A Review on $\text{TiO}_2$, $\text{SiO}_2$ and $\text{TiO}_2$-$\text{SiO}_2$ Nanocomposite Synthesis and its Applications

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ABSTRACT

In past few years, antireflection sol-gel coatings have been an area of great interest and attracted researchers as they are reliable due to their low cost and also find potential applications in a variety of commercial purposes. Oxides of higher refractive index such as $\text{ZrO}_2$, $\text{TiO}_2$, and $\text{Ta}_2\text{O}_5$ and oxides of lower refractive index such as $\text{SiO}_2$ finds application in various fields like fabrication of various types of coated optics and different optical filtering. $\text{TiO}_2$ photocatalytic coatings are extensively known for their amazing behavior of self cleaning using hydrophilic surface which can easily wash off dirt particles. $\text{SiO}_2$ and $\text{TiO}_2$ shows unique and highly tunable optical and photocatalytic properties. Various techniques are used by researchers for the synthesis of $\text{TiO}_2$, $\text{SiO}_2$ and $\text{TiO}_2$-$\text{SiO}_2$ nanocomposite. In this paper we will be going through most of the available synthesis techniques used by researchers and its applications in various fields.

I. INTRODUCTION

Nanotechnology had become an area of great interest finding applications in various fields and is creating miracles with its unique properties and specialties in nano range. Nanomaterials play a vital role in the field of nanotechnology in the form of nanoscale particles, tubes, rods or fibers and are finding applications in various fields like Electronics, Cosmetics, Health care, Information Technology, Textiles and Environmental Protection. The characteristics and specific functions of nanoparticles may be controlled and varied after the requirement by varying their shape and size at the nanometer scale.

$\text{SiO}_2$ and $\text{TiO}_2$ nanomaterials have been an area of wide research in the past few years due to its amazing properties in self cleaning and photocatalytic applications. Also due to their relative low cost they find potential application for a variety of purposes such as Solar cells, wind screens, thermal collectors, architectural glasses, high power lasers and video display panels. Photocatalytic coatings of $\text{TiO}_2$ nanoparticles are well known due to their excellent self cleaning behavior.[1] $\text{SiO}_2$ and $\text{TiO}_2$ core shell nanoparticles (csns) have attracted great attention due to their highly unique and tunable optical and photocatalytic properties and also higher dispersion of the supported $\text{TiO}_2$. Thus, development of facile, reproducible and effective techniques for the synthesis of $\text{SiO}_2$ and $\text{TiO}_2$ csns and a fundamental understanding of their improved properties, achieved from combination of different core and shell materials, is of great significance.[4]. Wide area of applications are available including the photocatalytic and self cleaning property.

Various methods for the synthesis of $\text{SiO}_2$-$\text{TiO}_2$ nanoparticles are also available like Sol gel method, Pulse laser deposition, Electrochemical route, Chemical co-precipitation method, Solid state reaction method, Thermolysis, Chemical bath deposition method and Spray pyrolysis method.
SYNTHESIS OF \(\text{TiO}_2\), \(\text{SiO}_2\) and \(\text{TiO}_2-\text{SiO}_2\)

II. NANOComposite

Although many synthesis techniques are available and have been used by the researchers but the most frequently used synthesis technique is the Sol–gel method. In a research work silica nanostructures was synthesized using sol–gel method and the two parameters considered are aging time and the calcinations temperatures and the average particle size of silica was in the range of 79.68 nm to 87.35 nm.[1] The sol–gel method has been widely used as a substitute technology in preparing monoliths, powders, coatings and fibers. Another researcher had used sol–gel method in which \(\text{TiO}_2-\text{SiO}_2\) have been prepared by the sol–gel method by using titanium isopropoxide and varied silica precursors: tetraethyl orthosilicate and tetra methyl ortho silicate.[4]

