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REMOVAL OF CD(II) FROM AQUEOUS MEDIUM USING MAGNESIUM OXIDE NANOPARTICLES

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ABSTRACT: Heavy metal contamination in drinking water has become a severe threat to all living beings without any boundaries. Generally, these contaminants can be either anthropogenic or originate from industrial activities or unavoidable natural disasters. However, during the last few decades, uncontrolled pollution in natural water bodies has led to a number of irreversible outcomes all over the world. As it undergoes bioaccumulation, it may cause complex health issues in all living creatures. Mostly, heavy metal contaminated industrial effluents enter natural water bodies, due to inadequate prior treatment. Polluted water can be treated using different chemical and physical adsorption methodologies. In this study, MgO nano particles were prepared separately using commercially available dolomite and aqueous Mg2+ solution, in the presence of HTAC (hexadecyl-trimethylammonium chloride) surfactant, with the aim of removing Cd(II) from the aqueous medium. Using Fourier transformed infrared (FT-IR) spectroscopy, Cd (II) adsorption was observed and development of a band at 739 cm-1 in the spectrum confirmed the formation of the Cd-O bond. Further, agglomeration of nanoparticles was determined by scanning electron microscope (SEM) which provided strong evidence for Cd(II) trapping. The removal of Cd(II) was observed under different conditions including dosage, shaking time, settling time and pH. According to the results, the optimized parameter for the nano MgO was 6 mg dosage, 30 minutes shaking time and 10 minutes setting time within the PH range of 6.0 to 8.0.

Keywords: heavy metal adsorption, nano-magnesium oxide, magnesium oxide nono wires

1 INTRODUCTION

Human activities like mining, industrial waste, and the use of pesticides and fertilizers mainly cause an increase in heavy metal content in ground and surface water sources. This may lead to health risks for humans and other living organisms. Since the World Health Organization (WHO) has listed four heavy metals (As, Pb, Hg, and Cd) on its list of 10 chemicals with major potential health concerns (Bratbak & Dundas, 1984), it is important to remove these heavy metals from contaminated water before consumption.

Though there are numerous methods to remove heavy metals from contaminated water, various types of materials have been used as adsorbents in heavy metal removal. Considering the adsorbent materials, nano metal oxides (NMOs) play a major role in heavy metal removal since they have a higher surface area compared to other materials. Nano MgO is a very promising material for use as an adsorbent due to its strong adsorption ability as well as high surface reactivity and adsorption capacity compared to commercial analogues, and the simplicity of its production from naturally abundant materials (Shen & Ostroverkhov, 2006).

Heavy metal-contaminated wastewater has been treated using various techniques to improve water quality. To remove heavy metals from aqueous media, ion exchange, chemical precipitation, and adsorption methods were used. In the adsorption process, various types of nano-sized metal oxides (NMO) are widely used, appearing in different forms such as flakes and tubes. The main factors affecting the adsorption of heavy metals in aqueous media are the size and shape of the NMOs (Hua et al., 2012; Fernández-García & Rodriguez, 2011). Therefore, scientists have widely studied the use of shape-controlled, highly stable, and monodisperse NMOs in water purification. In order to assess the mode of adsorption and adsorption capacity of the adsorbent, the Langmuir and Freundlich adsorption isotherms are commonly used (Chen & Li, 2010; Thommes et al., 2015).

Chen and Li (2010) synthesized Fe^{2+}-containing nano-sized goethite and hematite via the co-precipitation method and suggested that the prepared NMOs are effective for the removal of Cu^{2+} from aqueous solution. Gao et al. (2008) synthesized MgO nanoparticles using magnesium carbonate hydrate (MCH) with various morphologies. Flower-like mesoporous MgO microspheres exhibited excellent adsorption of both heavy metal ions and organic pollutants (Gao et al., 2008). Manathilake et al. (2014) synthesized calcium carbonate nanoparticles from dolomite using a low-cost method, yielding nanoparticles sized between 38.9 nm and 51.6 nm. Nano MgO exhibits high surface reactivity and adsorption capacity, making it highly effective in heavy metal adsorption. MgO nanoparticles have been successfully synthesized using naturally occurring dolomite and a novel colloid of poly(acrylate) (PA^-) to encapsulate $Mg(OH)_2$ (Manathilake et al., 2014a).

The objective of this study is the synthesis and characterization of MgO nanoparticles using dolomite and Mg(II) solution, as well as the investigation of adsorption characteristics with Cd(II) in aqueous media and the design of a filter material for Cd(II) adsorption.

2 METHODOLOGY

Commercially available dolomite was sieved and calcined at 1000°C before starting the synthesis process. Mg(II) solution was then treated with calcined dolomite while stirring in the presence of hexadecyl trimethyl ammonium chloride (HTAC). After that, the synthesized $Mg(OH)_2$ was dried at 100°C and calcined at 450°C to obtain MgO nanoparticles.

Next, the synthesized MgO nanoparticles were characterized using XRD, SEM, EDAX and FTIR. Finally, the parameters (dosage, shaking time, settling time, and pH) were optimized for the adsorption of Cd(II) in the aqueous medium on MgO nanoparticles.

