Supplementary Information

Carbon Nanotube - MoS_2 composites as Solid Lubricants

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Transmission Electron Microscopy measurements: In Figure S1 a low magnification TEM image of the CNT-MoS_2 is shown. The inset shows a higher magnification image of MoS_2 clusters attached on to the CNT surface. Electron diffraction patterns taken from CNT-MoS_2 composites are shown in figure S1 b. The TEM calibration for calculating lattice spacing was performed using a standard gold film. The diffraction pattern shows bright spots as well as circular ring patterns. Some of the bright spots were used to calculate the d-spacing and were found to correspond with lattice spacing of MoS_2. The random distribution (devoid of any particular order) indicates that the electrodeposited MoS_2 on the CNT surfaces are polycrystalline in nature. The analysis of the ring patterns in the TEM diffraction patterns were found to match with lattice spacing of carbon and were indexed accordingly. The observed d-values and there corresponding hkl planes are tabulated in table S1.

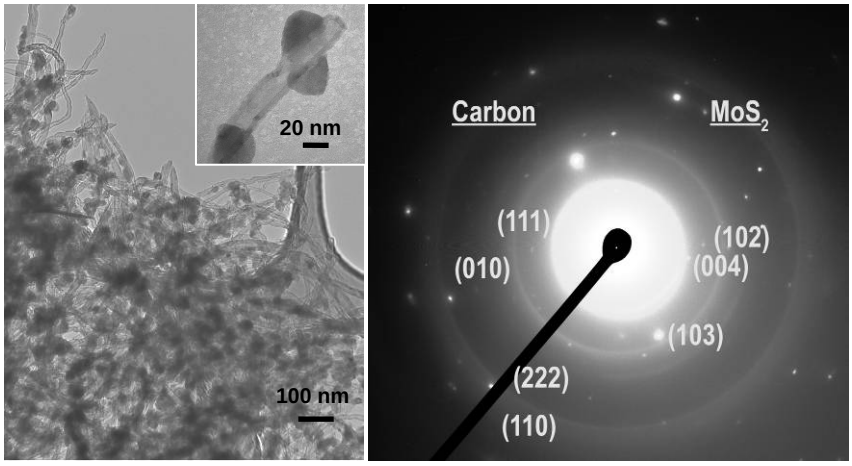

Figure S1. Low magnification TEM image of CNT-MoS_2 composite. Inset shows a small portion of the same composite showing nanometer sized clusters attached on CNT surface. (b)

Details of TEM diffraction pattern obtained from the composites are shown. Ring patterns from carbon as well as diffraction spots from polycrystalline MoS_2 are shown.

Table S1: Calculated d-values and hkl planes from TEM diffraction of CNT-MoS2 composite.

Carbon			MoS_2		
d-values (A^0)		(hkl)	d-values (A^0)		(hkl)
JCPDS 75-2078	Observed		JCPDS 6-0097	Observed	
3.347	3.341	111	2.501	2.551	102
2.080	2.100	010	2.277	2.279	103
1.673	1.680	222	3.075	3.031	004
1.228	1.225	110			

Raman Measurements: Phase identification inside and outside of the wear tracks was examined using a Renishaw SPM micro-Raman system. The Raman spectra of the CNT-MoS_2 composite is shown in figure S2. Figure S2 shows the spectra obtained from the complete frequency range. The Raman spectra were taken at different positions of the as produced CNT-MoS_2 composite film as well as from the wear track formed on the film due to the tribological measurements. Both the spectrum shows strong peaks at ~1580 cm^{-1} which is associated with E_{2g} mode of highly crystalline graphite (G-band) and is due to the presence of the CNTs. Peaks at ~1347 cm^{-1} (disorder induced) were also observed in our samples. These are associated with inherent defects in the structure of CVD grown nanotubes which occurs due to the low growth temperature used for their production. Second order Raman modes for CNTs at ~2694 cm^{-1} associated with the D band are also observed in the spectrum.

In the lower wave number region of these spectrums (indicated by an arrow) marked differences were noted. The spectrum taken from the top surface of the as deposited film showed signatures of MoO_3. E_{2g} mode (at ~377 cm^{-1}) and A_{1g} mode at 406 cm^{-1} for MoS_2 was observed only for the spectrum taken from the wear track indication passive oxidation behavior of MoS_2 clusters, once supported on CNT surfaces.

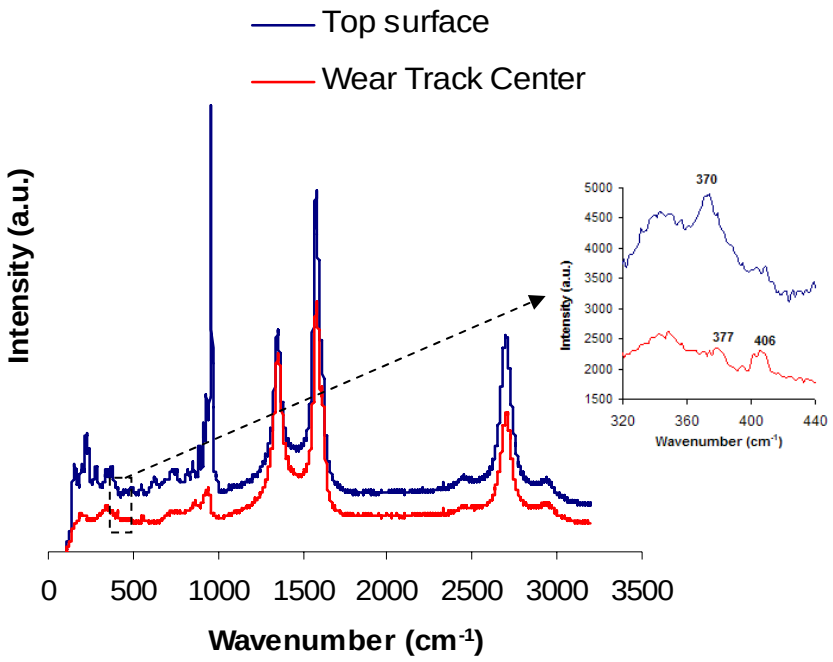

Figure S2. Raman spectra measured from the top surface of as deposited and the wear track of the CNT-MoS_2 film.

Emulsion Test

In figure S3 wear measurements indicating the lowering of friction coefficient (~15%) of commercial machine oil due to the incorporation of CNT-MoS_2 composite is shown.

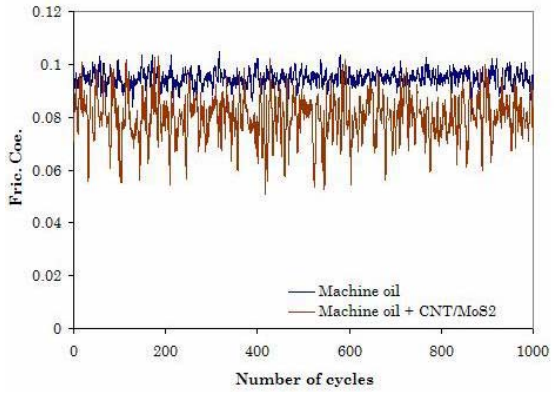

Figure S3. Friction measurements on as received commercial machine oil and emulsion prepared from commercial machine oil and CNT-MoS_2 composites is shown.