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Synthesis and Characterization of Nanoscale Iron Oxide for Environmental Uses

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Abstract

Synthesis of Nanomaterials: "This is a top-down approach. This method produced nanoparticles with magnetic and catalytic properties. Ball milling and subsequent annealing are simple methods for producing large quantities of different Nano powders. Atomic-level alloying is accomplished by milling elemental blends, pre-alloyed powders, and ceramics. Put four hardened steel balls in a stainless steel container filled with graphite powder. According to Shah and Ahmad (2010), argon gas is used to purge the container. Following extensive grinding, the pieces are annealed under vacuum at 1400°C. There has been no breakthrough in determining the mechanism underlying this procedure. According to this concept, mechanical alloying is a process in which "ball impacts repeatedly shatter an alloy and then cause it to congregate at the impact site. Since then, Mg2Ni has been manufactured using a solid-state mechanical alloying technique with powdered components (Iturbe-Garca et al., 2010). Nanoscale materials have sparked a lot of interest because their unusual physical properties distinguish them significantly from their more common coarser counterparts (Mandal et al., 2008; Deb et al., 2001). These micro-sized objects are larger than atoms and molecules but significantly smaller than solid blocks. Simply because "they violate the laws and principles of absolute quantum chemistry and classical physics." Nano-phase and nanostructure materials are essential building blocks in many fields, including electronics, because of their ultra-small dimensions, large surface areas, useful interfacial defects, and interface-dominated nature. Optics, pharmaceuticals, paint, coatings, superconductors, semiconductors, and catalysis are some of the fields covered. Dye and pigment consumption has risen dramatically in recent years (Dong et al., 2011; Zhou et al., 2010). Dye waste is a well-known environmental pollutant, with some of it toxic or even carcinogenic (Wang et al., 2005; Zhu et al., 2012). These colors are highly visible in water even at low concentrations and should be avoided (Hu et al., 2010). Chromophores give a molecule its color, while auxochromes make it more water-soluble and increase its affinity. These two elements are the primary reason why molecules of color can exist (Gupta et al., 2009).

Keywords: Semiconductors, Nanostructured Materials, Atoms and Molecules.

INTRODUCTION

Nanostructured materials, defined as "grains, layers, or forms smaller than 100 nm," have sparked renewed interest in nanotechnology (Hornyak et al., 2009). Nanomaterials, unlike other materials, have unique nanometer-scale properties. At least one dimension of a nanomaterial must be less than 100 nm (Chattopadhyay et al., 2009). Inorganic nanostructures, which include metal oxides, ceramics, and composites, have matured into an interdisciplinary topic over the last two decades as a result of international efforts in both theory and experimentation. Nanostructured materials are well-known for their stability, environmental friendliness, and diverse technical applications (Bhushan et al., 2010). Surface-dominant nanostructure metal oxides have the potential to almost completely replace all bulk metal oxides in a variety of Applications include catalysis, solar cells, and hydrogen storage batteries; membrane and separation technology; structural applications requiring a high degree of rigidity; sensor technology; optical and electronic devices, and tissue devices, among others (Wang et al., 2009; Kim et al., 2010). Another reason for the growing interest in one-dimensional "nanostructures" is that they possess distinct and exciting properties that cannot be found in their bulk or particle counterparts. This includes nanowires, nanotubes, nanorods, and nanofibers (Tiwari et al., 2012; Zhang et al., 2008). Our studies have focused on iron oxide and alumina 1D nanomaterials, as well as a mixed nanocomposite of these two materials. Ceramics are primarily made of alumina and iron oxide. Alumina has a broad range Potential quality in chemistry and physics. It is a common electrical insulator with high chemical resistance that is used as a catalyst in a variety of chemical processes, including microelectronics, membrane applications and wastewater treatment. As a result, iron oxide has a large impact on the environment and is widely used in a variety of technical fields. Because of its antiferromagnetic properties, it is an n-type semiconductor. Because of its low toxicity and ability to catalyze multiple chemical processes, it is suitable for a wide range of environmental and biochemical applications. Nanocomposite production, on the other hand, seeks to maximize the synergistic impact of the two metal oxide compounds involved. Controlling inter-particle electron transfer in composite nanomaterials gives them an advantage over Zhang et al. (2009) describe individual nanomaterials.

