Supplementary Material (ESI) for Journal of Materials Chemistry

Polyaniline-Coated Single-Walled Carbon Nanotubes: Synthesis, Characterization and Impact on Primary Immune Cells

Shoshana Ben-Valid,[a] Hélène Dumortier,[b,]* Marion Décossas,[b] Ruthy Sfez,[a] Moreno Meneghetti,[c] Alberto Bianco[b] and Shlomo Yitzchaik[a,]*

[a]Institute of Chemistry and the Nanoscience and Nanotechnology Center, The Hebrew University of Jerusalem, Jerusalem 91904, Israel

[b]CNRS, Institut de Biologie Moléculaire et Cellulaire, UPR9021 Immunologie et Chimie Thérapeutiques 67000 Strasbourg, France

[c]Department of Chemical Sciences, University of Padova, 35131 Padova, Italy

Electronic Supporting Information

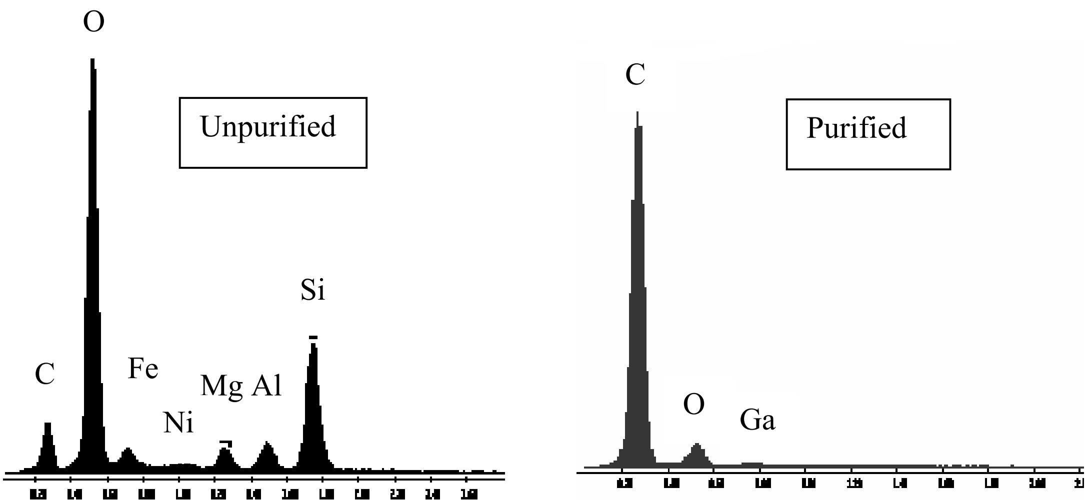

Figure S1. EDX spectra of unpurified and purified SWCNTs. The main peak in the EDX of the raw SWCNTs is the oxygen originating from metal-oxides where the main peak in the purified SWCNTs is carbon as expected. This analysis shows that most of the metals were removed in this cleaning protocol.

