Silica for drug-delivery: when simulation can complement experiment

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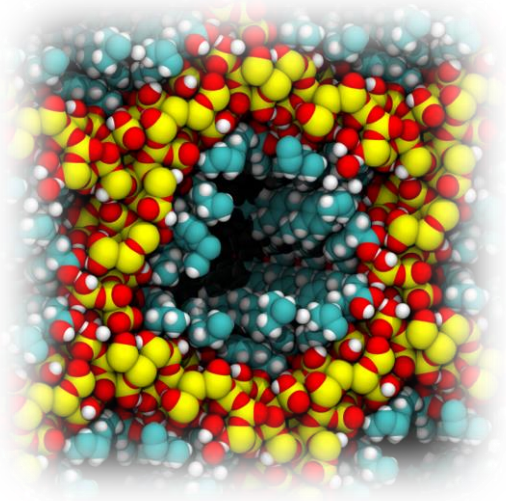

The delivery of drugs in the organism through nanocarriers is a topic of great interest in pharmaceutical research, with the aim of protecting the drug from degradation, targeting the diseased tissue and controlling the release. Among materials employed for drug delivery, silica (silicon dioxide) plays a key role, particularly in its mesoporous form. Although much research has been performed on the topic of silica drug delivery, the understanding of the interactions occurring between the material surface and drug molecules is still scarce, despite this knowledge is essential for determining the final performance of a drug delivery system. This is particularly true when the active principle is a biomolecule (e.g. a protein) and the contact with the material can alter its biological activity. Molecular modeling can give a precious insight on this issue, acting as a "virtual microscope" to study the processes occurring inside the drug carrier, at the organic-inorganic interface.

We will present here an overview of a several years long computational endeavor (including one PRACE project1) aiming at shedding some light on silica-drug interactions. Both large scale quantum[2,3] and classical[4] atomistic simulations will be reported. Particularly, recent evolutions in HPC architectures and the concurrent development of more efficient software have dramatically increased the size and complexity of the systems that can be modeled by fully quantum mechanical methods, at a very high accuracy level. Emphasis will be put on how their results can interface with and complement the experimental investigation, providing a collection of data (energetics, IR, NMR, CD spectra, correlated to drug's feature and water content) that can help pharmaceutical researchers to better predict and rationally design the features of novel drug delivery systems.

1. PRACE Project 2012-2013 "Mesoporous silica for drug delivery: a quantum mechanical simulation".
2. Delle Piane et al., *J. Phys. Chem. C* **2014**, 118 (46), 26737–26749.
3. Gignone et al., *J. Phys. Chem. C* **2015**, 119 (23), 13068–13079.
4. Hildebrand et al., *ACS Biomater. Sci. Eng.* **2018**, 4 (12), 4036-4050.