Amino-Functionalized Graphene Oxide for drug delivery applications

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The study of biomolecules adsorbed at the graphene-liquid interface is critical for advanced applications of graphene-based hybrid nanomaterials in life science. Recent research activities on biomaterials have focused their experimental and theoretical studies on the structure and reactivity of water at graphene surfaces, ideal model systems for 2-dimensional surface science [1]. Graphene oxide (GO) [2-3] is a composite material obtained by means of exfoliation in water, using sonication, of graphite oxide. GO exhibits an excellent water solubility, low toxicity, and ultrahigh specific surface area, and it is more and more studied as nanoplatform in theranostics [4]. The chemical functionalization can dramatically change the GO properties. In particular, functionalized GO surfaces could be adaptable for various applications such as in optoelectronics [5], drug-delivery vehicles [6] and biodevices [7].

In this study we present a comparison between GO and R_2N-functionalized GO in terms of spectroscopic, optical and binding potentiality features for biological sensing and drug delivery. In more detail, we functionalized in graded way the GO nanostructures to tune the surface properties and build a biocompatible platform for fluorescence imaging and drug delivery. The amino-conjugation of GO surface was achieved either through chemical or physical methods, by covalent grafting of amino groups from hydrazine/amine solvent mixtures or via nitrogen-argon plasma treatment, respectively. The microwave plasma was created by a surfaguide pulsed at 2.44 GHz, and the plasma discharge was set in pulsed mode. To avoid an overheating and a massive etching of the carbonious matrix of the GO, the sample was collocated in the post discharge zone of the plasma, where a flux of H_2 was introduced during the plasma treatment, to increase the amino selectivity
Curcumin, a polyphenolic substance with antioxidant, anti-inflammatory and antineoplastic pharmacological actions, was loaded into small unilamellar vesicles, dye-labeled with rhodamine; the release of the drug to the GO-based platform was therefore investigated by theoretical calculations and experiments as function of the pH (7.4. and 5.5) and of the GO functionalization.

MD simulations of both GO and functionalized GO were carried out to estimate the binding energy of the aggregates, as function of the GO surface termination as well as of the pH (Figure 1).
An integrated approach with fluorescence confocal microscopy coupled with Raman spectroscopy and DFT modeling was employed to provide a description of solvent and solute interaction with nanosized sp^2-carbon sheets, including single, double and few layer graphene. Moreover, the samples were characterized by atomic force microscopy under air and physiological conditions, zeta potential, light scattering, Raman, fluorescence and UV-vis spectroscopy.
The transfer of the curcumin (with a characteristic green fluorescence) on the different GO-functionalized surfaces was followed by laser confocal scanning microscopy.

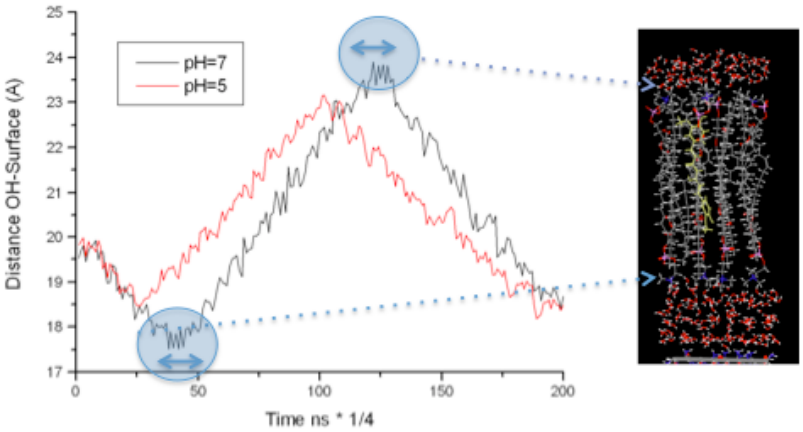

Figure 1: pH –dependent 'phase-lag effect', driven by electrostatics and H-bonds, for curcumine *floating* whitin the lipid bilayer at the interface with GO**.**

Results evidenced the higher efficiency of release on the amino-functionalized GO sheets (Figure 2).

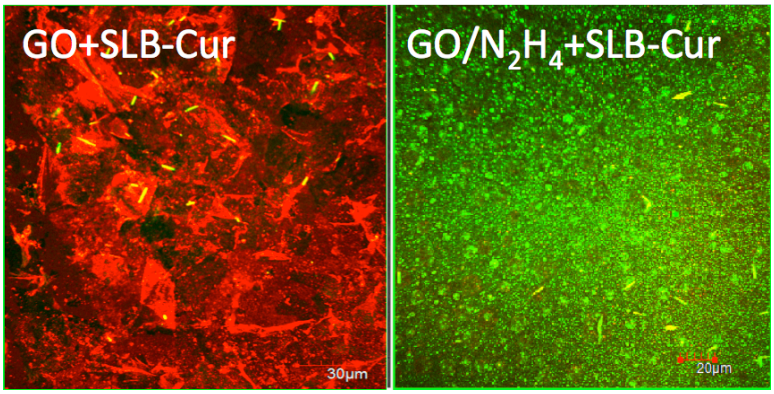

Figure 2: Merged fluorescence images of green (ex/em: 488/500-530 nm) and red (ex/em: 543/555-655) for GO (*left*) and amino-functionalized GO (*right*) upon the interaction with curcumin-loaded lipid vesicles.

In summary, in the present study we scrutinized the aqueous interface between GO sheets and their amino-conjugated derivatives, as very promising nanoplatforms for a fine tuning of the surface reactivity at the water interface.
Both experimental and theoretical findings evidence the high potentiality of the hybrid curcumin-SLB/GO assembly for a controlled drug release driven by the GO surface characteristics as well as the environmental conditions, such as the pH. [8]

References

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