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Synthesis of Iron Oxide Nanoparticles Coated Sand by Biological Method and Chemical Method

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Abstract

Iron oxide nanoparticles can be prepared by physical, chemical and biological methods. Due to the practical difficulties in using iron oxide nanoparticles for water treatment, these nanoparticles may be coated onto some supports. This paper focuses on the preparation of iron oxide nanoparticles coated sand by biological method using polysaccharide templates and chemical method i.e. sol-gel method. The synthesized particles were characterized using energy dispersive spectroscopy (EDS), scanning electron microscope (SEM) and powder X-ray diffraction analysis (PXRD). From EDS analysis the highest percentage coating of iron on the sand surface was obtained for the iron oxide nanoparticles coated sand synthesized using chitosan templates. The PXRD analysis revealed the crystallite size of the synthesized particles as 42.8 nm. The SEM image showed the presence of almost spherical shaped particles on the sand surface and the coating was discontinuous.

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Keywords: Iron oxide nanoparticles; polysaccharide templates; sol-gel method.

1. Introduction

Iron oxide nanoparticles are gaining more attention now-a-days in environmental remediation due to their small size, large surface area and magnetic property. Iron is one of the most widespread elements in the earth. Iron oxides

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are chemical compounds composed of iron and oxygen. Altogether, there are sixteen known iron oxides and oxyhydroxides. Previous studies showed that iron oxide coated sand has high efficiency for removing various contaminants from water/wastewater [1,2,3,4,5,6]. Application of iron oxide based nanomaterial is more attractive for removal of heavy metals contamination from the water because of their important features like small size, high surface area, and magnetic property [7,8]. Magnetic property of iron oxide nanoparticles enables easy separation of adsorbents from the system and could be reused for further application. Reusability of iron oxide based nanomaterial leads to a decrease in the economic burden [9]. The facileness of resource and ease in synthesis render nanosized ferric oxides (NFeOs) to be low-cost adsorbents for toxic metal sorption. Since elemental iron is environmentally friendly, NFeOs can be pumped directly to contaminated sites with negligible risks of secondary contamination. The iron oxide nanoparticles have been utilized in various promising applications, such as catalysis, electronic devices, information storage, sensors, drug-delivery technology, biomedicine, magnetic recording devices, and environmental remediation [10]. The intensively studied NFeOs for heavy metals removal from water/wastewater include goethite, hematite, amorphous hydrous ferric oxides, maghemite, magnetite and nano zero valent iron.

Up to now there are several methods that can be used to synthesize iron-oxide-based nanomaterials. The methods can be generally classified as physical, chemical and biological methods. Previous studies showed that chemical methods are commonly used for the synthesis of iron oxide nanoparticles. The commonly employed chemical methods include hydrothermal synthesis, thermal decomposition, co-precipitation, reverse micelles and micro-emulsion technology, sol-gel synthesis, sonochemical reactions, hydrolysis and thermolysis of precursors, flow injection synthesis, electrospray synthesis and colloidal chemistry method.

The major drawbacks of the chemical methods are the low dispersion in solvents, wide particle size distribution and the uniformity of the size of the particle of these nanomaterials was rather poor [11]. These methods causes aggregation of particles. So there is an increasing interest in the use of green resources for nanoparticle synthesis. The distinct advantages that biological synthesis protocols have over the conventionally used physical and chemical methods include [12]:

- clean and eco-friendly method, as toxic chemicals are not used.
- the active biological component like enzyme itself acts as a reducing and capping agent, thereby reducing the overall cost of the synthesis process.
- small nanoparticles can be produced even during large-scale production.
- external experimental conditions like high energy and high pressure are not required, causing significant energy saving.

For practical applications the iron oxide nanoparticles must be coated onto some supports such as sand, bentonite, perlite etc due to agglomeration of particles, difficult separation, low hydraulic conductivity and excessive pressure drops when applied in flow through systems.

Hence, this paper focuses on the preparation of iron oxide nanoparticles coated sand by biological method employing polysaccharide templates and chemical methods i.e sol-gel method.

2. Materials and methods

2.1. Preparation of sand

River sand of gradation between 2.36 mm and 0.85 mm was used. The sand was soaked in 8% nitric acid solution for 24 hours, rinsed with de-ionized water to pH 7 and dried at 105^0 C for 24 hours in preparation for surface coating.

2.2. Synthesis of iron oxide nanoparticles coated sand

Iron oxide nanoparticles coated sand was prepared by biological methods using starch and chitosan templates and chemical method by sol-gel method. Sol-gel method is the widely used chemical method for the synthesis of nanoparticles. The methods employed are discussed below: