Halloysite Clay Nanotubes: Characterization, Biocompatibility and Use as Drug Carriers

Viviana Vergaro[1]*, *Elshad Abdullayev*[2], *David Mills*[2], *Giovanna Giovinazzo*[3], *Angelo Santino*[3]
Roberto Cingolani[1], *Yuri M. Lvov*[2] *and Stefano Leporatti*[1]
[1]*National Nanotechnology Laboratory of CNR-INFM, University of Salento, ISUFI, Lecce, 73100, Italy*
[2]*Institute for Micromanufacturing, Louisiana Tech University, 911 Hergot Ave, Ruston, LA 71272, USA*
[3]*Institute of Sciences of Food Production C.N.R. Section of Lecce, via Monteroni, 73100, Lecce, Italy*
email: viviana.vergaro@live.it

One way to utilize the high functionality and stability of bio-related materials is to create hybrids consisting of materials of biological origin and inorganic materials. Halloysite is defined as a 1:1 layered aluminosilicate, chemically similar to kaolin, which has predominantly hollow tubular structure in the submicron range [1-3]. Halloysite is an economically viable raw material that can be mined as a raw mineral. As for most natural materials, the size of halloysite particle varies within 1-2 microns of length and 15-100 nm of inner diameter depending on the deposits or even within different locations in a specific deposit. Halloysite nanotubes (HNTs) are efficient nano-containers capable of entrapping a range of active agents [2] within the inner lumen, followed by their retention and slow release [3]. Halloysite is a green environmentally friendly object available in commercial quantities. The lumen of the halloysite tube accomodates globular protein diameters, allowing their entrapment within the inner lumen of the halloysite while retaining their activity for use in biocatalysis. In this work a combination of high resolution imaging technique such as TEM, SEM and SFM have been employed to elucidate the structure. We have investigated their visco-elastic properties by force-indentation measurements (Young Modulus (E) between 180 and 230 kPa, in Contact Mode) and performed cytotoxicity tests (viability preserved until HNTs concentration of 50µg\ml and maximal incubation time of 72 hours) utilizing neoplastic cell lines (breast and cervical cancer cells). Furthermore their uptake has been confirmed by Confocal Laser Scanning Microscopy (CLSM) after their functionalisation with fluorescence molecules. The results indicate that halloysite nanotubes have been readly uptaken by neoplastic cells and exhibit a high level of biocompatibility. To confirm their possible biomedical use as a therapeutic nanocarrier we have successfully encapsulated bioactive compounds (e.g. resveratrol) and studied their anti-neoplastic effect into model cancer cell lines. Research on use of the clay nanotube for sustain drug delivery for dermatological treatment and bone repair is in progress. A typical drug release time from these biocompatible nanotubes was 20-50 hours (e.g. for anticancer dexamethasone) and for proteins 50-200 hours.

References:

[1] R. Price, B. Gaber, Y. Lvov J. Microencapsulation **18**, (2001) 713.
[2] Y. Lvov, D. Shchukin, H. Mohwald, R. Price ACS Nano Journal **2**, (2008) 814.
[3] N. Veerabadran, Y. Lvov, R. Price Macromolecular Rapid Commun. **30**, (2009) 99.

Figures:

1) (a) and (b) TEM images of HNTs (scale bar 200 nm); (c) Three-dimensional topographic Tapping Mode SFM view of HNTs; (d) Tapping Mode Amplitude image of HNTs and corresponding height profile (inset).
2) CLSM images of HNTs uptake by cancer cells. HNTs appear green since they are FITC-marked and became yellow after internalisation into cancer cells. Nuclei are Hoechst stained (blue).