3 RESULTS AND DISCUSSION

3.1 SEM Analysis

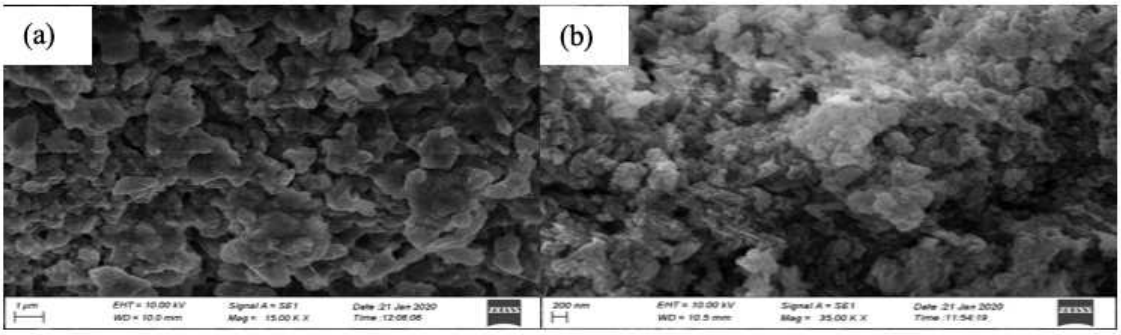

Figure 1. XRD analysis (a) MgO nanoparticles (b) Cd adsorbed MgO nanoparticles

The SEM image of MgO nanoparticles reveals the inhomogeneous nature of the surface due to agglomeration of nanoparticles. This nature has changed upon adsorption of Cd (II), thereby improving the surface as shown in Figure 1. These observations suggest that the metal ions may become trapped and adsorbed onto the surface of the magnesium oxide nano particles.

3.2 FTIR Analysis

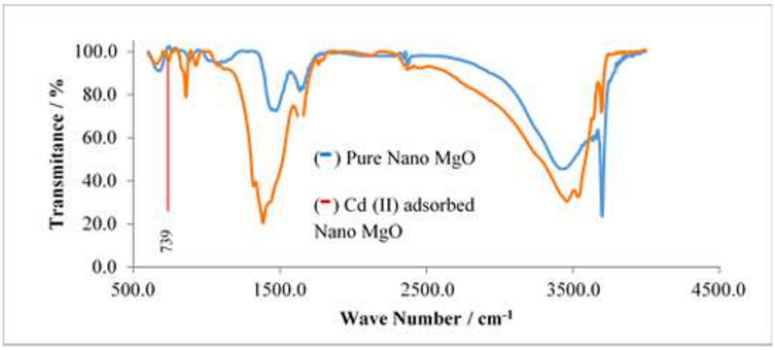

Figure 2. FTIR analysis of MgO nanoparticles and Cd adsorbed MgO nanoparticles

The FTIR analysis revealed the appearance of a new peak following the adsorption of Cd (II) onto nano MgO. A new band observed around 739 cm-1 attributed to the formation of Cd-O bonds adsorption onto nano magnesium oxide (Kaviyarasu., 2014).

3.3 Optimization Parameters

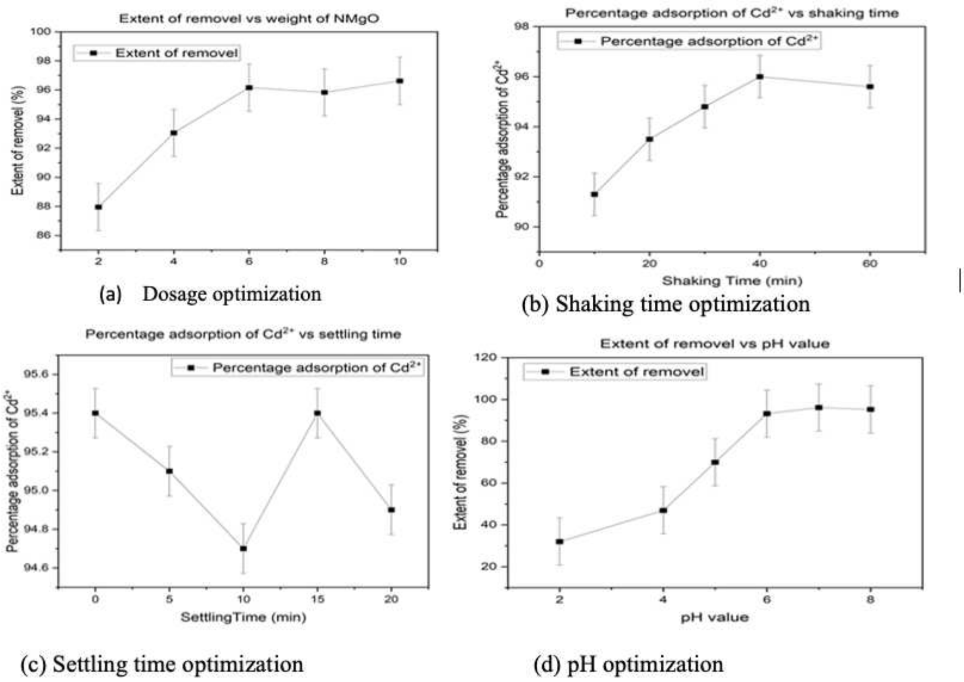

Figure 3. Summary of the parameter optimization

Figure 3(a) shows the optimization of adsorbent dosage, indicating that a dosage of 6 mg achieves approximately 95% removal of Cd(II). Figure 3(b) presents the effect of shaking time, with maximum Cd^{2+} removal observed after 40 minutes of agitation. In Figure 3(c), settling time optimization is depicted, showing that a 10-minute settling period results in 95% Cd^{2+} removal. According to Figure 3(d), the optimal pH range for Cd^{2+} adsorption lies between 6.0 and 8.0.

4 CONCLUSION

Significant differences in the surface and structure of dried MgO nanoparticles were observed after treatment with Cd(II), as confirmed by SEM and FTIR analyses. The MgO nanoparticles exhibited excellent adsorbent characteristics for Cd(II) in aqueous media, achieving a removal efficiency of over 90%.

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