iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** III **Month of publication:** March 2018

DOI: http://doi.org/10.22214/ijraset.2018.3311

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

Iron oxide Nanoparticles: Synthesis and Characterization by Chemical Deposition method

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Abstract: Here we report the deposition method of iron-oxide film. Synthesis, characterization and physico-chemical properties of oxide nanomaterials. Iron oxide thin film deposited onto the plain glass material. Iron oxide nanoparticles were synthesizes using chemical method by iron chloride and aqueous ammonia solution as a herald. In order to establish the composition of the iron oxide nanoparticles and its relation with size, the morphological, structural and magnetic properties of the prepared samples were investigated using DLS, SEM and TEM. The scanning electron microscopy (SEM) images show morphology of Iron oxide obtained by the above method and the growth of iron nano-rod of the as-deposited Iron-Oxide thin film. Iron oxide thin film is water dispersible, highly stable for more than 100 days at neutral pH with a size of less than 10-15 nm.
Keywords: Iron-Oxide, Nanomaterial, deposition, SEM, Chemical Method

I. INTRODUCTION

Iron oxide nanoparticles with mean diameter ranging from 7 to 20 nm were synthesized using two routes: the precipitation method in controlled atmosphere and a reduction–precipitation method under air, in some cases followed by a hydrothermal treatment[1]. The smallest nanoparticles were obtained by the reduction–precipitation method[2].

Metal nanoparticles[3-5] play a very important role in many areas of chemistry; physics and materials science[6]. The metal elements are able to form a large diversity of oxide compounds[7]. These can adopt a vast number of structural geometries with an electronic structure that can exhibit metallic, semiconductor or insulator character[8]. In technological applications, oxides are used in the fabrication of microelectronic circuits, sensors, piezoelectric devices, fuel cells, coatings for the passivation of surfaces against corrosion, and as catalysts[9]. In the emerging field of nanotechnology, a goal is to make nanostructures or nanoarrays with special properties with respect to those of bulk or single particle species. Oxide nanoparticles and metal nanoparticles[10-13] can exhibit unique physical and chemical properties due to their limited size and a high density of corner or edge surface sites. Particle size is expected to influence three important groups of basic properties in any material. The first one comprises the structural characteristics, namely the lattice symmetry and cell parameters[14]. Bulk oxides are usually robust and stable systems with well-defined crystallographic structures. However, the growing importance of surface free energy and stress with decreasing particle size must be considered: changes in thermodynamic stability associate with size can induce modification of cell parameters and/or structural transformations and in extreme cases the nanoparticle can disappear due to interactions with its surrounding environment and a high surface free energy[15]. In order to display mechanical or structural stability, a nanoparticle must have a low surface free energy[16]. As a consequence of this requirement, phases that have a low stability in bulk materials can become very stable in nanostructures [17-21].

Iron-Oxide is an adaptable practical material. Iron-Oxide nanostructures, for example, nanotubes, nanowires, nanorods, nanobelts, nanocables, and nanoribbons stimulate extensive interests for logical research because of their significance in major material science thinks about and their potential applications in nanoelectronics, nanomechanics, and level board shows. Especially, the optoelectronic gadget use of Iron-Oxide nanostructure gets to be distinctly one of the major concentrations in late nanoscience investigates [22].

II. EXPERIMENTAL SECTION

A. Chemical and Instruments

All starting materials, Reagents, metal salts, and other chemicals were obtained from Sigma-Aldrich. All aqueous solutions were prepared with quartz distilled deionized water, which was further purified by a Millipore Milli-Q water purification system. All the solvents employed for synthesis were commercially available and used as received without further purification. The SEM were obtained from a Bruker Nano Analytics VMP-DS, (USA). Nanostructure by high-energy X-ray diffraction.