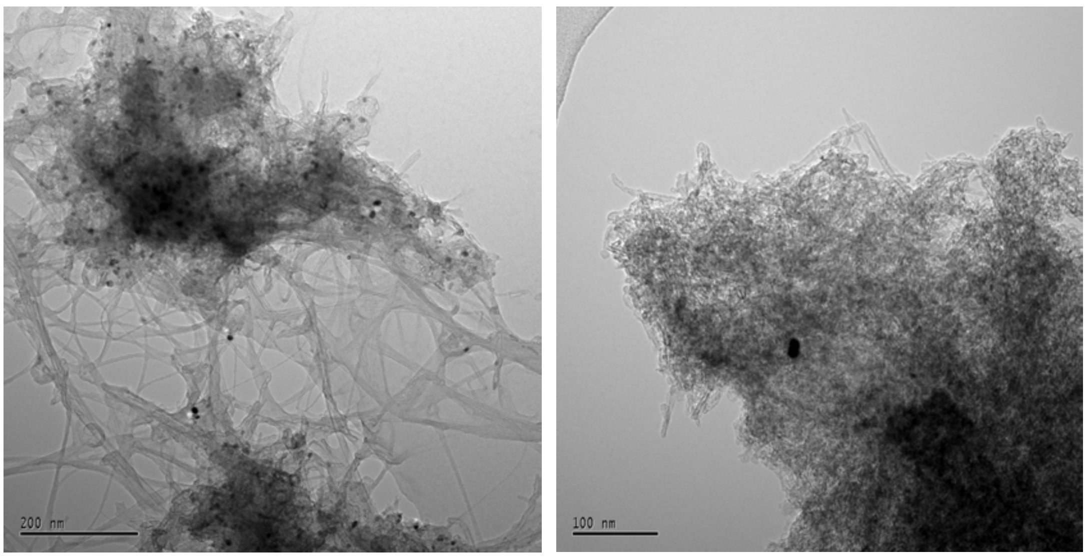

Figure S2. TEM images of SWCNTs before (left) and after (right) purification.

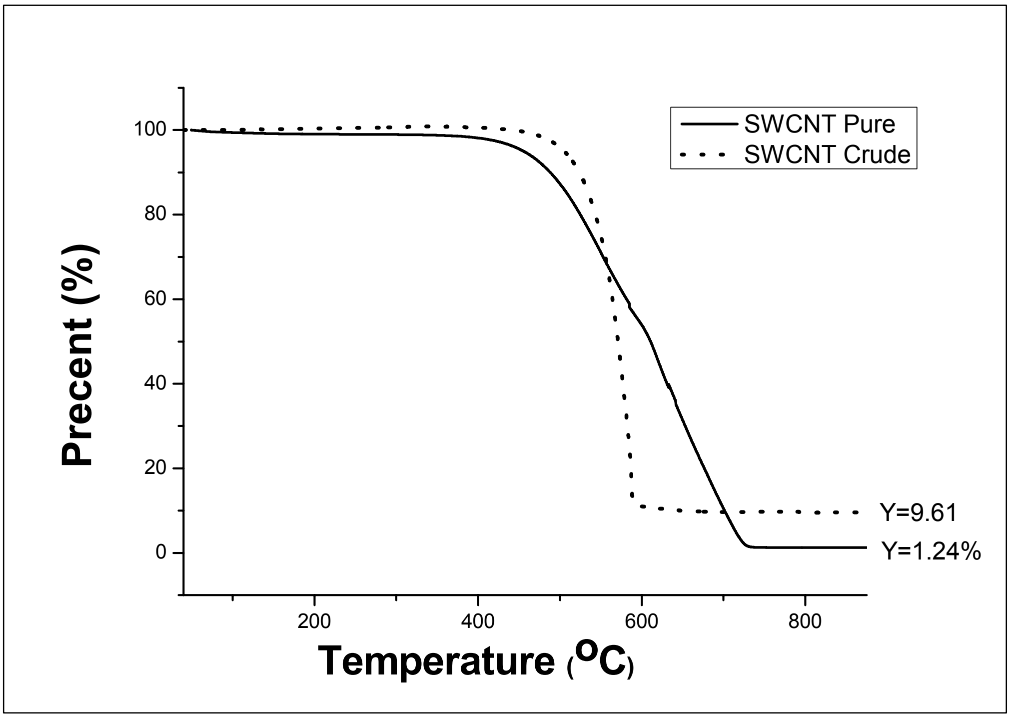

Figure S3. TGA profile of SWCNTs before (dotted line) and after purification (black line). The TGA profile show quantitatively that the weight percent of metals decreases from 9.61 % to 1.24 % by this purification protocol. The TGA was determined in air from 50 to 875°C and the temperature was increased at a rate of 10°C/min.

