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Kuwat Triyana, Khairurrijal, Risa Suryana,
Heru Susanto and Sutikno

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Preface

The present volume contains selected papers of the 2013 International Conference on Advanced Materials Science and Technology (ICAMST 2013) held on September 17-18, 2013 in Yogyakarta, Indonesia. The conference, which has been jointly organized by Universitas Gadjah Mada, Institut Teknologi Bandung, Sebelas Maret University, Diponegoro University, and Semarang State University, Indonesia, has accepted more than 330 abstracts. After having reviewed the abstracts, 220 papers were presented in the conference. Finally, under a tight peer-review process by at least two expert referees for each paper, 157 papers were accepted in Advanced Materials Research, an international journal indexed by Scopus.

The papers are categorized into several groups that cover new developments and research results related to theoretical and experimental studies of advanced materials as well as their various processing and wide variety of applications. They include nanofibers and membranes, nanoparticles and powders, thick and thin films, biomaterials, electronic materials, magnetic materials, optical materials, composites, ceramics, and alloys as well as measurement and characterization techniques of materials.

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Editors,

Dr. Kuwat Triyana
Department of Physics, Universitas Gadjah Mada (triyana@ugm.ac.id)

Prof. Dr. Khairurrijal
Department of Physics, Institut Teknologi Bandung (krijal@fi.itb.ac.id)

Dr. Risa Suryana
Department of Physics, Sebelas Maret University (rsuryana@uns.ac.id)

Prof. Dr. Heru Susanto
Department of Chemical Engineering, Diponegoro University
(heru.susanto@undip.ac.id)

Dr. Sutikno
Department of Physics, Semarang State University (smadnasri@yahoo.com)

Conference Organizers

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Magnetic $CuFe_2O_4$ Nanoparticles for Adsorpstion of Cr(VI) from Aqueous Solution

Poedji Loekitowati Hariani[1,a], Fahma Riyanti[2,b]

[1,2]Department of Chemistry, Faculty Matematics and Science

Sriwijaya University, Palembang, Indonesia

[a]pujilukitowati@yahoo.com, [b]fatechafj@yahoo.com

Keywords: magnetic $CuFe_2O_4$, co-precipitation, adsorption, Cr(VI).

Abstract. $CuFe_2O_4$ nanoparticles were synthesized by co-precipitation method from the solution of $CuCl_2$ and $FeCl_3$ in alkaline condition. The prepared magnetic $CuFe_2O_4$ can be used to adsorb Cr(VI) ions from aqueous solution and separated from medium by magnetic technique. The characterization of $CuFe_2O_4$ with X-Ray diffraction (XRD) showed cubic units shells with diameter in the range 15-20 nm which obtained by Transmission Electron Microscope (TEM). The saturation of magnetization was around 13 emu g^{-1} measured with Vibrating Sample Magnetometer (VSM). Batch adsorption studies were carried out to optimize adsorption condition. Effective conditions for adsorption of Cr(VI) were found at the weight of $CuFe_2O_4$ was 1.0 g with contact time of 60 minutes and pH 3 with adsorption capacity 9.20 mg g^{-1}.

Introduction

Heavy metals in the environment are problem that cannot be resolved until now. Various treatments such as coagulation, precipitation, sedimentation, ultrafiltration, ozonation, electrochemical, and reverse osmosis had been applied to remove heavy metal in solution. One of heavy metal pollutants in the environment is chromium. Chromium has wide applicability in the steel and alloy industries. Chromium species exist mainly in two different oxidation states in water environment, Cr(VI) and Cr(III) ions [1]. Cr(VI) and Cr(III) have contrast different in physiological effects. Cr(III) is essential for human beings [2], and necessary for maintenance of glucose, lipid and protein metabolism in mammals [1], but Cr(VI) can be toxic for biological system, carcinogenic in humans and mutagens and teratogens in biological system [3,4]. Exposure to Cr(VI) and its compounds cause irritation to skin, resulting dermatitis and ulcer formation [2,5]. It has been reported that Cr(VI) is about 500 times more toxic than Cr(III) and the common concentration of Cr(VI) found in wastewater are around 50-100 mg/L [6]. According to EU and WHO standards the maximum total chromium content in drinking water is 0.05 mg L^{-1}[5]. Therefore, developing techniques to removal Cr(VI) from wastewater is an important.

