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BIOSYNTHESIS AND CHARACTERIZATION OF SILICON-GERMANIUM OXIDE NANOCOMPOSITE BY DIATOM

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Diatoms are single cell photosynthesizing eukaryotic algae that produce intricately structured cell wall made of nano-patterned silica. The biologically fabricated nanostructures offer substantially different properties related adhesion, tribology, optic and electronic behavior. In this study biosynthesis and characterization of Silicon- Germanium (Si-Ge) oxide nanocomposite in the diatom, *Stauroneis* sp., by two stage cultivation process. The exponential growth of *Stauroneis* sp., inoculated with enrichment medium amended with Germanium. The silicon to germanium concentration molar ratio was 1:0.5. Scanning electron microscopic studies reveals that no structural change is observed when germanium concentration is low, the increased concentration of germanium led to structural changes of the diatoms. The Si-Ge oxide nanocomposite was characterized by Electron Microscopy equipped with energy dispersive spectroscopy to evaluate the chemical composition and structural properties of the diatoms.

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1. Introduction

The cell wall structure is a species-specific characteristics demonstrating that diatom silica morphogenesis is genetically encoded. It is expected that these structures exhibit superior properties in a wide range of applications. The fabricated and self assembled of semiconductor nanostructures that possess unique optical and electronic properties [1]. The supramolecular chemistry and catalysis have led to novel surface and size dependent chemistry such as enation selective catalysis at the surface. The ability of diatoms to make complex, nanoscaled, three dimensional silica shells called “frustules” offers attractive possibilities for their application to nanobiotechnology [2]. Bioengineered nanosystem is extremely difficult to realize on the basis of current scientific knowledge and bottom up assembly is very powerful in creating of identical structures with atomic precision, such as supramolecular functional entities in living organisms. In this regards diatoms, a prolific class of single celled algae that make micro scale biosilica or frustules with intricate submicron features dominated by two dimensional pore arrays, have been advertized as a paradigm for the controlled production of nanostructured silica with interesting properties [3]. The fabrication of novel biomaterials through molecular self assembly is studied currently [4]. In this study we report that the fabrication of Silicon- Germanium oxide nanocomposites characterized by Electron Microscopy and EDS.

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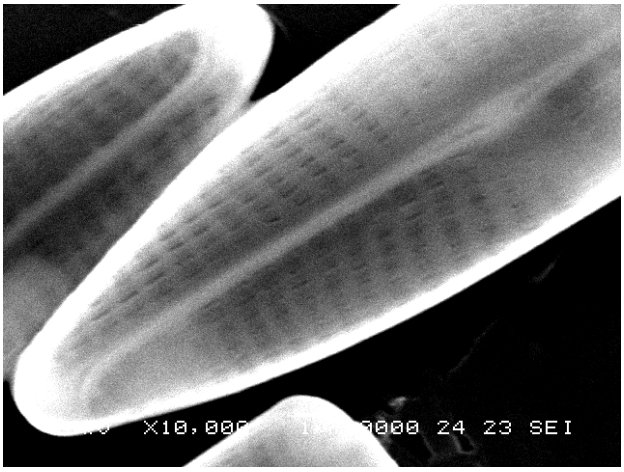
2. Materials and methods

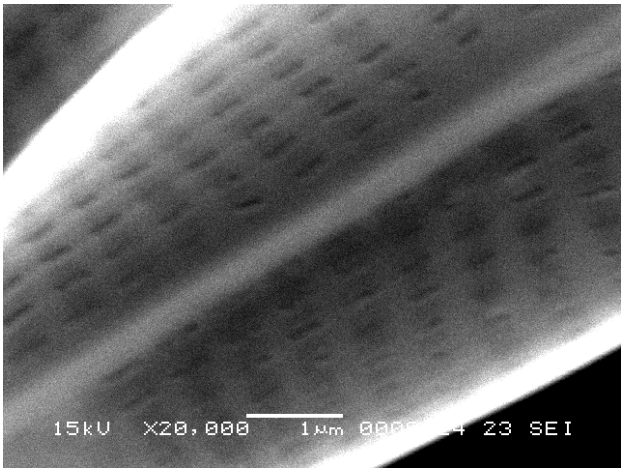
The photosynthetic freshwater diatom, *Stauroneis* sp., was isolated from the freshwater ponds from Bharathidasan University Campus and maintained in F/2 medium and cultivated in appropriate growth conditions such as light (2000lux), pH (8.0±0.2). The two stage cultivation methods is follwed for the synthesis of silicon-germanium nanocomposites as described [5]. In first stage, the cells were grown in nutrient medium containing sufficient silicon concentration for its growth. The silicon concentration (30mg/l) and cell density is monitored at regular intervals. When all the silicon was used up and the cell density had become constant, the cells were then considered to be starved of silicon, this condition prevails one week. In the second stage, the silicon and germanium (1:0.5) is added to the liquid medium for the biosynthesis of Silicon – Germanium nanocomposites. After 7 days the cells were harvested from the medium and washed thrice in deionized water in order to remove surface adsorbed germanium and other trace elements. Then the sample was centrifuged at 2000rpm for 5mins. The pellet was collected and dispersed on the thin slide and allowed to dry in hot air oven. The small portion of slide was placed onto carbon tape affixed to a stub, the gold was coated before introduction to the Scanning Electron Microscopy equipped with EDS.