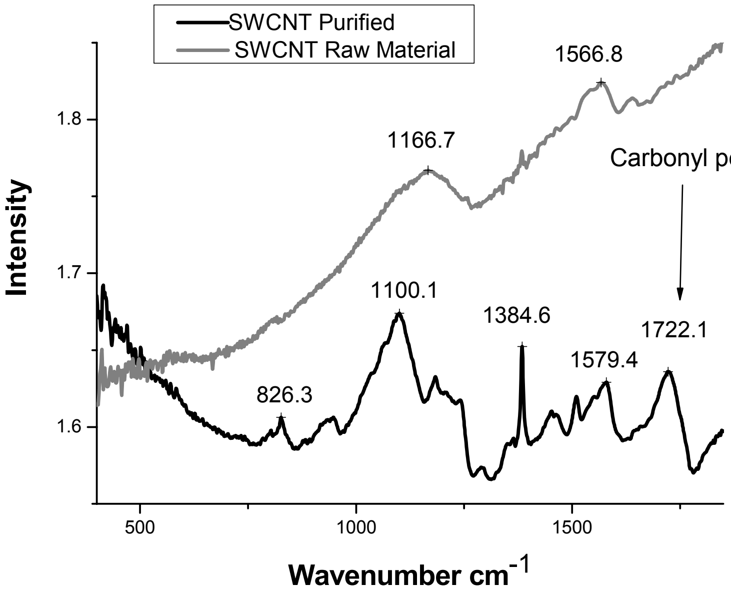

Figure S4. FTIR spectra before (grey) and after (black) purification of SWCNTs. The characteristic signals of SWCNTs in the IR region are at about 1100 cm^{-1} and 1579 cm^{-1}. The difference between the spectra of the raw SWCNTs and the clean material was found at 1712 cm^{-1} and 1722 cm^{-1}. These signals come from the carbonyl of carboxylic acid generated at the open ends of the purified SWCNTs.

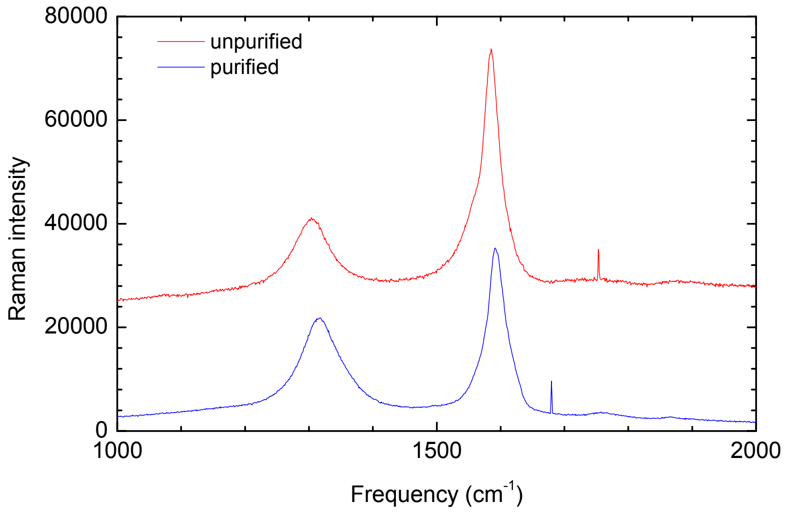

Figure S5. RAMAN spectra before (red) and after (blue) purification of SWCNTs. The peak area ratio of the D/G band in the raw SWCNTs and SWCNTs after purification is 0.37±0.08 (n=15) and 0.46±0.05 (n=15), respectively. The RAMAN spectrum shows a higher ratio between the D/G bands after cleaning, results which mean that the SWCNT structure is damaged during the cleaning procedure.