Literature Review

When working with nanoscale materials, new manufacturing methods must be used to achieve diverse shapes and "morphologies." We used sol-gel, hydrothermal, and electrospinning methods to synthesize 1D alumina, iron oxides, and mixed oxide nanostructures. Many people are interested in the potential uses of nanomaterials in environmental research and engineering. A healthy environment is necessary for good human health. It is becoming increasingly difficult to meet the ever-increasing demands for environmental cleanliness in contemporary society (Zhang et al., 2010). Nanomaterials are an effective tool for detecting and removing "environmental contaminants." Recently, researchers have investigated the use of nanomaterials to clean the environment and address environmental concerns. A new class of functional materials, nanoscale Materials can be used as effective adsorbents due to their large surface area to volume ratio and surface active sites. Nanomaterials' environmental applications include green chemistry, photo-catalytic degradation of organic dyes, remediation of contaminated water, pollutant monitoring and detection, antibacterial activity, and so on.

This thesis will synthesize and characterize nanoscale one-dimensional "polymer and ceramic materials such as alumina, iron oxide, and their composite oxides. Nanomaterials and composites have been used to study the adsorption of toxic metal ions, the removal of organic dyes from water, and antibacterial applications.

Statement of the Problem

Recent advances in nanoparticle structures for quantitative measurements have been made possible by the development of "multifunctional nanomaterials" (Chan et al., 1998). Composite materials are made up of many different components that are intermixed. In many cases, the combination of various materials can mask or mitigate the negative characteristics of the individual components. Because each component is housed in its own compartment, a single nanoparticle can contain "multiple" components (Janczak et al., 2012). To qualify, at least one phase of a composite "nanomaterial" must have nanometer-sized particles. There are several benefits to combining nanomaterials in the form of nanocomposites (Novoselova, 2012). With their unique combination of characteristics, These nanocomposites outperform their "single-component" counterparts and are considered the preferred materials of the twenty-first century.

The study aims

To investigate the feasibility of using 1D Fe2O3/Al2O3 nanomaterials for removing toxic metal ions (e.g. Cr, Pb, Ni, Cu, As, Hg) and organic dyes from aqueous solutions through chemisorption/adsorption.

Research Questions: • Can 1D Fe2O3/Al2O3 nanomaterials effectively remove toxic metal ions like Cr, Pb, Ni, Cu, As, and Hg?

Research Methodology

S D Fine, India will produce an analytical grade of "aluminum isopropoxide (AIP)" with a purity of 99.0%. SRL from India supplied the isopropanol (IPA) and acetic acid (AA) used in this experiment. Merck India Ltd. supplied Congo red, sodium hydroxide, and nitric acid. All compounds can be used without further purification. Double-distilled water will be used to formulate and dilute solutions. The sol-gel method will be used to create boehmite (AlOOH)

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nanomaterials. The hydrolysis of aluminum isopropoxide (AIP) precipitated aluminum in the form of fine hydroxide gel, which will be used as an experimental method. It will first be mixed with 2-propanol and acetic acid, and water will be gradually added to the mixture while it be constantly stirred. Throughout the procedure, the molar ratios of AIP/AIP, H2O/AIP, and IPA/AIP will be kept within acceptable limits. Using a water bath, the precipitate will be heated to 80°C for 20 hours, filtered, washed with 2-propanol, and dried for 8".

Research Design

Creating nanomaterials with "well-defined size and shape" is a significant challenge. Nanomaterials can be created in a variety of ways, depending on the material of interest and the size range. Nanomaterials can be synthesized by producing a large number of nuclei while preventing grain growth and aggregation. This is the underlying idea. A variety of metals, metal oxides, sulphides, polymers, and "composite nanomaterials" can be synthesized using physical and chemical methods.

1**. Physicochemical Techniques**

Several methods have been used to synthesize and commercially produce a variety of nanomaterials, thin films, and nanocomposite materials over the last few decades. Most of the physical pathways used to synthesize" nanomaterials can be summarized as Fallows:

2**. Laser-assisted tissue removal.**

Thermally activated high-power laser pulses will be used to remove carbon from a target using the laser ablation technique. This approach allows for the deposition of nanocrystalline thin films and powder. Thus, a supersonic stream of particles (plume) strikes the target surface. As the plume moves away from the target, the forward velocity distribution of the various particles becomes more pronounced. The ablation process occurs in a vacuum or in the presence of some background gases. The substrate "must be heated to a high enough temperature (roughly 700-800°C)." This procedure is useful for both high melting point elements and transition metals. This technique has been used to produce sulphide compounds. Traces of highly toxic and radioactive elements can also be removed. Using this procedure. This method has the advantage of being able to generate materials at a rate of 2-3 gm/min. Nanocrystalline NiO thin-film electrodes will be created by ablating a metallic nickel target with a reactive pulsed laser in an oxygen environment (Wang et al., 2002). Laser ablation of gold immersed in various liquid alkanes will produce different results, ranging from n-pentane to n-decane (Compagnini et al., 2003; Dahl et al., 2007).

