One-pot synthesis of silica-based nanostructures

Giulia Della Rosa[1]
Alessandra Aloisi[2], Riccardo Di Corato[1], Rosaria Rinaldi[1,2,3]

[1] University of Salento, Department of Mathematics and Physics, Via Monteroni, 73100 Lecce, Italy
[2] CNR-IMM Institute for Microelectronics and Microsystems, Via Monteroni, 73100 Lecce, Italy
[3] University of Salento – ISUFI, Via Monteroni, 73100 Lecce, Italy

alessandra.aloisi@cnr.it

Due to inspiration from naturally occurring biomineralization, biopolymers and proteins have attracted interest in the materials science community as scaffolds for templated synthesis of inorganic materials [1]. Biomolecule-controlled nucleation and growth of inorganic hydrated silica (SiO_2) regulates, in the marine environment, the nanopatterned cell wall architecture of the unicellular microalgae diatoms [2]. The ability to *in vitro* precisely template inorganic nanomaterials provides an opportunity for the development of green nanomaterials.

In this work, opposite approaches for the synthesis of organic/inorganic silica-based nanostructures are proposed: (1) A top-down approach aiming at extract and isolate SiO_2 nanoblocks (NBks) from *Thalassiosira weissflogii* diatom cell walls (Fig 1). Thereafter, the quasi-spherical shaped NBks, immersed into a fluidic vortex, rearrange themselves in intriguing geometrical intermediates, from spherical to toroidal, forming super assembled units (major axis, 150-300 nm). (2) A biomimetic bottom-up approach has been developed to synthesize SiO_2NPs miming the natural processes of silica formation in diatoms living organisms (Fig 2). The organic-based scaffold is an aqueous solution of spermidine, a polyamine presenting chemical common features of diatoms silica-nucleating long chain polyamines. The chance to *in vitro* control the 3D self-assembly aptitudes and the underlying patterns results in several unique SiO_2NPs. By slightly varying reaction parameter settings, SiO_2NP design varies from a spherical to a *pacman-like* shape, exhibiting a dense or hollow structure and presenting diverse average diameter dimensions in the range between 250 nm to 600 nm. NP surface chemistry and chemical stability permit a selectively functionalization for various applications from targeting to imaging [3]. Moreover, in the present proof of principle studies, SiO_2NPs are proposed as a platform for oligonucleotide delivery as well as gold NPs-decorated assemblies for nanomedicine application or integration within optical micro devices.

Looking ahead, the capability to regulate the formation and the arrangement of the inorganic structures using organic matter principles, is a very attractive and sustainable route for the development of structurally-complex and chemically- and/or bio-active tunable materials.

References

[1] B.A. Krajina et al., j.pmatsci (2018)
[2] M. Sumper et al., j. Mater. Chem (2004)
[3] M. Liong et al., ACS Nano (2008)

Figures

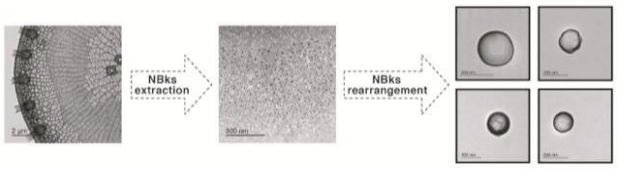

Figure 1.
Top-down approach. SiO_2NBks isolation from the cell walls of the diatom *Thalassiosira weissflogii* and rearrangement in super assembled units.
The authors thank prof Farinola and collaborators who provided diatom samples.

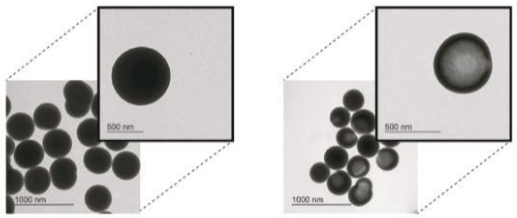

Figure 2.
Biomimetic approach. Different SiO_2NPs obtained by varying the one-pot synthesis starting parameters.