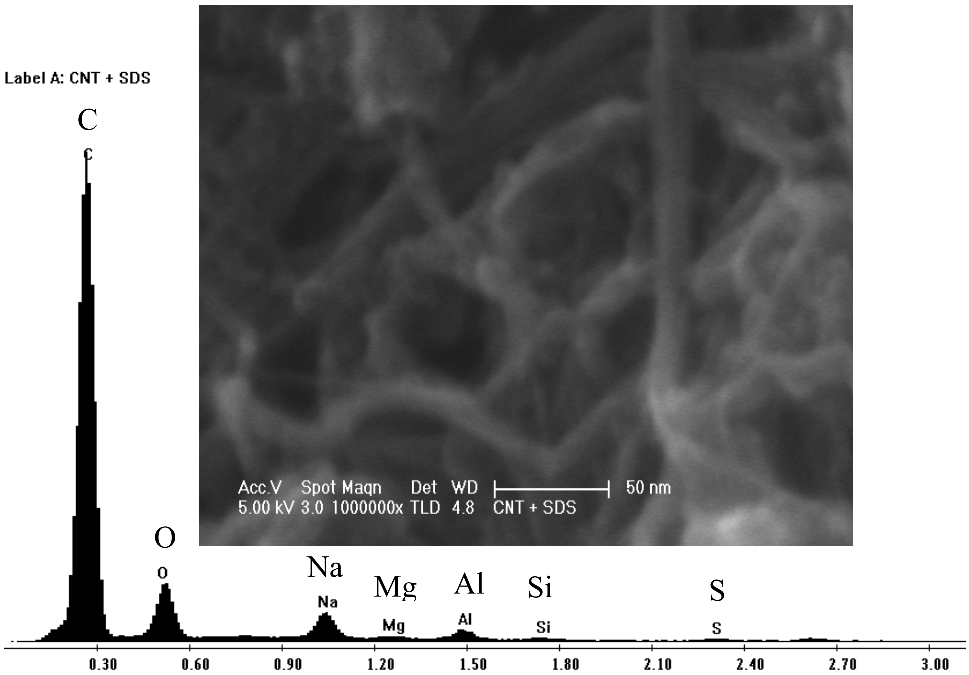

Figure S6. SEM and EDX images of SWCNTs coated with SDS. The SEM image show that the diameter of the SWCNTs increases from 6.4 to 8.5 nm when they were treated with SDS. The EDX spectra show the sodium peak and a low intensity sulfur signal which originate from SDS.

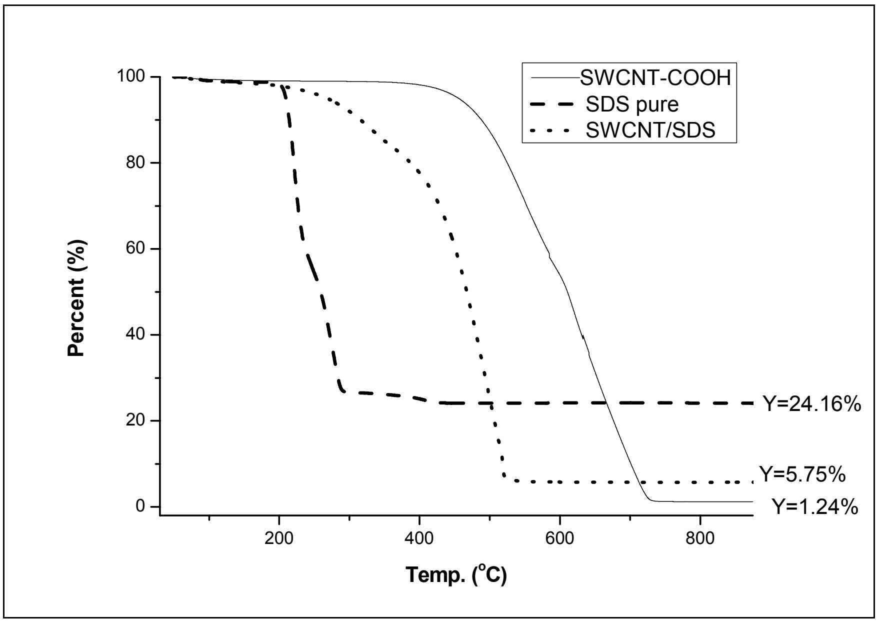

Figure S7. TGA profile of pure SDS (dashed line), SWCNTs coated with SDS (dotted line) and pure SWCNT (black line). The TGA was performed in air from 40 to 900^{o}C and the temperature was increased at a rate of 10^{o}C/min. The ratio between SDS and SWCNTs was determined from the residue left at 900^{o}C in each of the three above species. We have solved the following two equations $1.24X+24.16Y=5.75$, $X+Y=1$ to calculate the 100Y which is the % of SDS in the hybrid corresponding to 19.67.

