Abstract

In nature, among the phytoplanktons, monocellular and photosynthetic algae diatoms are dominant species having up to ten thousand known and classified species of huge variety of shapes and dimensions [1, 2]. According to researchers' reports diatoms produce oxygen, about 40% in oceans and about 20-25% in the world, through the photosynthesis process [1-3]. The frustules of diatoms are found abundantly in all oceans and freshwater bodies. They appear in a huge variety of species possessing unique frustule morphologies, shapes and dimensions. The dimensions of frustule pores, called the areolae, can range from 2000 nanometer to micrometer scale (from 2 microns to 500 microns in diameter, depending on species and position in the cell wall structure) and they interact very efficiently with light by means of diffractive processes [3]. Fortunately, diatoms can be grown in a large scale at ambient conditions in the laboratory following simple culture procedures and thereby opening a pathway for the controlled production of nanostructured silica with unique photonic properties. Due to the self-assembly into hierarchical structures of diatoms, increasing interests in bio-inspired approach for synthesis of semiconductor and metal oxide nanoparticles with metabolic insertion of impurities like TiO_2, Ge, etc. into biosilica frustules have been observed [5-7]. Semiconductor embedded diatom frustules are a reliable way to degrade polluting dyes via a photocatalytic mechanism. The diatom cell contains photosynthetic pigments, fucoxanthin and chlorophyll-protein molecular complexes that have reducing and stabilizing properties [1, 8]. Due to this, diatoms have also the potentiality to synthesize silver nanoparticles by a simple, environment friendly, cost effective, high yield and one step green synthesis process.

The first chapter of this doctoral thesis is an introductory chapter that gives an extensive description about freshwater diatoms. The works done by other researchers have been thoroughly reviewed and reported here. We have discussed some important properties and findings of diatom frustules and their applications in various research fields from researcher's reports. We have also discussed the advantage of these natural nanostructures over manmade nano structures in this chapter.

In chapter 2, we have described the culture process of diatom species by using reference medium "WC" in laboratory. The diatom cell isolation and cleaning process have been reported elaborately in this chapter. Eventually the diatom frustule acts as a template for synthesis of nanoparticles. We have described the synthesis of single anatase phase TiO_2 nanoparticles (named as DT500) and mixed phase TiO_2 nanoparticles (named DT800) that have been synthesized by the diatom frustule templates. The green biosynthesis of silver nanoparticles using diatom cells

containing fucoxanthin, acting as a reducing and stabilizing agent, have also been described. The process of metabolic insertion of arsenic in diatom cells has also been discussed in this chapter.

In chapter 3, Different characteristic techniques e.g. X-ray diffraction, Raman spectroscopy, optical microscopy, scanning electron microscopy, transmission electron microscopy, energy dispersive X-ray spectroscopy, FTIR spectroscopy and N_2 adsorption/desorption isotherm analysis were employed to study morphology and compositional properties of the as-synthesized diatom frustules based materials and raw diatom frustules. The optical properties of the materials were investigated using UV-Visible spectroscopy. These as-synthesized materials, DT500 and DT800, show broad absorption of visible light as compared to bare TiO_2 nanoparticles. In this chapter, a comparative study of photocatalytic behavior of the as-synthesized materials was also presented. DT800 shows better visible light photocatalytic activity as compared to DT500. The reusability and durability properties of DT800 catalyst were also studied.

In chapter 4, the structural and optical characterizations of the as-synthesized silver nanoparticles deposited on diatom frustules (SND) via the green synthesis technique have been reported. The synthesized material shows a broad spectrum of absorbance in the visible range. Further, the sensing behavior of this SND material on dissolved ammonia at room temperature has been investigated.

In chapter 5, a comparative study of arsenic treated diatom frustules with untreated ones is done. We have found some distinct evidence of the presence of arsenic in the arsenic treated diatom frustules and this indicated probable application of diatoms in the detection of arsenic in water bodies.

In the concluding chapter 6, we have highlighted the conclusions taken from the present investigation. We have summarized several important findings and noted their relevance in probable future works.

References

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