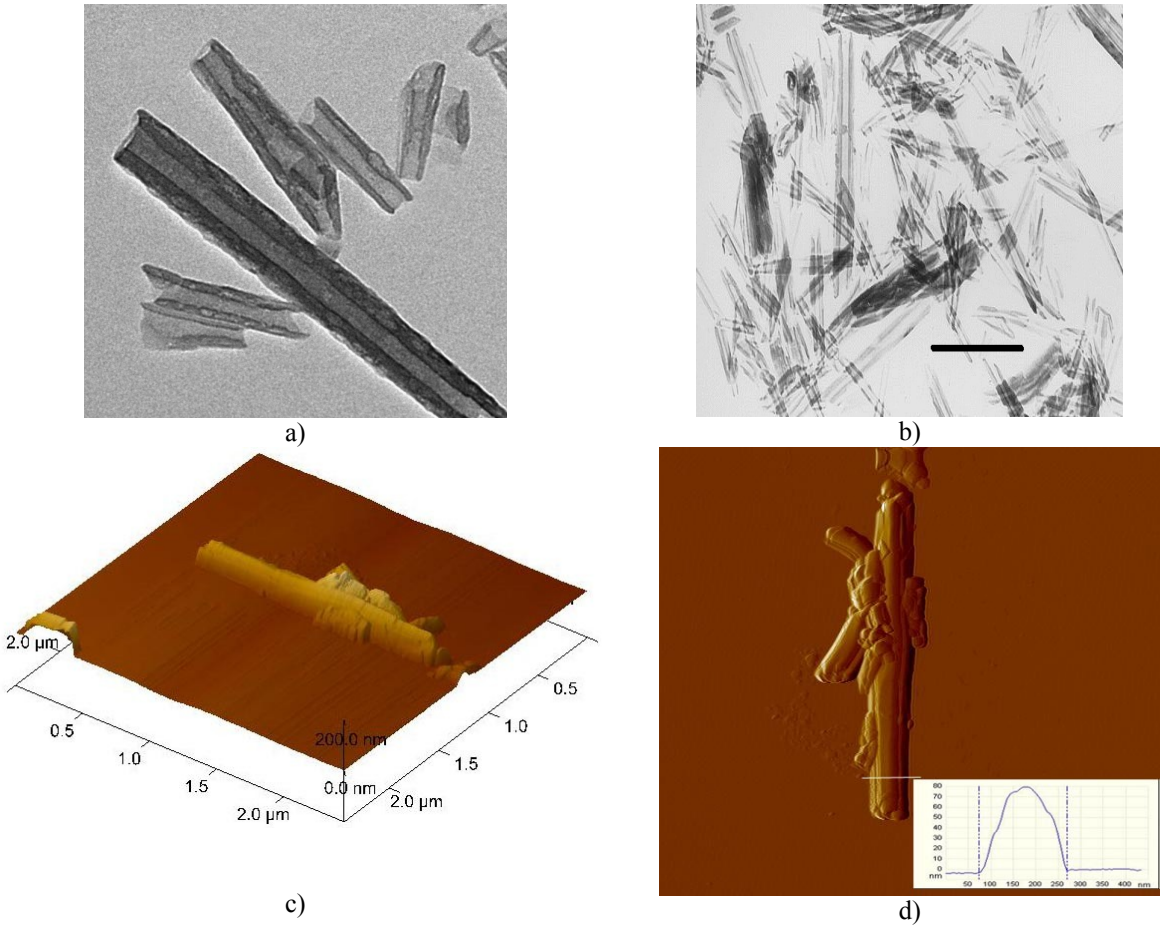

Figure 1

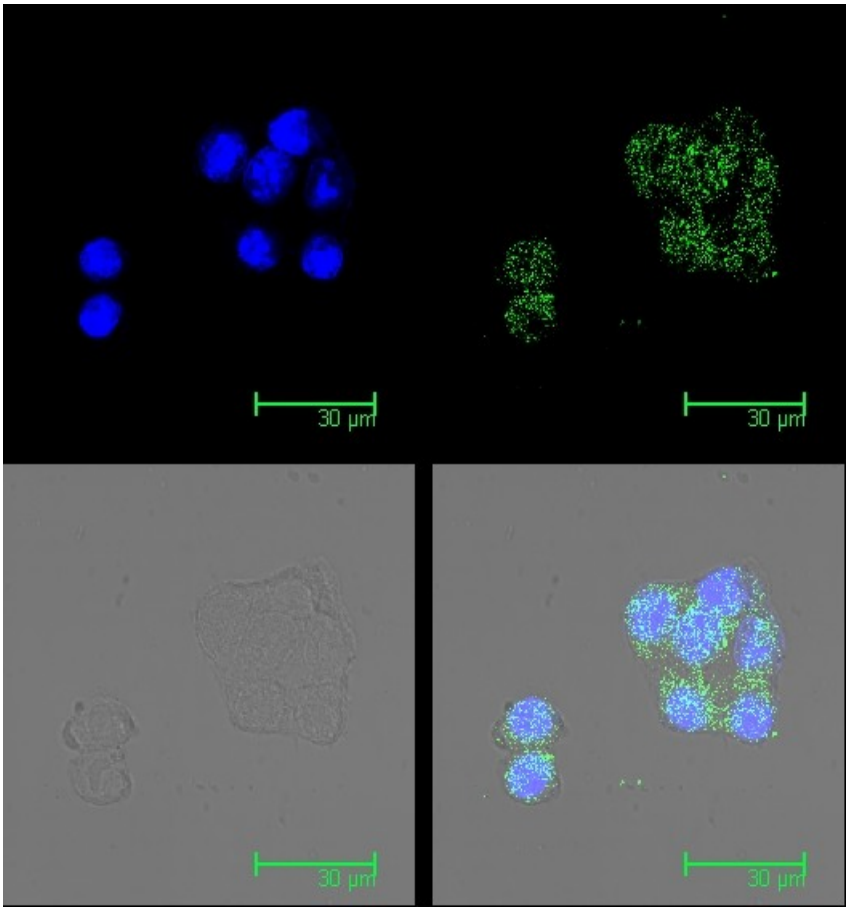

Figure 2