Chapter 4
Fundamentals and Sources of Magnetic Nanocomposites and Their Sorption Properties

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ABSTRACT

Over the years, adsorption has been the most widely applied technique for pollutants remediation in conventional water and wastewater treatment regimes with commendable results. Consequently, multiple adsorbents have been synthesized, characterized and tested for various pollutants sequestration such as; heavy metals, dyes, pharmaceutically active ingredients, among others, in aqueous media. Unfortunately, most of the sorbents face many inherent limitations such as high production cost, difficult separation of adsorbent from solution, and complex synthesis processes. Therefore, an efficient adsorbent that would be sustainably adopted for industrial application in wastewater treatment requires, among other properties, a simple and efficient recovery step from a continuous flowing system. The regenerated adsorbent must also possess near original properties after several cycles of reuse.

DOI: 10.4018/978-1-5225-2136-5.ch004
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INTRODUCTION

Nanotechnology aims at designing materials characterized by at least one dimension below 100 nm. When the dimensions of a material are reduced to the nanoscale, the physico-chemical characteristics significantly depart from that of the bulk state. Nanostructured materials exhibit unique chemical, mechanical and magnetic properties that are useful in a wide range of applications. For centuries, adsorption has played an important role in the wastewater treatment processes and it still remains the widely used technique presently. Higher pollutant reduction efficiency and insensitivity to toxic substances compared to the other methods of water purification partly explain its popularity. Several adsorbents widely used for water purification include activated carbon, zeolite, clay minerals etc. However due to their high generation costs, agricultural biomass derived adsorbents have presented an attractive alternative due to their low cost and high abundance (Ngeno et al., 2016). Though these adsorbents have shown stupendous results as effective in the removal of pollutants from wastewater, they suffer one inherent limitation. It is difficult to separate them from wastewater in a continuous flow system. To address this challenge, studies conducted in the past few years incorporating magnetism in both natural and synthetic sorbents to improve their removal from water via magnetic separation have yielded stupendous results compared to conventional technologies. This chapter concisely discusses synthesis methods and adsorption capacities and mechanisms of selected magnetic nanocomposite adsorbents under diverse physicochemical conditions for removal of cations, dyes and organic pollutants from wastewater. Magnetic nanocomposites present eco-friendly properties and are potential alternatives for application in water purification processes subject to commercial viability evaluation before practical use.

The general use of magnetism in water treatment processes such as biological processes and coagulation is an age-old concept dating back to as early as 1873 (Hay, 1873). However, the use of magnetism in adsorption processes is a relatively newer concept; gaining interest among researchers day by day. Magnetic adsorbents are a new class of adsorbents where a base adsorbent is embedded with magnetic particles which are oxides of metals such as Fe, Co, Ni and Cu (Ambashta and Sillanpaa, 2010). In the presence of an external magnetic field, the magnetic adsorbent is quickly and easily segregated from water owing to the presence of the metal oxide component in the adsorbent.
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