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Editorial

Special Issue on New Frontiers in Diatom Nanotechnology

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Diatoms are unicellular algae that live in aquatic environments. The diatom cell is enclosed in a porous biosilica microshell, called a frustule, which is characterized by a nanostructured morphology showing pores of tens of nanometers and a large specific surface area up to 200 m^2/g. The [impressive similarities between the morphology of frustules and that of artificially-produced porous silica, the low cost, and the availability all around the world make the nanostructured silica of diatoms an attractive source of material for several technological applications. Other peculiar properties of the diatom biosilica include biocompatibility, tailored surface chemistry, chemical inertness, and thermal stability.

The Special Issue "New Frontiers in Diatom Nanotechnology" focused on, but was not limited to, some recent technological applications of nanostructured biosilica in the fields of nanoengineering, photonics, biosensing, drug delivery, and tissue engineering.

The Special Issue of *Applied Sciences* entitled "New Frontiers in Diatom Nanotechnology" collects three original papers [1–3] and two reviews [4,5], providing new insights into the applications of diatom nanotechnology.

Vona et al. [1] investigated the in vivo incorporation of iridium, ruthenium, aluminum, and zinc luminescent organometallic complexes into *Phaeodactylum tricornutum* diatom microalgae. This biotechnological protocol is a simple method for preparing biosilica doped by luminescent organometallic complexes, with the benefit of easily achieving silica nanostructures that combine the photoluminescence of organometallic complexes with the structural properties of diatoms, optimized by nature over a billion years. Moreover, the film-forming properties of the semibenthonic diatom can be exploited for the self-assembly of in vivo luminescent biosilica films, which offer interesting potential applications in photonics.

Delasoie et al. [2] investigated the use of natural diatoms as drug scaffolds for carbon monoxide releasing molecules (CORMs). To this aim, they functionalized the *Coscinodiscus* frustules with the drug cis-$[Re(CO)_2Br_4]^2$ complex (ReCORM-2) and its vitamin B12 derivative (B_{12}-ReCORM-2) via standard chemisorption techniques. The effects of the drugs on the neovascularization were studied in vivo in the zebrafish (*Danio rerio*) model. Applying doses $\geq$25 µM, the molecules significantly reduced the development of intersegmental and subintestinal vessels in zebrafish, revealing a high anti-angiogenic potential. In addition, the diatom frustules did not induce any toxic in vivo response in the zebrafish embryos, including inflammation.

Sriram et al. [3] demonstrated the application of diatoms and diatomaceous earth (DE) in removing toxic dyes such as Congo Red (CR), which was used as a model compound, from water. In this work, DE was modified by Mg–Al-layered double hydroxide (DE-LDH) using a simple co-precipitation method. LDHs are ideal candidates for the removal of organic and inorganic pollutants from water; they also have some advantages such as low cost, non-toxicity, higher adsorption capacity, and high thermal stability. In order to study the DE-LDH adsorbents, isotherms were used in the batch adsorption, and kinetic studies were carried out for CR removal. The study suggested the promising application of DE-LDH as an effective material for application in the removal of CR from aqueous solutions for the purpose of industrial wastewater treatment.

Rogato and De Tommasi [4] reviewed the most remarkable physical and chemical techniques aimed at frustule modification, also examining the latest techniques developed

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for controlled morphological mutation. In particular, frustule metabolic doping, frustule metallization for plasmonic applications, frustule functionalization for protein immobilization, frustule silicon replica, and frustule genetic modification were examined. The possibility to tune the frustule morphology by means of genetic engineering in order to obtain self-replicating nanostructures optimized for a specific task was described in detail.

Tramontano et al. [5] highlighted the key features of diatom biosilica, presenting some of the most advantageous properties that support the use of frustules in drug delivery, biosensing, and regenerative medicine. This work provided insight into the functionalization strategies which can be used to modify diatom surfaces and tailor them according to the specific field of application. The authors described the latest and most attractive results related to the biomedical applications of diatom biosilica, which had already been approved by the Food and Drug Administration (FDA) as a safe material for food and pharmaceutical production.

The results described in this Special Issue highlight the extraordinary potential of diatom nanotechnology and support the decision to deeply research this topic.

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