There are several methods used to treat wastewater which contain Cr(VI), such as reduction [7], adsorption [6, 8, 9], and extraction [10]. Adsorption has obtained favor in recent years due to proven efficiency in the removal pollutants from wastewater because availability, profitability, ease of operation and economic. Ferrites of type MFe_2O_4 (M is a different metal cation) have been exploited for wastewater treatment and resulting excellent adsorptive properties with capability of effective recovery by a magnetic separation tecgnique [11]. Ferrites is also known to its excellent chemical stability [12]. Magnetic nanoparticles have large surface area also easy and inexpensive to synthesize [13]. In this study, copper ferrite ($CuFe_2O_4$) was prepared and the adsorption of Cr(VI) ions were demonstrated. Interaction of magnetic nanoparticles with Cr(VI) caused by attractive electrostatic is influenced by pH solution [8].

Experimental Procedures

Analytical grade $CuCl_2$, $FeCl_3$ and $K_2Cr_2O_7$ were obtained from Merck. $CuFe_2O_4$ was prepared by co-precipitation method. Prepare 400 mL solution consisting of 0.02 mole of $CuCl_2.2H_2O$ and

0.04 mole $FeCl_3$ at room temperature under vigorous magnetic stirring, slowly raised the pH by adding NaOH (5 mole L^{-1}) up to about 10. Stirring was continued for 30 minutes and the suspension was heated to 95-100 ^{0}C for 2 h [6,14]. Synthesis of $CuFe_2O_4$ reaction[14]:

$$2FeCl_3(l) + CuCl_2(l) + H_2O(l) + 8NaOH(l) \rightarrow CuFe_2O_4(s) + 8NaCl(l) + 5H_2O(l) \quad (1)$$

After cooling, the prepared $CuFe_2O_4$ was repeatedly washed with distilled water until the pH is neutral. By simple magnetic procedure, the obtained materials were separated from water and dried in oven at 105^{0}C. The crystalline structure of $CuFe_2O_4$ was determined using X-Ray diffraction Shimadzu XD-610 with Cu Kα radiation in the 2θ range 10-80^0, Transmission Electron Microscope JEOL JEM 1400 and Vibrating Sample Magnetometer Lakeshore 74004.

Batch adsorption studies were performed by mixing $CuFe_2O_4$ particles with 100 mL of the 100 mg L^{-1} Cr(VI) ions solution in a flask. This process was carried out using shaker at a constant speed of 120 rpm. All adsorption experiment was carried out at a fixed temperature 0f 25 ^{0}C ± 1. The effect of weight of $CuFe_2O_4$ on the adsorption capacity was studied using weight variation from 0.8 to 1.2 g at pH 5 and contact time of 75 minutes. The effect of pH on the adsorption capacity was studied with pH adjustment from 3 to 8 using 0.1 M HCl and 0.1 M NaOH solutions. The contact time for adsorption process varied at 15, 30, 45, 60 and 75 minutes. Determination of Cr(VI) ions in solution used Atomic Absorption Spectroscopy (AAS) Shimadzu AA-6300 at 540 nm.

Result and Discussion

Characterization of $CuFe_2O_4$.

Fig.1 show XRD patterns of $CuFe_2O_4$, indicated that the metal oxides can be indexed on a cubic structure. Nine characteristic peaks at 18.7^0, 30.2^0, 35.6^0, 37.2^0, 43.6^0, 57.1^0, 62.8^0, 74.5^0, and 79.5^0 were corresponding to the (111), (220), (311), (222), (400), 511), (440), (533) and (440) crystal planes of $CuFe_2O_4$ [15].

