Biological and Bioactive Silicon Systems

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1 Introduction

Silicon will probably be the most important element of the 21st Century. Silicon is the most “renewable” or “sustainable” element in that approximately 74% of the Earth’s crust is made up of silicon and oxygen. Silicon is an essential micronutrient for humans and it is also biotransformed on a vast scale by organisms such as diatoms and sponges (it has been reported to be bioprocessed at scales $>6.7 \times 10^9$ tonnes of silicon per year) [1, 2]. It is also the basis of the global electronics and optoelectronics industries. Silica and silicates are used in glasses, glazes, ceramics, and composites. These materials have applications in a wide range of areas such as pharmaceuticals, industrial catalysts, cosmetics, detergents and dental materials [3–6]. Silicones are the most successful of the inorganic polymers and they find applications as fluids, resins, rubbers, gels and foams [7]. Silicon carbide is an important ceramic and silica is applied in composite materials as the reinforcing phase. In the field of coatings, silicon is widely used in a variety of chemical vapour deposition methods and in related thin film deposition techniques [8–11]. Silanes are utilised as primers and adhesion promoters. Small molecule silicon chemistry continues to engage materials scientists worldwide [12].

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2 SILICON—The Journal and its Scope

With the stated intention of bringing together various aspects of the science and technology of silicon, a new journal—*SILICON*—was launched in 2009. Over the last three years and twelve issues, *SILICON* has successfully published a diverse array of new developments pertaining to the element silicon (Si). In addition to the ‘regular’ issues that have been published covering reviews, articles and book reviews, the volume 2, issue 4 was devoted to the 2010 Kipping Award recipient Professor Yitzhak Apeloig [13]. A list of selected topics published in the journal is given below with reference to representative articles.

- Polymers and Materials Science and Engineering [14–19]
- Biology [20] and Biotechnology [21, 22]
- Space [23]
- Biomaterials and Medicine [24–27]
- Environmental Science [28, 29]
- Organic and Inorganic Chemistry [30–35]
- Photonic Devices [36] and Solar Cells [37]
- Surface Engineering [38–40] and Adhesion Science [24–26, 41–43]

3 An Overview and a Discussion of the Contents of *Biological and Bioactive Silicon Systems*

The present issue forms the second special issue of *SILICON* and it is dedicated to *Biological and Bioactive Silicon Systems*. This issue comprises of an editorial, a preface, ten research articles, a book review, and a closing end-piece. Our sincere thanks go to all of the contributors to this issue, to the expert referees who have provided rapid

and constructive feedback, to the journal production team and to the editorial board.

This special issue features several articles devoted to aspects of biological and bioinspired silica. Loucaides and co-workers present a comprehensive review on “*Controls on the recycling and preservation of biogenic silica from biomineralization to burial*”. Diatoms are estimated to be responsible for 20% of global carbon fixation [2] and have become the dominant primary producers (40%) in the ocean [44]. The growth of such ecologically important unicellular microalgae depends on the availability of dissolved Si and thus the authors suggest that diatoms form “an important link between the marine Si and C cycles” [45].

van der Walle presents a review on how one can utilise the understanding gained from biological silica spicule formation in sponges to generate industrially relevant novel materials and new technologies [46]. Müller and coworkers, using a theoretical approach report a new catalytic mechanism of silica polymerisation using the silicatein proteins from sponges. This model proposes that the catalytic effect of silicatein promotes the formation of cyclic species of silicic acid which are reactive and could easily promote silica polycondensation [47]. Vrieling, Wolterbeek and coworkers present their results on the cell biology aspects of the uptake and transport of silicon within diatoms in order to unveil a mechanistic understanding. Their experimental results are complemented with extensive mathematical modelling [48]. Frampton and Zelisko report the activity of three enzymes in hydrolysing a model alkoxysilane. The authors compare the enzymatic hydrolysis with the nature of the active sites present within the enzymes under consideration in order to identify the principles involved in the enzymatic processing of silicon-based substrates [49]. A book review of a landmark contribution to the biological and nanobiotechnological aspects of silica is also presented [50].

Nayak and Bera report the utilisation of silica derived from rice husks as a low-cost source for silica. The data presented in this article on the bioactivity and biodegradability of rice husks derived silica suggest that these materials are not only promising biomaterials but that they are also cost-effective [51]. Coradin and coworkers have prepared biocomposite membranes from cellulose and polysiloxane. Due to their ability to degrade in the presence of enzymes, these biocomposite and biodegradable materials could find applications as separation media [52].

The special issue also includes research on the applications of silicon-based materials in dentistry. In particular, Matinlinna and coworkers present an article focusing on the dental applications of silicas and silanes [27, 41–43]. In the forthcoming *Silicon Biomaterials*, Jukarainen and coworkers present experimental results on the application of silicone-containing copolymers as blood contacting materials [53]. Using a fibrinogen and thrombin assay, they demonstrate that

the composition, structure and chain conformations are important variables for generating non-thrombogenic surfaces and interfaces. The issue closes with a personal commentary on bioinspired silicon-based materials by Clarson [54].

In summary, this special issue on *Biological and Bioactive Silicon Systems*—an important area for future research—encompasses contributions from a wide range of aspects pertaining to the interactions of silicon with biological components and systems.

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