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Covalent Crosslinking of Single-walled Carbon Nanotubes with Poly (allylamine) to Produce Mechanically Robust Composites

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Supporting Information:

General procedures

All chemicals were purchased from Aldrich unless stated otherwise. Field emission scanning electron microscopy (SEM) studies were performed using a Hitachi S-4300, which was operated at 5.0 kV, on gold coated fracture surfaces. Fourier transform infrared (FT-IR) measurements were performed in transmission and reflectance mode using a Digilab FTS-6000 spectrometer using Perkin-Elmer micro-sampling attachment. Thermogravimetric analysis (TGA) measurements were carried out in air for all the samples using a Perkin Elmer Pyris 1 TGA with a temperature scan rate of 10 °C per min. The ultra-sonic bath used was a Grant XB6 at 50-60 Hz. The ultrasonic processor used was Model GEX-750 ultrasonic processor operated at 20 %. Room temperature Raman spectra were recorded with a Renishaw 1000 micro-Raman system equipped with a Leica microscope and an Edinburgh Instrument PL machine with a Xe900 excitation source and Bentham detector. Mechanical tests were performed by Zwick tensile tester Z100 using a 100N load cell with a cross-head speed of 0.5 mm/min. Centrifugations were performed on a Hettich Zentrifugen, Universal 32.

Experimental Procedure

Carboxylic acid functionalized SWCNT's (P3, Carbon Solutions, Inc.), 10 mg, were dispersed in 20 mL of Millipore water using bath sonication for 15 min. N-(3-dimethylaminopropyl)-N′-ethylcarbodiimide hydrochloride, EDAC, (0.5 mM) and excess 4-dimethylamino pyridine ,DMAP, were added to the dispersion. The dispersion was stirred for 10 min. Poly (allylamine) hydrochloride, (PAH, MW ~70,000, 50 mg) was added to the dispersion and the dispersions were stirred

overnight. Next, the dispersion was filtered on a PVDF membrane (Millipore, Durapore membrane filters, 0.45 μm pore size) and left to dry at ambient temperature. The SWCNT-PAH composite films were peeled off the filter membrane to give free-standing buckypapers. The buckypapers were cut into strips of 2.25 cm width and several centimetres in length. The thickness of the strips ranged from 20-40 μm. control experiments were performed as above however no (EDAC) was used.

Experiments with varying amounts of PAH (50-85 % wt of composite) were performed while keeping the amount of SWCNT contant. The tensilt strength increased linearly until reaching maximum laoding at 83 %wt. (Fig 1). Increased loading of PAH did not result in any increase in strength or modulus. The non-crosslinked composites showed no increase with varying amount of polymer due to lack of strong chemical bonds.

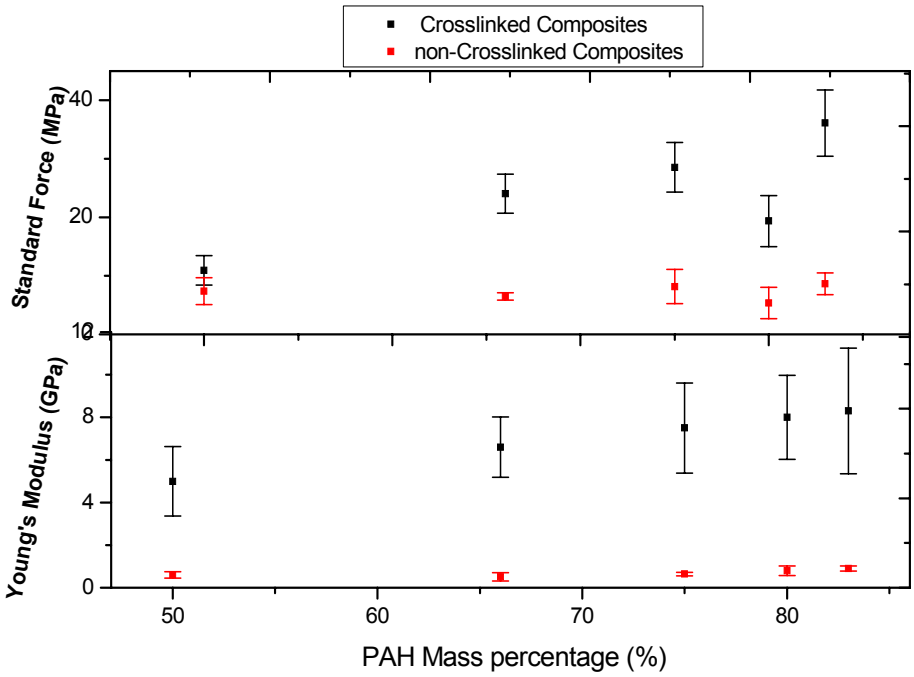

Figure 1: Mechanical properties of SWCNT-PAH composites at increasing mass percentage of PAH

Raman spectra of composites at different PAH mass percentages were also taken. The I_G/I_D was found to almost constant for all composites (Fig. 2).

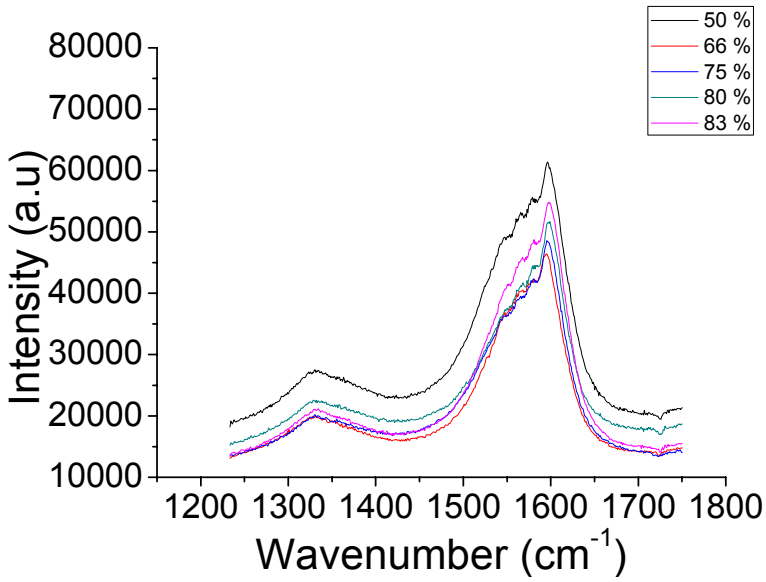

Figure 2: Raman spectra of SWCNT-PAH composites at increasing mass percentage of PAH