3**. The condensation of inert gases.**

The first method for producing nanocrystalline metals and alloys will be gas condensation. An inert gas, usually He or Ar, is used in conjunction with a low-pressure evaporation chamber to chill a substance before it evaporates. As a result, this procedure is known as "inert." "Gas evaporation," or IGE. Nanoclusters are formed when evaporated atoms or molecules collide with gas atoms or molecules. Thermal evaporation sources, such as Joule heated refractory crucibles and electron beam evaporation devices, are used to evaporate metallic or inorganic materials in an atmosphere of 1-50 mbar. Inert gas condensation on a sputtering reactor will produce gold and palladium nanoparticles, with researchers observing that the particles are icosahedral in shape and have no core-shell structure.

4. Process with a high-powered ball mill (mechanical alloying method).

This is a top-down approach to nanomaterial synthesis. This technology has produced nanoparticles with magnetic and catalytic properties. To generate large quantities of diverse Nano powders, ball milling and subsequent Annealing methods are straightforward. Milling of elemental blends, pre-alloyed powders, and ceramics is used to achieve "atomic-level" alloying. Four hardened steel balls are placed in a stainless-steel container filled with graphite powder. The container is evacuated with argon (Shah and Ahmad, 2010). After a long period of "milling," the parts are annealed at 1400°C in an inert environment. This process's mechanism is still unknown. According to this theory, mechanical alloying is the process of continuously fragmenting and coalescing an alloy at the collision site as a result of ball collisions. Since then, Mg2Ni has been created by mechanically alloying powdered" elements in a solid-state process (Iturbe-Garca et al., 2010).

5. The application of chemical vapor deposition.

Chemical vapor is a materials processing method Deposition (CVD) is frequently used. Substrates are exposed to one or more volatile precursors, which react to form a solid deposit or thin film on the substrate's surface. Solid thin-film coatings on surfaces are the "most common use of this technology," but it is also used to generate high-purity nanomaterials and powders, and to fabricate composite materials using infiltration methods (Creighton et al., 2001). CVD's versatility allows for a diverse range of chemical reactions. According to general experience, low temperature CVD yields MWNTs, whereas high temperature CVD (900-1200°C) yields SWNTs. Depending on the parent materials, carbon nanofibers and Nano beads may also be produced. Single-walled carbon nanotubes (SWNTs), with Highly graphitized structures will soon be produced using an improved nitrogen-pretreatment Fe-Mo/MgO catalyst. They concluded that nitrogen pretreatment increases catalytic activity and facilitates the growth mechanism, resulting in longer SWNTs. SWNTs with extended, highly graphitized lengths will also be produced (Patil et al., 2012).

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6. Electrodeposition.

Template-assisted electrodeposition allows for the creation of nanomaterials with controlled shape and size. Advances in materials science have accelerated the growth of applied electrochemistry. This technology creates arrays of nanostructured materials with specific layouts using an electrochemical cell for vast areas requiring low-cost, low-temperature processing. During electro deposition, nucleation can occur immediately or gradually. Moghaddam et al. conducted research on the synthesis of ZnO nanoparticles and the electrodeposition of a polypyrrole/ZnO nanocomposite film in 2009. Li et al. (2013) used in-situ electro "deposition" to produce polyaniline nanoparticles (PANI). When PANI nanoparticles are electrodeposited, the growth time is used to control their shape and an active or restricted template as a cathode. As a result, electro deposition of oxide films from aqueous solution offers several advantages over other methods. This technology is especially useful.

Data analysis

In this study, we will use hydrothermal methods to synthesize Fe_2O_3 and Al_2O_3 nanocomposites. The $Al(NO_3)_3$

•$9H_2O$ and $FeSO_4.7H_2O$ salts will be dissolved in equal amounts of distilled water. Then, "All of the components in the solution will be thoroughly mixed by vigorously shaking the container. In addition, 25 ml of 2M NH_3 solution and 25 ml of NaOH solution will be combined in a 1:1 ratio to create a mixed precipitant. The combined precipitant can be dissolved drop by drop in the aforementioned combination solution while vigorously stirring. The pH of the solution will be measured in real time with a pH metre. In this case, the green precipitate formed at 5.6 pH. The precipitate had The developed solution will be transferred to a new container via a 100 ml teflon-cupped pressure cooker. The pressure cooker will be sealed before being placed in an electric oven set to 180 degrees Celsius for six hours. After cooling to room temperature, the product will go through several rounds of centrifugation and deionization before being dried at 50°C for five to six hours and ground into a "powder." Calcinating the bright yellow powder at 500 to 1000 degrees Celsius yields a Fe_2O_3-Al_2O_3 nanocomposite.

