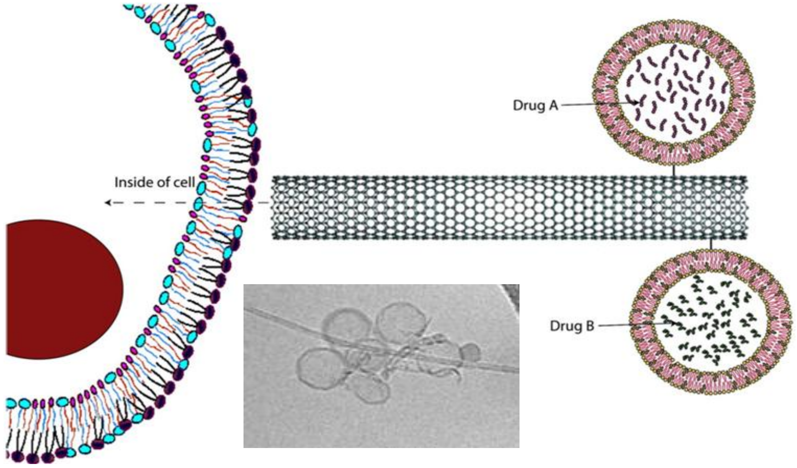
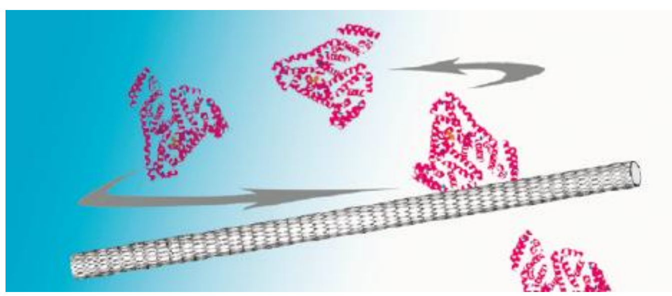
Oren Regev – Abstract of research activity



Nanotube-liposome c onjugates as a platform for drug delivery. Carbon nanotubes (CNT) are widely explored as carriers for drug delivery due to their facile transport through cellular membranes. However, the amount of loaded drug on a CNT is rather small. Liposomes on the other hand are employed as carrier of a large amount of drug. The aim of this research is to develop a new drug delivery system, in which drug-loaded liposomes are covalently attached to CNT to form a CNT-liposomes conjugate (CLC). The advantage of this novel approach is the large amount of drug that can be delivered into cells by the CLC system, thus preventing potential adverse systemic effects of CNT when administered at high doses. This system is expected to provide versatile and controlled means for enhanced delivery of one or more agents stably associated with the liposomes.

Karchemsky, F., Barenholz, Y., Zukker, D. and **Regev, O.** Carbon Nanotubes-Liposomes conjugate as a platform for Drug Delivery into Cells, *Journal of Controlled Release* **2012** 160, 339–345.

Peretz, S. and Regev, O., Carbon Nanotubes as nanocarriers in medicine, *Current Opinion in Colloid and Interface Science*, **2012**, accepted.

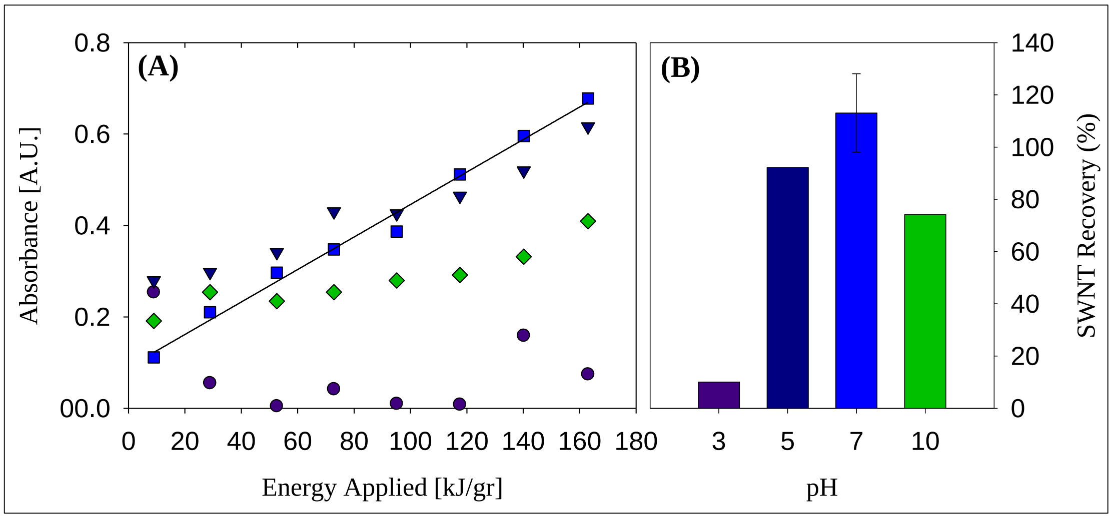


Are dispersant strongly bound to carbon nanotubes? Nanotube can be dispersed by a variety of molecules. We investigate the dynamics of protein-assisted carbon nanotube dispersion in water. We find that in equilibrium, only a small fraction of the dispersants is indeed adsorbed to the nanotube surface, while there is a fast exchange process between the adsorbed and free protein molecules. Self-diffusion NMR spectroscopy in combination with cryo-transmission electron microscopy imaging are employed.

Frise, A.E., Edri E., Furó, I, and **Regev, O.** Protein dispersant binding on nanotubes studied by NMR self-diffusion and cryo-TEM techniques, *J. Physical Chemistry letters* **2010** 1, 1414.

Frise, A.E., Pages, G. Shtein, M., Pri Bar, I, Regev, O. and István Furó Polymer Binding to Carbon Nanotubes in Aqueous Dispersions: Residence Time on the Nanotube Surface as Obtained by NMR Diffusometry, *J. Physical Chemistry B.* **2012**, 116(9), 2635-2642.

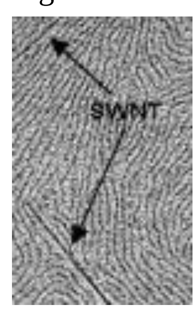
Nanotube dispersion dynamics is studied by UV-vis spectroscopy (enhanced with chemometric analysis) and low temperature transmission electron microscopy (cryo-TEM). We studied the effect of both pH and BSA-to-SWNT ratio on SWNT exfoliation dynamics and recovery. We found that indeed, BSA properties (i.e. electric charge and conformation) affect the exfoliation dynamics in a similar manner as it affects the SWNT recoveries: bulkier protein conformation → faster exfoliation → higher SWNT recoveries. Higher BSA-to-SWNT ratio results in lower recoveries and slower dynamics, suggesting that entropic consideration may take part in the exfoliation-stabilization process of SWNT.



The effect of pH on the dispersion dynamics of BSA-dispersed SWNT. (A) The absorbance progress along the dispersion process of SWNT at four different pH values; namely, 3, 5, 7 and 10 (circles, triangle, squares and diamonds, respectively); [SWNT] = 2mg·mL^{-1} [BSA] = 0.5mg·mL^{-1}. (B) The SWNT recovery, calculated by chemometrics, after centrifugation ('stable').

Edri, E.; **Regev, O.**, "Shaken, not stable": Dispersion mechanism and dynamics of protein-dispersed nanotubes studied via spectroscopy, Langmuir *25*(18), 10459-10465 (**2009**).

Confinement of nanometric objects in liquid crystals - integration of individual single-walled carbon nanotubes (SWNTs) within a lyotropic hexagonal liquid crystal (LC) focusing on shear effects and ordering of the single-wall nanotubes within the elongated micelles.



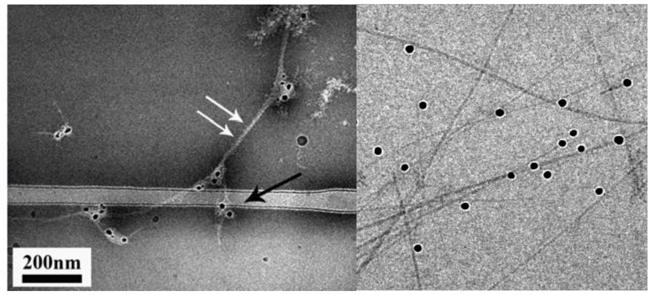
Weiss, V.; Thiruvengadathan, R.; **Regev, O.**, Preparation and characterization of a carbon nanotube-lyotropic liquid crystal composite. *LANGMUIR* **2006,** 22, (3), 854-856.

Nativ-Rot, E., Regev, O., Yerushalmi-Rozen, R, Self-assembled arrays of surfactant micelles templated by single-walled carbon nanotubes, *CHEMICAL COMMUNICATIONS* **2008**, 17 2037-2039.

