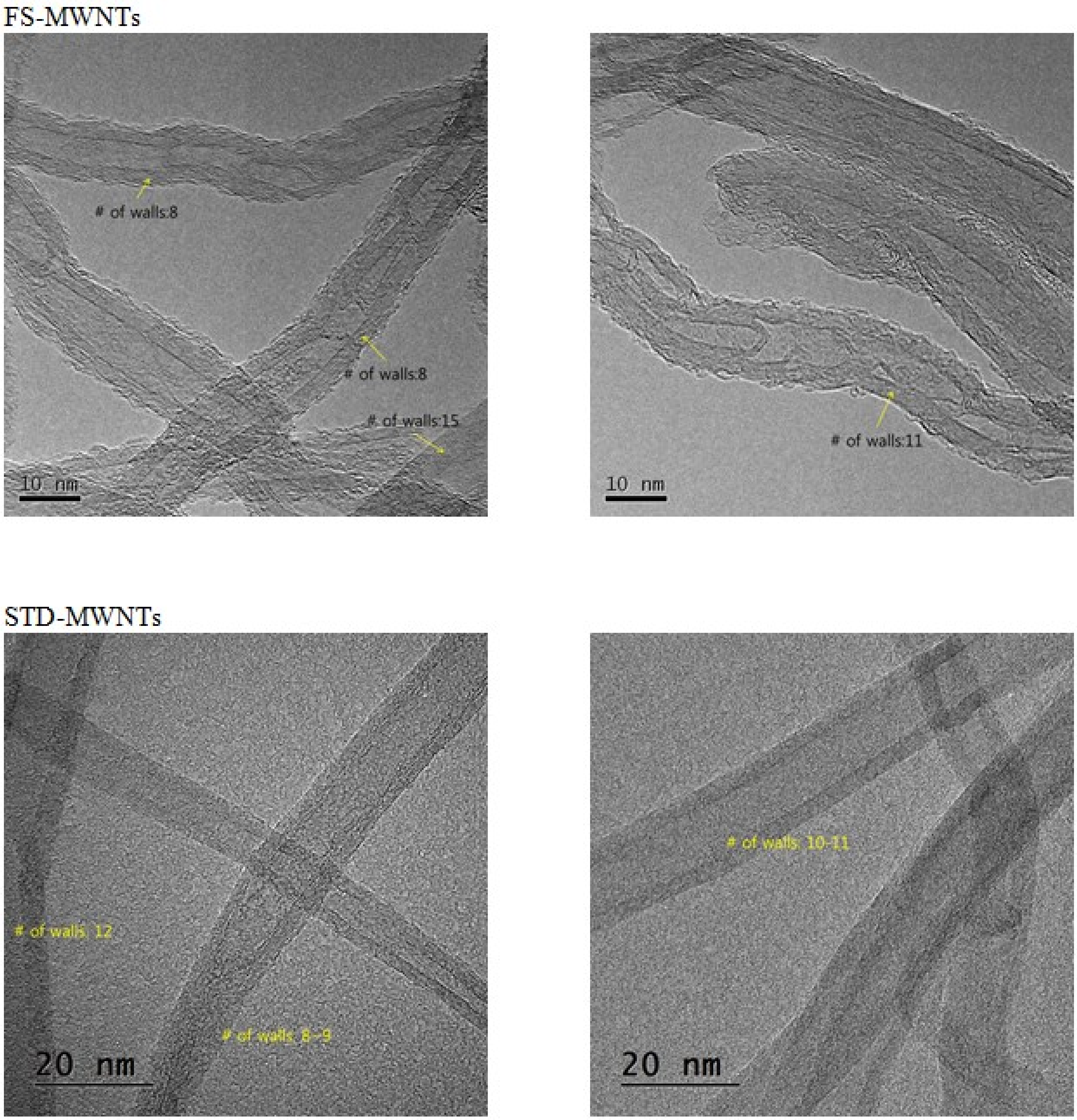


Figure S4. TEM micrographs of FS-MWNTs and STD-MWNTs.

Selection of the catalyst for MWNT growth

The Fe-Co bimetallic catalyst was used for MWNT fabrication. The combination of Fe and Co proved to create a synergistic effect and enhanced the affinity for C atoms, leading to increase in the diffusion coefficient of C atoms, and higher catalytic activity for the CNT growth [A]. It can be attributed to the fact that the lattices of Fe and Co both have certain solubility to C atoms [B]. The Fe-Co catalyst was also reported to have good activity for the preparation of carbon nanotubes through CVD method in many studies, as cited in [B]. In our experiments, the MWNTs synthesized with Co-Al_2O_3, Fe-Al_2O_3, and Fe-Co-Al_2O_3 catalysts were compared in diameter. MWNTs from the monometallic catalysts were 20-40nm, but those from the bimetallic catalysts were 8-12 nm in diameter [A]. Using the MWNTs with smaller diameter and higher surface area, more conductive percolation networks were acquired in polymer matrix at same amount of filler loading.

Fe monometallic catalyst plays a dominant role in the formation of bamboo-like morphology, because source gases create graphitic envelopes around Fe nanoparticles. At a certain carbon concentration, the Fe particle releases itself out of the graphitic envelope [C]. The bamboo-like morphology indicates imperfection or local distortion in hexagonal graphitic–based structures, which is one of main causes to degrade electrical conductivity of CNTs. The Fe-Co bimetallic catalyst was the best choice to acquire high electrical conductivity of MWNT/silicone composite in a practical manner.

A) Z. Konya, J. Kiss, A.Oszko, A. Siska, I. Kiricsi, XPS characterisation of catalysts during production of multiwalled carbon nanotubes, Phys. Chem. Chem. Phys. 2001;3:155-158.

B) J. Wen, W. Chu, C. Jiang, D. Tong, Growth of carbon nanotubes on the novel FeCo-Al2O3 catalyst prepared by ultrasonic coprecipitation, J Nat Gas Chem 2010;19:156-160

C) M. Arjmand, K Chizari, B. Krause, P. Potschke, U. Sundararaj, Effect of synthesis catalyst on structure of nitrogen-doped carbon nanotubes and electrical conductivity and electromagnetic interference shielding of their polymeric nanocomposites, Carbon 2016;98:358-372.