Electrospinning will be used to create Fe_2O_3 nanofibers before they are combined with Al_2O_3 to form composite nanofibers. To create a 10% wt% PVP solution, we will dissolve PVP polymer power in 100% ethanol and violently mix in iron. Acetylacetonate is an iron precursor." The iron precursor sol will be combined with the PVP/ethanol solution after 1-2 drops of acetic acid have been added to the mixture. We will always use a 2:1 polymer-to-iron precursor ratio. We used a metal needle to mix iron acetylacetonate-PVP in a 3 ml plastic syringe. The polymer solution will be fed to the needle tip using a syringe pump at a constant rate of 1.5 mL/h. One electrode of a variable high voltage (Glassman, Japan) power supply (12.5kV) will be attached to the needle, while the other electrode, covered in aluminum film, will be connected to the grounded collector. The distance between the collector and the tip of the needle will be 10. centimetres. All experiments will be carried out with an ambient temperature and humidity of 45-50%. The as-spun "high-temperature composite fibers" will be calcined to produce nanofibers of Fe2O3, Aluminium foil electrodes will be connected to the grounded collector via a high-voltage power supply (Glassman Japan). The distance between the end and the storage was kept constant at 15 centimetres throughout. Each experiment will be carried out at room temperature and 50% to 55% relative humidity. In this case, heating or chemical reduction may convert the silver ions in PAN nanofibers to metallic silver. A piece of the as-spun PAN/AgNO3 composite membrane will be immersed in a 160°C, 0.1 M NaBH4 aqueous solution for 30 minutes at room temperature. Polyaniline nanofibers "After being washed with distilled water, the silver nanoparticles will be baked for two hours at 60°C.

CONCLUSION

One-dimensional nanosized alumina, particularly boehmite phase, and iron oxides are important ceramic materials with potential chemical and physical properties. In this dissertation, we created one-dimensional nanocomposite materials made of aluminum and iron oxide. In the current study, rod and fiber-shaped alumina, iron oxide, and iron oxide-alumina mixed nanocomposite materials were successfully produced using sol-gel, hydrothermal, and electrospinning procedures. FT-IR, XRD, SEM-EDAX, TEM, TGA-DTA, BET, UV-Vis, and AAS were used to characterize the synthesized 1d nanomaterials and mixed oxide nanocomposites in terms of their synthesis, structural and size properties, surface morphology, and sorption capacities. Hazardous metal ions such as Cr (VI), Pb (II), Hg (II), Ni (II), fluoride (II), and organic dyes like Congo red will Removed from the aqueous solution using the alumina and iron oxide-alumina mixed nanocomposites that will be synthesized. The needle-shaped boehmite generated by the sol-gel process has been shown to be a particularly effective adsorbent for the removal of Congo red (CR) dye. With a maximum sorption capacity of 198 mg/g, 99 percent of CR can be removed in 10 minutes of contact time. The adsorption ability of the boehmite phase to remove CR dye decreases with higher sintering temperatures and subsequent conversion to alumina. The absence of an oxyhydroxy group effectively removes the "Congo" red dye from alumina. Electrospinning was used to create alumina nanofibers with a diameter of 100-500 nm. To remove Cr (VI) and fluoride (F-), nanofibers made of alumina have proven to be effective adsorbents. The greatest removal for Cr (VI) will be found to be 70%, while the maximum removal for fluoride ions will be 50%. As an added bonus, the pseudo-second-order rate rule governs adsorption rates. Chemically produced hydrothermal iron oxide-alumina nanocomposites will be used to remove

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Congo red dye. Within 15 minutes of contact, a mixed iron oxide-alumina nanocomposite will remove Congo red dye completely (100 percent), with an adsorption capacity of 498 mg/g. The electrospinning process, on the other hand, resulted in Fe2O3-Al2O3 nanocomposites. Adsorbents for hazardous ions such as Cr, Pb, Hg, and Ni are available. To determine why this material prefers to absorb a metal ion, We can investigate the electronegativity of metals and how they behave in the anion/cation state. We discovered that the metal removal affinity on the mixed oxide nanocomposite fiber surface" will be Cu Pb Ni Hg.

The limitations of the study

Nanoparticle structures for quantitative measurements have advanced in recent years as a result of the development of "multifunctional nanomaterials" (Chan et al., 1998). Composite materials are made up of many different components that are intermixed. In many cases, the combination of various materials can mask or mitigate the negative characteristics of the individual components. A single nanoparticle can contain multiple components because each component is housed in its own compartment (Janczak et al., 2012). At least one phase. To qualify as a composite nanomaterial, the particle size must be in the nanometer range. There are several benefits to combining nanomaterials in the form of nanocomposites (Novoselova, 2012). With their distinct combination of properties, these nanocomposites outperform their single-component counterparts and are regarded as the "21st-century materials of choice."

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