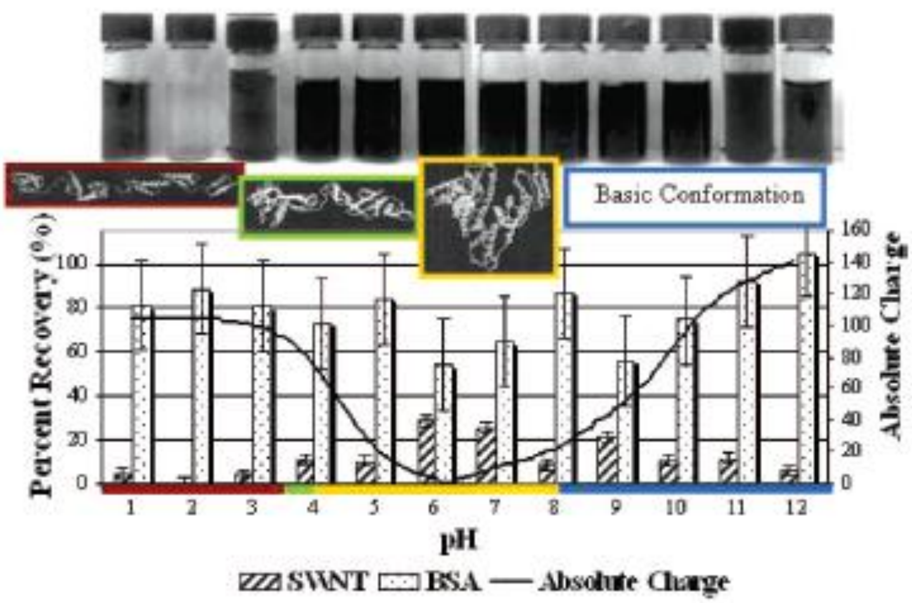
Nativ-Rot, E., Yerushalmi-Rozen, R. and **Regev O.,** Phase behavior and shear alignment in SWNT- surfactant dispersions, *SMALL* **2008**, 4 (9), 1459–1467.

The interaction of proteins with nanotubes is explored through labeling the protein (BSA) by colloidal gold nanoparticles (right) or staining (left). We found that most protein molecules are located close to the SWNTs and the average distance between adjacent protein molecules along the SWNT is a few tens of nanometers, much longer than earlier assumed.

Goldberg-Oppenheimer, P.; **Regev, O**., Exploring a nanotube dispersion mechanism with gold-labeled proteins via Cryo-TEM imaging. *SMALL* **2007,** 3, (11), 1894-1899.
Edri, E.; **Regev, O.**, Cryo-Staining techniques in cryo-TEM studies of dispersed nanotubes, *Ultramicroscopy*, **2010**110 (7) 754-760.



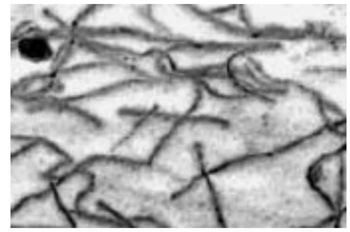
The pH effect on the BSA configuration and then on the SWNT dispersion quality is then determined.



pH effect on the composition of BSA-dispersed SWNT system. Lower panel: BSA (dotted) and SWNT (striped) recoveries. The continuous black line is the absolute electrical charge of the protein molecule at a given pH, as calculated from its sequence. Note the two different ordinates. Middle panel: BSA conformation at a given pH range. Upper panel: Ocular observation of the SWNT dispersion at different pH values; the darker the solution the higher the SWNT concentration is.

Edri, E.; **Regev, O.** pH Effects On Protein-Dispersed Carbon Nanotubes Studied By Spectroscopy-Enhanced Composition Evaluation Techniques, *ANALYTICAL CHEMISTRY* **2008**. 80 (11) 4049-4054.

Polymer-Nanotubes composites - We have developed a new approach to reinforce a highly viscous polymer of basically any type by a network consisting of *individual* or bundles of few single-wall carbon nanotubes (SWNTs). We use a surfactant to disperse and exfoliate bare SWNTs in water, which are then mixed with latex nanoparticles in aqueous solution to form, after drying and subsequent processing, a *conductive* composite consisting of homogeneously dispersed SWNTs in a polymer matrix of choice.



Regev, O.; ElKati, P.; Loos, J.; Koning, C., Preparation of conductive nanotube-polymer composites using latex technology. *ADVANCED MATERIALS* **2004,** 16, (3), 248.
Grossiord N., Loos J., Meuldijk J., **Regev, O.**, Conductive carbon-nanotube/polymer composites: Spectroscopic monitoring of the exfoliation process in water, *Composite Science and Technology* **2007** 67(5), 778-782.

Koning, C.E., **Regev, O.**, Loos J., Reinforced Polymers, PCT No.21468/WO **2005**.