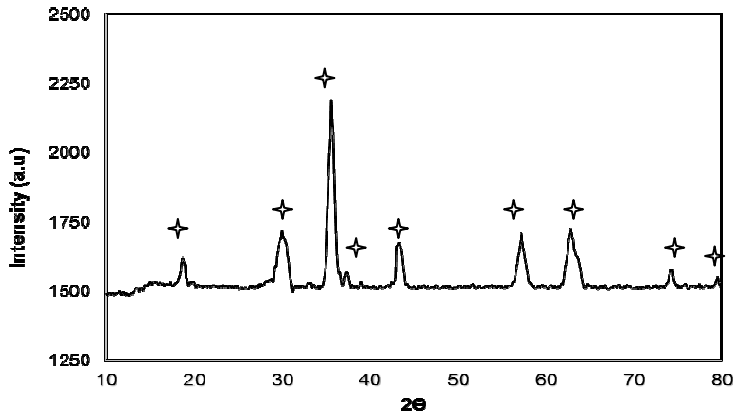

Figure 1. XRD pattern of $CuFe_2O_4$

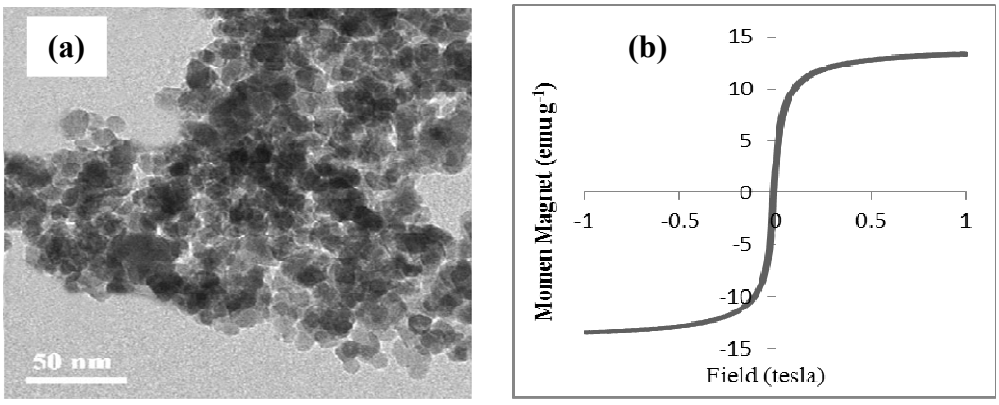

Figure 2. Characteristics of the $CuFe_2O_4$ by (a) TEM and (b) VSM

Fig. 2 (a) shows TEM image of $CuFe_2O_4$, the particle size of the $CuFe_2O_4$ was found about 15 to 20 nm. Hence, the prepared $CuFe_2O_4$ by co-precipitation method is found to be nanophase. Fig. 2 (b) show the saturation of magnetization of $CuFe_2O_4$ was 13 emu g^{-1}. Saturation of magnetization obtained is smaller than the standard saturation magnetization of $CuFe_2O_4$ as 22.5 emu g^{-1} at room temperature [16].

Optimum adsorption condition. Fig. 3 (a) shows the weight adsorbed of Cr(VI) (mg g^{-1}) with change in the weight of $CuFe_2O_4$. It can be observed that the adsorption capacity of Cr(VI) increased with an increased in the weight of $CuFe_2O_4$ nanoparticles. After equilibium, the adsorption capacity of Cr(VI) decreased because the weight of $CuFe_2O_4$ increased but amount of Cr(VI) is limited. Effective weight was found at 1 g $CuFe_2O_4$ with the adsorption capacity 8.20 mg g^{-1}.