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ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

III. CHEMICAL METHOD

Iron oxide thin films were deposited on glass slide from aqueous solution of $FeCl_3$ and ammonia by chemical deposition method. For deposition of the film, commercial quality glass microscope slides of dimension 10 mm x 20 mm x 1 mm are utilized. Before utilize, these glass slides were soaked in aquaregia, a mixture of concentrated HCl and HNO_3 in the proportion of 4:2. They were removed after 24 hrs. and washed thoroughly in cold detergent solution, rinsed in distilled water and drip dried in air. The legitimately degreased and cleaned substrate surface has the benefit of reducing highly adhesive and uniform film. The substrate was immersed vertically at the centre of reaction bath in such a way it ought not touch the walls of the beaker. The reagents utilized as a part of this experiment were iron chloride, aqueous ammonia. 0.2 M of iron chloride was prepared and small drops of ammonia were added and stirred continuously using a magnetic stirrer to obtain optimum pH of 8.8 for this deposition. 80 ml solution of iron chloride and aqueous ammonia were placed in 100 ml beaker and the substrates whose surface had been set up under standard conditions were vertically suspended in the beaker and the solution was constantly stirred using magnetic stirrer in a water bath of consistent temperature of 80-90^oC. The deposition time was 90 minutes. Following 90 minutes the substrate with deposited thin films were removed, washed with distilled water and left to dry. Toward the finish of the dip period, the films are washed and drip-dried in air. Post deposition annealing of the films expelled the water molecules bringing about the Iron oxide.

IV. RESULTS AND DISCUSSION

A. SEM study

The scanning electron microscope (SEM) uses a focused beam of high- energy electrons to generate a variety of signals at the surface of solid specimens. The signals that derive from electron-sample interactions reveal information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample. SEM was adopted to visually examine the morphology of GO-CS-PHGC. The typical SEM image of GO presents a wrinkled sheet-like structure, as shown in Figure1

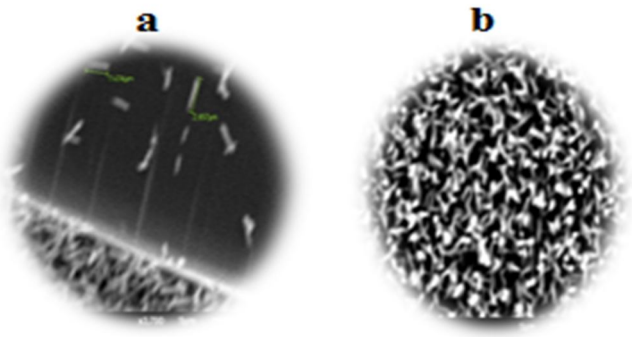

Figure 1: (a) and (b) SEM image surface morphologyy of as-deposited iron-oxide thin film

We have characterized by employing scanning electron microscopy (SEM). SEM was used for morphological characterization of sample. SEM image surface morphology of as-deposited Iron-Oxide thin film is demonstrated as follows. 27 (a) (b) Figure 10: (a) and (b) SEM image surface morphologyy of as-deposited ZnO thin film

B. XRD study X-ray diffraction (XRD)

XRD is an analytical technique looking at X-ray scattering from crystalline materials. Each material produces a unique X-ray "fingerprint" of X-ray intensity versus scattering angle that is characteristic of its crystalline atomic structure. Qualitative analysis is possible by comparing the XRD pattern of an unknown material to a library of known patterns. To analyze different class of materials various X - ray techniques have been used. These techniques can be classified into three main categories: X – ray absorption X - ray fluorescence X - ray diffraction Xray diffraction is a main and an important technique that has been used since long to address all issues related to the crystal structure of the bulk solids, including lattice constants and geometry, preferred orientation of polycrystals, identification of unknown materials, crystals defects and stresses. The results of our structural investigations of the iron oxidefilms were finished with X ray diffraction and show (100), (002), (101) etc distinct diffraction peaks for the films developed in this study, as appeared in Fig.2 and Table 1 indicated miller indices, particle size and inner planer spacing.