3. Results and discussion

The incorporation of the Germanium into diatom cells was achieved and nanostructured pores could be found without morphological aberrations (**Fig. 1**). In this study the freshwater diatom, *Stauroneis* sp., was used to fabricate Silicon- Germanium by its metabolic activity. The SEM was used to assess and validate the integrity of the diatoms. The diatom, *Stauroneis* sp., frustules is observed in different growth conditions. After separation of diatom frustules from the organic matter, the sample was dispersed in alcohol, and then placed on the stub [6]. The characteristics peaks of Germanium were observed at 1.22 keV, 9.8 keV and 10. 4keV. The maximum peak of silicon was observed at 1.9keV (**Fig. 2**). It has been reported that the distribution profile of germanium in the diatom frustules is similar to that of silicon intensity is quite different [6]. It has been reported that silica from bioreactor cultured *Nitzschia frustulum* cells possessed blue photoluminescence, where the luminescence intensity and wavelength were dependent on the change in frustules nanosturucture as the cell culture moved from the exponential to the stationary phase of growth [5]. The soluble Germanium can be metabolically inserted into biosilica of the pennate diatom, *Pinnularia* sp., by two stage bioreactor process [7]. The metabolic incorporation of germanium into the biosilica of the diatom *Nitzschia frustulum* is described for the biological fabrication.



a



b

Fig. 1 SEM images of Stauroneis sp., grown in enriched medium (F/2) along with germanium(1a). It showed clear image of nanopore structures (1b).

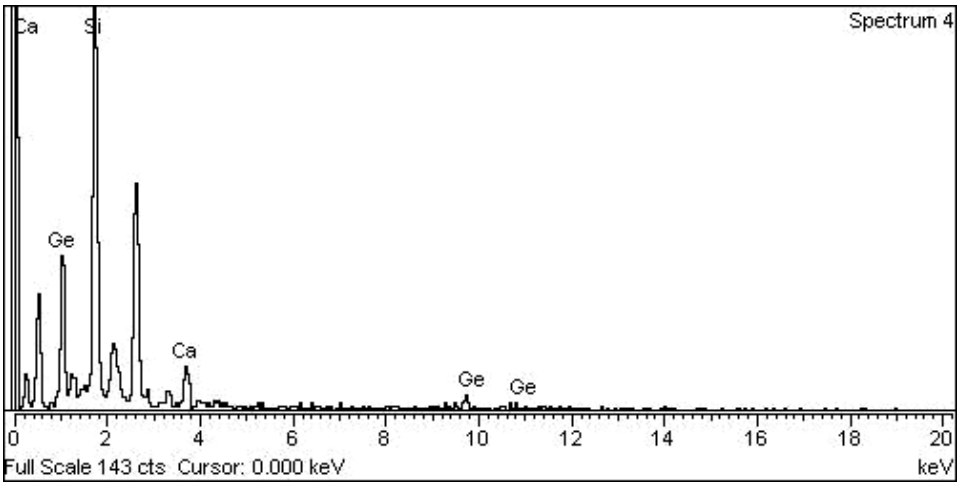


Fig 2. EDS spectrum of germanium doped culture Stauroneis sp., grown in enriched medium with germanium.

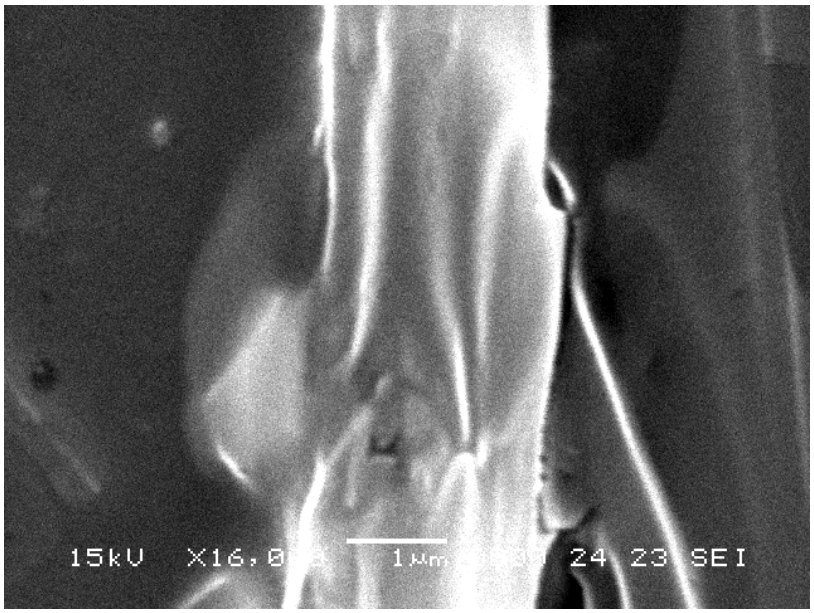


Fig 3. SEM images of Stauroneis sp., grown in enriched medium (F/2) along with germanium in molar ratio of 1:1. It showed aberrated diatom structure.

Fig. 3 shows that due to the equal volume of Silicon- Germanium, the diatom cells are fully aberrated. An Electron Microscopic study reveals that due to the incorporation of germanium, the diatom cells lead to various degrees of aberrations and also unavailability of sufficient silicon for the cell wall biosynthesis. The *Stauroneis* sp., with high percentage of germanium concentration has been found to cause cell aberrations than with the low percentage. The difference in bond length between silicon oxide and germanium oxide probably weakens the diatom frustules and cause them to break easy during the processing of the cells [6].

In this study incorporation of germanium into diatom cells were achieved. Several workers also reported that there was no Silicon- Germanium homogeneity in the distribution of the diatom cells. The experimental protocol should be standardized to achieve the homogeneity intricate Silicon-Germanium nanocomposites. These optoelectronic properties of the nanocomposites, which depend on the amount of Germanium assimilation can therefore be controlled.

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