Mesoporous \(\text{TiO}_2\), \(\text{SiO}_2\) nanoparticles and \(\text{TiO}_2/\text{SiO}_2\) nanocomposites were successfully synthesized by sol–gel method in which Titanium (IV) isopropoxide, tetra-ethylorthosilicate were used as starting materials. Mesoporous materials are of great interest as catalysts because of their unique textural and structural properties. The UV–Vis spectrum of the synthesized samples shows similar absorption in the visible range. The \(\text{TiO}_2/\text{SiO}_2\) nanocomposite’s BET surface area is found to be 303 m\(^2\)/g. The average Pore diameter is about 10nm.[5] Another research using Sol–gel method was done in which \(\text{TiO}_2\) and \(\text{SiO}_2\) nanoparticles are first synthesized and then the superhydrophobic self cleaning \(\text{SiO}_2/\text{TiO}_2\) layers are fabricated on glass. The synthesis of \(\text{SiO}_2\) and \(\text{TiO}_2\) nanoparticles was done using chemical method.[5]

In a research done in 2012 Broadband antireflective coatings via the design concept of three Layer interference coating i.e \(\text{SiO}_2-\text{TiO}_2\), \(\text{TiO}_2\) and nanoporous \(\text{TiO}_2-\text{SiO}_2\)composite thin films were employed as bottom, middle and top layers.[9] In a research Silicon based solar cells have been fabricated for single layer \(\text{SiO}_2\) and double layer \(\text{SiO}_2/\text{TiO}_2\) antireflective coatings (ARC) using RF sputtering technique. A research work was done in 2014 in which Sol–gel method and Dip coatings method was used in combination to form multilayer \(\text{TiO}_2/\text{SiO}_2\) coatings on both sides of the glass substrates [15]. \(\text{TiO}_2\) nanoparticles are synthesized using simple Sonochemical method in a research work done in 2007. The mean diameter of the synthesized nanoparticle is about 20nm. It is initially treated with 10M NaOH solution aqueous solution [17]. Titanate nanoparticles synthesis using Hydrothermal reaction is also carried in which \(\text{TiO}_2\) and NaOH is used as the precursors and the calcinations temeratur is set to 500°C for 4hrs.[14]

III. APPLICATIONS IN VARIOUS FIELDS

\(\text{SiO}_2, \text{TiO}_2\) nanomaterials individually as well as when used as composites shows unique properties which makes it an an area of great interest and hence finds as wide area of applications including Electronics, Cosmetics, Health care, Information Technology, Textiles and Environmental Protection. Many researchers have worked on the application of these materials in different fields due its highly tunable and amazing properties.

\(\text{SiO}_2, \text{TiO}_2\) nanomaterials are used to develop thin films and coatings which have been used by the researchers as an area of application on glass substrates etc. Also a researcher used \(\text{SiO}_2\) as nanofluids for cooling applications in Fuel cell (Polymer Electrolyte Membrane Fuel Cells i.e PEMFC) as their operation is very much sensitive to micro electrochemical changes and can only tolerate a small temperature variation. \(\text{SiO}_2\) nanofluids act as a cooling agent in the thermal management in such conditions. Titanium dioxide is well known semiconductor material in some applications which includes photocatalysis and dye-sensitized solar cells which are used to enhance its performance, some modifications have been investigated by such chemical and physical treatment.[4]
Photocatalytic degradation of methylene blue dye (MB) was studied making use of the Titanate nanoparticles in which it is exposed to UV light inside a tubular reactor. [14] Another research work based on the self cleaning and hydrofobicity of wool fabrics was analysed in a research work done in 2012 for coffee stain removal under UV and water contact angle respectively.

IV. CONCLUSION

Various researchers had used different synthesis techniques and had used for various applications. The main area of application focused by researchers are for self cleaning and on photocatalytic properties. Although Sol–gel method is the most widely used synthesis technique various researchers have worked on the different synthesis techniques under various circumstances so as to get the required nanomaterial or composites under available resources.

V. REFERENCES


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