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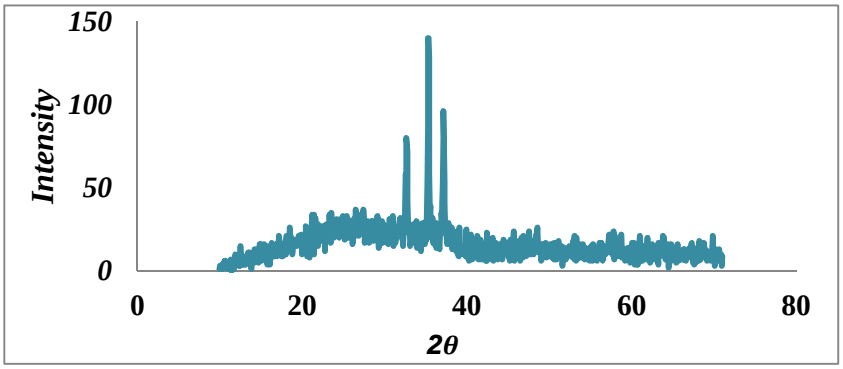

Figure 02: Showed XRD of thin film.

Table 1. Showed miller indices, particle size and inter planer spacing.

Line	Assigned Indices (hkl)	Calculated spacing	Observed spacing	Particle size (nm)
1	100	3±0.2	3.01	8
2	002	2±0.2	2.05	11
3	101	2±0.1	1.07	14

V. APPLICATIONS OF IRON OXIDE

As a result of its various properties, both chemical and physical, iron oxide is broadly utilized in many areas. It assumes an important part in an extensive variety of utilizations, going from tires to earthenware production, from pharmaceuticals to farming, and from paints to chemicals[23-25]. Iron-Oxide nanoparticles[26] have attracted considerable interest due to their superparamagnetic properties and their potential biomedical applications arising from its biocompatibility and non-toxicity. Recent developments in the preparation of Iron-Oxide nanoparticles by thermal decomposition of iron carboxylate salts have significantly improved the quality of traditional Iron-Oxide nanoparticles in terms of size tunability, monodispersity and crystalline structure[27]. Using the proprietary monolayer polymer coating strategy, hydrophobic, organic ligand-coated Iron-Oxide nanoparticles have successfully been converted into water soluble, bio-accessible Iron-Oxide nanoparticles[28]. The high stability of these water soluble Iron-Oxide nanoparticles in harsh conditions of high pH and elevated temperature allow conjugation of these NPs with other biomolecules[29]. Additional biocompatible coatings for in vivo studies including polysaccharides and lipid molecules have also been developed, resulting in nanoparticles consisting entirely of materials that have been approved by the United States Food and Drug Administration. Enhancement in the quality of both organic and water soluble Iron-Oxide nanoparticles opens avenues of opportunities for development of Iron-Oxide nanoparticles based applications in As contrast agents for Magnetic Resonance Imaging (MRI), As drug carriers for target specific drug delivery, As gene carriers for gene therapy, As therapeutic agents for hyperthermia based cancer treatments, As magnetic sensing probes for in-vitro diagnostics (IVD), As Nanoadjuvant for vaccine and antibody production[24, 30].

VI. CONCLUSION

Iron-Oxide thin films have been successfully deposited on silica glass substrate using chemical deposition technique. Iron-Oxide films have been successfully prepared by CBD method using Iron chloride. The surface morphology of the films was also investigated. Particles size is obtained in nano range. Iron-Oxide can likewise be acquired with an variety of molecule structures, which decide its utilization in new materials and potential applications in an extensive variety of fields of technology. In this manner the improvement of a technique for synthesizing crystalline iron oxide which can be utilized on an industrial scale has turned into a subject of developing enthusiasm for science and in addition industry. The study of the literature that has been given here demonstrates that Iron-Oxide can be classed as a multifunctional material. This is on account of such properties as high chemical stability, low electrical constant, high electrochemical coupling index, extensive variety of radiation absorption, and high photostability. It can be expected that interest for Iron-Oxide will proceed to develop, and that this will prompt to the improvement of new conceivable outcomes for its application.

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V. ACKNOWLEDGMENT

The authors gratefully acknowledge the Instruments and software facility provided by Ganpat University. The authors also acknowledge GUJCOST, Gandhinagar, Gujarat University, Ahmedabad and Centre of excellence (Rajkot) and INFLIBNET (Ahmedabad) for e-journals.

