Chapter 4

Potential Applications of Nanomaterials in Wastewater Treatment:
Nanoadsorbents Performance

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ABSTRACT

High-quality water is one of the most important challenges around the world. Conventional techniques of wastewater treatment need to be developed. Therefore, finding sustainable, environmentally friendly, and efficient treatment techniques is required. In this regard, due to the extraordinary potential of nanotechnology resulted from nanoscale size characteristics, recently nanomaterials have been the subject of novel research and development worldwide. In this chapter, the authors review recent development of the direct applications of nanomaterial as an adsorbent in adsorption systems for integrating nanoparticles into conventional treatment technologies for wastewater treatment, especially a wide range of candidate nanomaterials and its properties. In addition, advantages and limitations as compared to existing processes are discussed.

INTRODUCTION

Nowadays, industrial technology is most important matters in quality of life. So, rapid population growth in developing region will continue to intensify the clean water demand from industry and energy perspective (Gupta et al., 2015a). The larger the industry is, the more waste and pollution it usually generates, and the bigger the impact on the environment. Recently, many physical and chemical methods have been developed to reduce the levels of pollution in the wastewater (Gupta et al., 2017b; Habeeb et al., 2017a; Habeeb et al., 2017c; Sadegh et al., 2016). Each method has certain advantages and disadvantages

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(Table 1). Example, coagulation method reported as a low-cost method but, utilization of chemicals was high and membrane filtration reported as high performance for removal of heavy metal ions with lower space requirement but is very expensive (Ahmed & Ahmaruzzaman, 2016). Among of all, adsorption is considered as an efficient and economical technique and it is easy to operate for pollution removal from wastewater effluents (Gupta et al., 2015b; Habeeb et al., 2017b; Rajabi et al., 2016; Zare et al., 2016). The general advantages and disadvantages of adsorption methods are given in Figure 1. In addition, since the adsorption is reversible in some cases, adsorbents can be regenerated. There are three types of adsorption, the interaction between adsorbent-adsorbate (physisorption), adsorbent-solvent (chemisorption) and adsorbate-solvent (electrostatic interactions) (Qiu et al., 2009; Zare et al., 2015a; Zare et al., 2015b). In addition, underlying mechanisms involved in the adsorption material surface have been studied. As reported, many factors affect the efficiency and performance of adsorbents e.g., initial ion concentration, adsorbent dosage, temperature, pH value, contacting time, ionic strength, coexisting ions, and stirring speed (Ambashta & Sillanpää, 2010; Yu et al., 2017). It is important to understand how adsorbent interact with different adsorbate (i.e. heavy metal ions and dyes) in the laboratory scale to determine their potential for application in wastewater treatment and their contribution to large scale (Wan Ngah et al., 2011). However, adsorption has certain limitations also, such as it could not achieve a good status at commercial levels due to the lack of suitable adsorbents of high adsorption capacity and unavailability of commercial scale columns. Moreover, the design of suitable adsorbent, which has good performance, should be considered as a crucial stage. To fulfill the objective of the development of an effective adsorbent that is active and rapid for pollution removal, the advancement in nanotechnology has proved an incredible potential for the developing novel adsorbents were developed by nanomaterials (Sadegh et al., 2017b).

Nanomaterials have a small size structures of a few nanometers (less than 100 nm) (Zarbin, 2007). In the field of wastewater treatment, a variety of materials have been developed having unique functionalities for potential decontamination of industrial effluents, surface water, groundwater and drinking water (Liao et al., 2003).

In this chapter, the application of nanomaterials as adsorbents for removal of pollution from wastewater has been reviewed. It also includes a summary of the nanoadsorbents for the removal of heavy metal ions and dyes. The recent output of adsorption systems and isotherm modeling of adsorption is also reviewed.

Figure 1. Advantages and disadvantages of the adsorption method