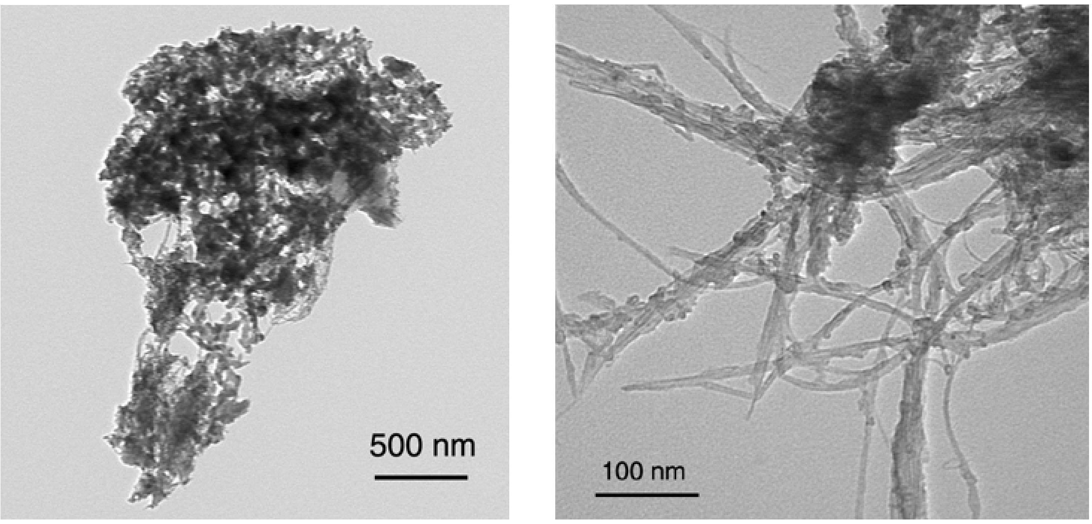

Figure S8. TEM images of SWCNT/SDS/PANI hybrids.