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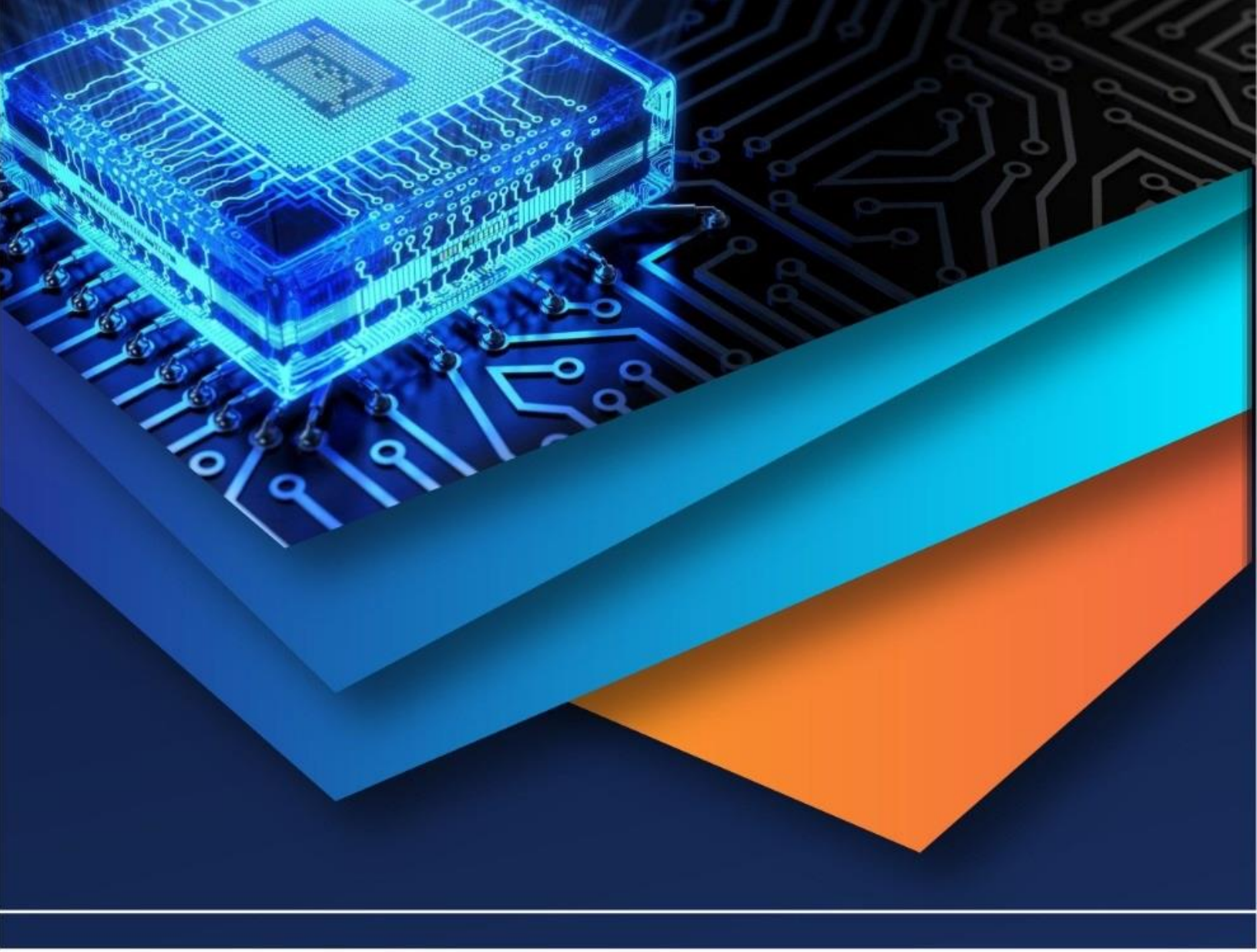

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