SMART NANOSTRUCTURED MATERIALS FOR WATER PURIFICATION

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by

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Dedicated to

Maa & Deuta

CERTIFICATE

This is to certify that the thesis entitled, **"SMART NANOSTRUCTURED MATERIALS FOR WATER PURIFICATION"** being submitted by **Mr. Arabinda Baruah** to the Indian Institute of Technology Delhi for the award of the degree of **Doctor of Philosophy** in Chemistry, is a record of bonafide research work carried out by him. Mr. Arabinda Baruah has worked under my guidance and supervision, and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard.

The results contained in this dissertation have not been submitted in part or full, to any other university or institute for award of any degree or diploma.

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ABSTRACT

The world is running out of clean fresh water. Highlighting this global water crisis, the journal, "*Nature"* has stated in its web focusas "More than one billion people in the world lack access to clean water, and things are getting worse. Over the next two decades, the average supply of water per person will drop by a third, possibly condemning millions of people to an avoidable premature death". Rapid industrialization is one of the major factors behind this growing scarcity of safe drinking water. Per day, millions of liters of waste water from industries are being released into the water bodies, making the water unfit for aquatic life as well as human use. To deal with this impending water scarcity, cheaper and more efficient methods for purifying and recycling waste water need to be developed and that is the motivation behind this research work. In the past two decades there has been unprecedented rise in the number of publications on the synthesis of novel nanostructured materials and their application in water treatment and photocatalysis. Various membrane processes have been developed for water treatment; among them, nanofiltration membranes are the most commonly used component in the advanced water purification and desalination technology. However, we currently have only few nanotechnology based water purifying and recycling devices in the market which are cheaper, portable and efficient. Removal of toxic metal ions and organic dyes from the industrial waste water is very much important before releasing the effluents into water bodies.

Themotivation of the present investigation is to develop cheaper, eco-friendly and efficient nanoadsorbents capable of binding organic impurities and toxic metal ions from waste water. We also focused on the synthesis of various photocatalyst nanoparticles and films for the degradation of organic pollutants in water.

Here, we have discussed the synthesis and application of some novel nanostructured materials which have been found to be highly potential for the treatment of industrial waste water. Removal of lanthanide ions from water has also been studied using surface modified porous nanomaterials. UV or visible light assisted photocatalytic degradation of organic contaminants in water using nanostructured materials is one of the most popularly used techniques for water remediation. Here we have discussed the fabrication of hetero-structured hollow spherical silica tantalum oxide nanoparticles and their Langmuir Blodgett films, and studied their photocatalytic efficiency towards the degradation of Rhodamine B under UV light. Preparation of nanomaterials having desired shape and size is of utmost importance as their optical and electronic properties are dependent on them. In addition to the above techniques, we have highlighted the less explored microfluidic route for the production of nanoparticles as well their photocatalytic application using microreactors. Our studies have shown that, the size and morphology of the synthesized nanoparticles depend on the flow rate, concentration of the reactants and the geometry of the micro-reactors. Nanoparticle embedded microchannels displayed excellent photocatalytic dye degradation efficiency.

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ABBREVIATIONS AND SYMBOLS

Å	Angstroms
°C	Centigrade
μm	Micrometer
nm	Nanometer
min	Minutes
h	Hours
s	Seconds
PXRD	Powder X-ray diffraction
TEM	Transmission Electron Microscopy
HRTEM	High Resolution Transmission Electron Microscopy
FESEM	Field Emission Scanning Electron Microscopy
EDAX	Energy Dispersive X-ray Analysis
DRS	Diffuse reflectance spectroscopy
BET	Brunauer - Emmett – Teller
BJH	Barrett-Joyner-Halenda
CTAB	Cetyltrimethylammonium bromide
UV-Vis	Ultraviolet -visible
MB	Methylene blue
RhB	Rhodamine B
MG	Malachite Green
MO	Methyl Orange
MDPA	Methylene diphosphonic acid

MA	Malonic acid
ICP-AES	Inductively Coupled Plasma - Atomic Emission Spectroscopy
LB	Langmuir-Blodgett
CB	Conduction band
VB	Valence band