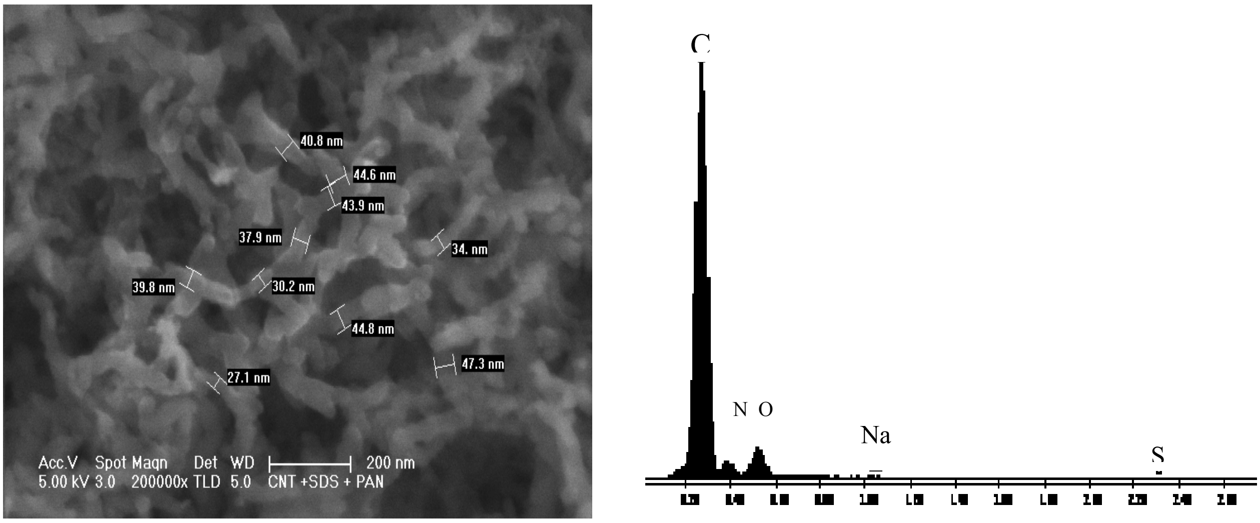

Figure S9. SEM (left) and EDX (right) images of the composite SWCNT/SDS/PANI. The SEM image of SWCNTs coated with PANI shows that the diameter increase to 42.1±3.8 nm (n=45). This value is indicative of bundles with a different number of SWCNTs. As expected EDX profile shows PANI's nitrogen which is absent in the EDX of SWCNT/SDS hybrid. The sodium signal decreased dramatically in comparison to the sodium peak in Figure S6 meaning that most of the sodium was exchanged by anilinium during the synthesis.

