Extraction of Magnetite from Millscales Waste for Ultrafast Removal of Cadmium Ions

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Abstract*: This research was conducted to produce the magnetite (Fe_3O_4) nanoparticles extracted from the industrial millscale waste. Then, the micron size samples were extracted and grounded on the high energy ball milling (HEBM) at various milling time for 4, 8, 12, 16 and 20 h. The formation of nanosized single-phase hexagonal spinel has been observed with XRD analysis as early as 4 h milling time. The FTIR transmission spectrum shows the appearance of a Fe-O functional group for each sample. HRTEM images showed that all the samples had a small particle size of 5-20 nm with uniform distribution. The specific surface area of the 5 adsorbents increased after the 8 h milling time and it showed reduction after that. The magnetite adsorbents then utilized the adsorbent in Cadmium ions removal of the aqueous solution. Fe_3O_4 with 8 h milling time was able to remove 9.81 mg of cadmium ions with 1 g of adsorbents consume. The removal of the cadmium ions detected related to the particles size, surface areas and saturation magnetization. This research successfully revealed that the higher saturation magnetization contributed to high removal percentages in cadmium ions of aqueous solutions. Fe_3O_4 extraction from mill scales waste is cost-effective, the process is eco-friendly and thus, potentially to be applied for wastewater treatment.

Keywords: Adsorption, cadmium, Magnetite, mill scales waste.

I. INTRODUCTION

Magnetic separation is one of the promising methods as it is alternative method compared to the conventional method for the wastewater treatment [1]. Therefore, it is must be expected to lower the operation and production cost of the adsorbents, negligible risks of secondary contaminant and ultrafast adsorption time. According to this condition, magnetite (Fe_3O_4) derived from mill scale waste would be the most potential magnetic adsorbent [2]-[5]. This magnetic adsorbent had been tested for the effectiveness in removal of ionic contaminant from an aqueous solution as reported recently. The ionic contaminant can be either in the positive or negative contaminant.

The advantage of using magnetite is that it is amphoteric solid which is pH-dependent, where the surface charges varied due to the pH of the solution. Cadmium (Cd) is one of the non-essential nutrients recently present over the standard limit of water quality (0.03 mg/L) [6]. Thus, intense works on removing this contaminant were broadly studied by most of the wastewater researchers. Previously, researchers reported that the Cadmium ions were removed using different types of adsorbents such magnetic activated carbon that had efficiently remove the Cd ions [7]. However, the production of the adsorbents produced the second pollution when they use heat energy to burn and get the adsorbent. The secondary pollution occurs when the burning process releases a large amount of carbon dioxide (CO_2). In addition, the time taken to remove the contaminant took a long time sometimes up to several weeks [2]-[4].

The magnetite had reported that it reached a platue within 10 minutes of contact time. More recently, researchers found that processing the mill scales without the involvement of any chemicals might improve the performance of the adsorption even the adsorbent are in micron size. Unfortunately, it took 6 weeks to reach the equilibrium and to complete the adsorption [4]. This longer time of separation time would contribute to higher usage of electrical power to generate the external magnetic for the separation process. Upon this situation, the cost will increase and the mission to reduce the cost is still not achieved. Therefore, the great advantage goes to the adsorbent that can completely remove the heavy metals in a short time where the operational cost can be maintained. Summary of the reported adsorbents with the condition of good adsorbents is shown in Table I.

In current literature had reported that magnetic enriched particles can be extracted from millscale waste through the external magnetic field.

Table I: Summary of reported adsorbents with the comparison of the production cost, secondary contaminant and adsorption time

Adsorbent	Production Cost	Secondary contaminant	Adsorption time	Ref.
Magnetic AC	High	Yes	>1 h	[7]
Magnetic Particles (Millscale)	Low	No	>1 h	[2]-[4]
Magnetic Graphene	High	No	<1 h	[8]
Magnetic CNT	High	No	<1 h	[9]

Revised Manuscript Received on 20 October, 2019.

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