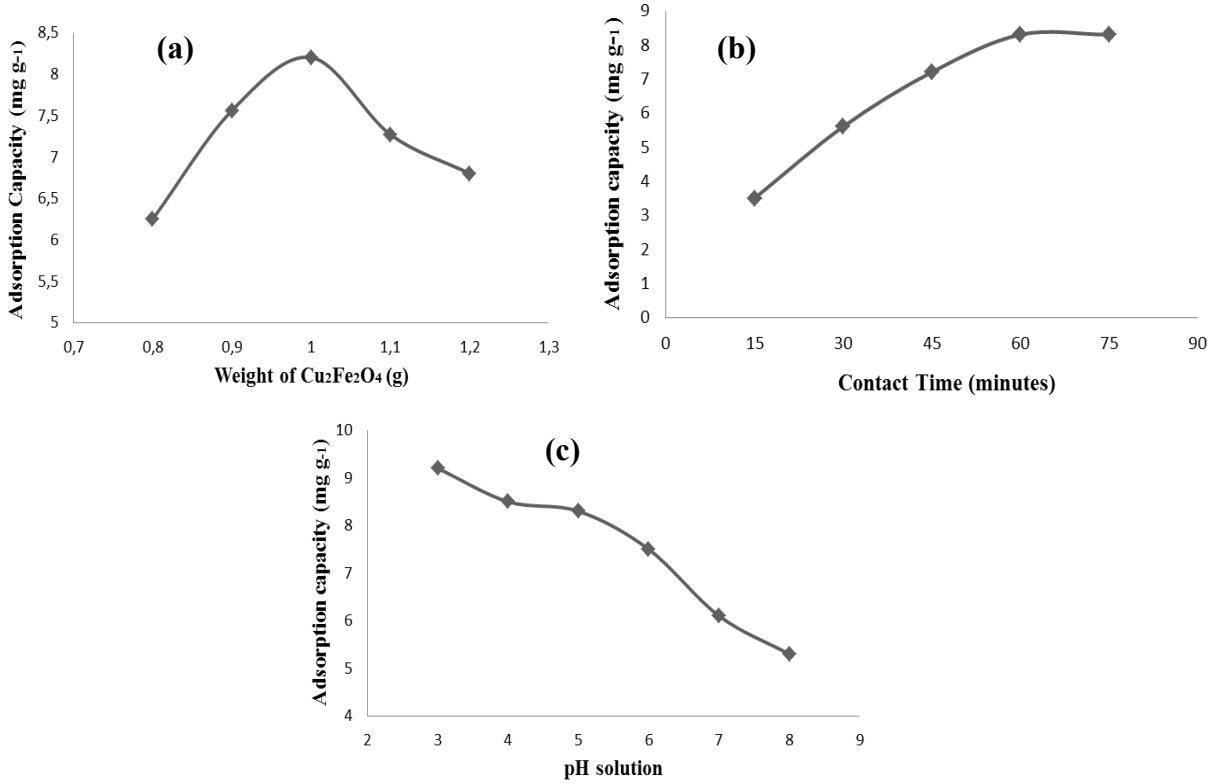

Figure 3. Adsorption capacity by varying of (a) weight $CuFe_2O_4$ (b) contact time and (c) pH solution

Fig. 3 (b) shows the effect of contact time on the adsorption capacity of Cr(VI). It can be seen that the adsorption process consist of two steps. In the first step, the adsorption capacity rate was at 0 to 60 minutes. The second step, the adsorption capacity was constant at 60 to 75 minutes. The effective contact time was found at 60 minutes with adsorption capacity 8.3 mg g^{-1}. The pH of solution plays an important role in the whole adsorption process and particularly on the adsorption capacity. The effect of pH on adsorption capacity of Cr(VI) arose apparently from the charge properties of both Cr(VI) ions and $CuFe_2O_4$. Fig. 3 (c) shows the effect of pH solution on the adsorption capacity of Cr(VI). The maximum of adsorption capacity was observed at pH 3 with adsorption capacity as 9.20 mg g^{-1}. At pH solution < pH_{pzc} $CuFe_2O_4$ (6.3-6.8) adsorbent surface could be positively charged due to the adsorption of H^+. Therefore, Cr(VI) at the pH from 2 to 6.5 exists mainly in the soluble forms of $HCrO_4^-$ and $Cr_2O_7^{2-}$ [6] so the anions are adsorbed by electrostatic attraction.

The adsorption capacity of $CuFe_2O_4$ to Cr(VI) was smaller when compared to the reduction method using H_2SO_4 and modified chitosan [7,9] but $CuFe_2O_4$ has the advantage such as it does not

require filtration and adsorption time was faster. The adsorption capacity of $CuFe_2O_4$ was calculated 9.20 mg g^{-1}. This value is not different with using Fe_3O_4 nanoparticles as 9.7087 mg g^{-1} [8].

Conclusions

Magnetic $CuFe_2O_4$ nanoparticles were successfully prepared by a chemical co-precipitation method, have cubic phase formed with 15-20 nm diameters size and magnetic saturation as 13 emu g^{-1}. The result of batch experiment for adsorption 100 mL of Cr(VI) with a initial concentration 100 mg g^{-1} showed that the optimum adsorption condition at weight of $CuFe_2O_4$ 1 g, solution pH 3 and contact time of 60 minutes with adsorption capacity as 9.20 mg g^{-1}.

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