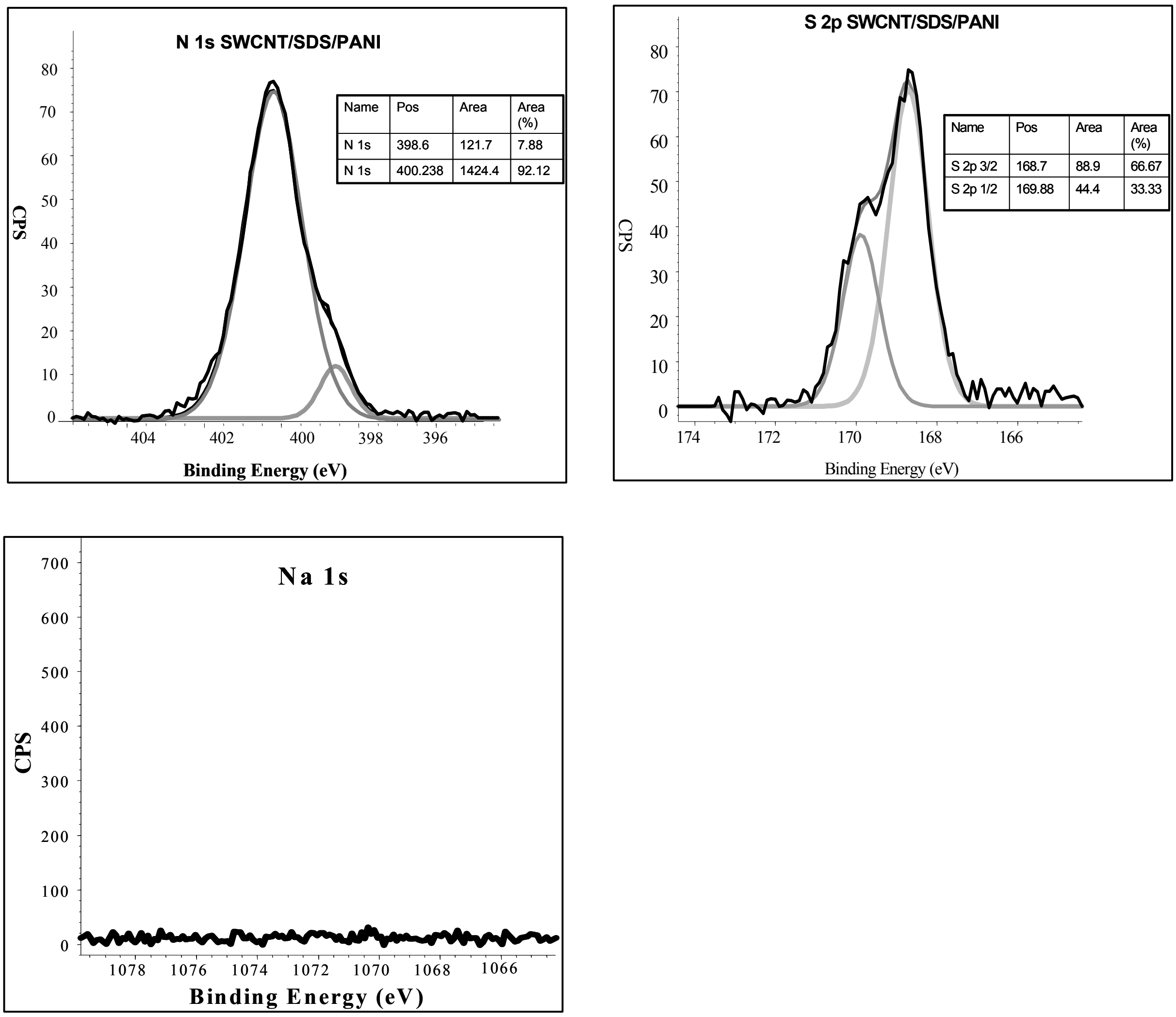

Figure S10. XPS spectra of the hybrid SWCNT/SDS/PANI. The spectra show that the hybrid contains sulfur which comes from SDS, quaternary and tertiary nitrogen from PANI and does not contain Na which is exchanged by the anilinium during the synthesis.

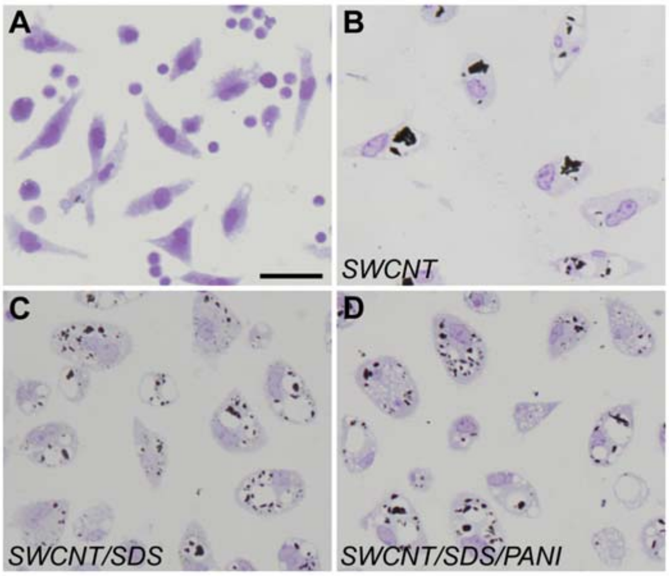

Figure S11. Optical microscopy images of macrophages incubated with the different SWCNT. Cells were fixed, embedded into Epon, cut into 500 nm-thick sections and stained with toluidine blue. The nanotubes are clearly visible inside the phagosomes. They are more aggregated in the case of the uncoated SWCNT. Upon SWCNT internalization, the cells change their morphology in comparison to control cells (A). Scale bar corresponds to 20 µm.

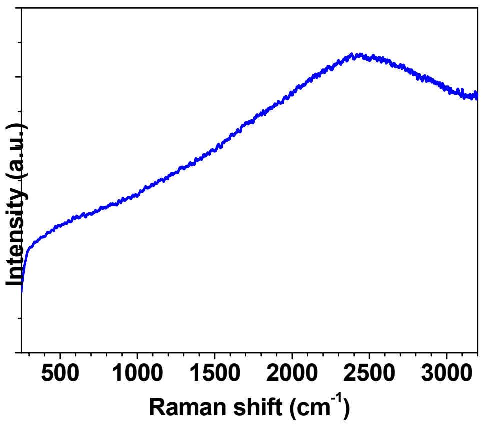

Figure S12. Raman spectrum excited at 633 nm of a macrophage in the absence of the nanotubes.