

Evaluation of Aluminium Dross as Adsorbent for Removal of Carcinogenic Congo Red Dye in Wastewater

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Abstract. In this study, aluminium dross waste generated from aluminium smelting industries was employed as adsorbent in removing of congo red dye in aqueous solution. The raw aluminium dross as adsorbent was characterized using Scanning Electron Microscope (SEM), Brunauer-Emmett-Teller (BET) for surface area and X-Ray Fluorescence (XRF) Spectroscopy. Adsorption experiments were carried out by batch system at different adsorbent mass, pH, and initial dye concentration. The results showed that the per cent removal of dye increased as adsorbent mass increased. It was found that 0.4 gram of adsorbent can remove approximately 100 % of dye at pH 9 for dye concentration 20 and 40 ppm. Therefore, it can be concluded that raw aluminium dross without undergone any treatment can be effectively used for the adsorption of congo red in textile wastewater related industries.

1. Introduction

Dyes have been recognised as an issue that usually contaminates soil and groundwater. There are a lot of industries that apply dyes in their products such as textiles, foods, leather, plastics, paints, cosmetics and etc. The list is endless. It is approximately 10,000 of different types of commercial dyes and pigments that available in market and it is about 700,000 tonnes of dyes are produced every year throughout the world [1]. Discharged of these compounds to the environment not just only visible to the human, it also could contribute high organic loading and ecotoxicity of water bodies. These compounds that are visible in water bodies could absorb and reflect the sunlight that can retard the photosynthesis process. Some of these dyes are very toxic, carcinogenic or mutagenic to the human [1]-[3].

In the removal of these dyes, the most challenging are anionic dyes due to the bright coloured, very reactive in water and show acidic properties. Congo red is the most common dyes that can be found in rubber, plastic, textile and paper industries. Congo red has a benzidine based anionic disazo dye which has the structural stability that makes it hard to biodegrade. There are several methods have been reported for the removal of Congo red pollution such as adsorption with activated carbon, chemical oxidation, reverse osmosis and biological treatment but among these methods, adsorption is the best



way to treat this pollution [3],[4]. This method usually being used in the removal of toxic dyes from waste water due to the high efficiency, simple and less cost compared to other treating process. Activated carbon has been extensively used in the adsorption of Congo red but due to the cost of the material itself, it become unfavourable for the water treatment [5]. Therefore, researchers had discovered several adsorbents such as fly ash and bentonite and etc. that act as an adsorbent in the removal of Congo red which is more cheaper than activated carbon [5],[6] and [7]. Hence, other possible material which has ability to adsorb the congo red from waste water is still need to be explored.

Aluminium dross is a by-product produced from aluminium smelting industries and consists of metal, salt oxides, and other non-metallic substances [8]. Globally, it was estimated 5 million tonnes of aluminium dross generated every year [9]. The consumption of aluminium dross is rising as it produced from the melting of aluminium scrap for production of can, tin, aluminium siding and other related aluminium products. However, the disposal of dross as a waste is a burden to the main manufacturer industries due to its negative side effects to the ecosystem, surface and ground water [8],[9]. Waste of aluminium dross has been applied in other application such as low quality refractory brick, catalyst, and as filler in to improve stiffness, abrasion resistance and to control micro cracking [10]-[12]. On the other hand, there are still large amount of it being dumped at the landfill without treated, this is due to its high cost and difficult to transport [13].

Therefore, in this study, aluminium dross is introduced as an adsorbent in the removal of Congo red in the aqueous solution. In the laboratory scale, it may seem do not have affected to the aluminium dross produced throughout the world, but if it applied to the industry, the usage of this waste may contribute to the management of aluminium dross disposal. In fact, aluminium dross also could be reducing since this waste can be converted into the useful product.

2. Research Methodology

2.1 Raw materials

Aluminium dross (AD) was obtained from aluminium smelting industry, Press Metal Company located in Samalaju Industrial Park, Bintulu, Sarawak, Malaysia. The properties of AD were investigated using Scanning Electron Microscope (SEM), Brunauer-Emmett-Teller (BET) for surface area (Quantachrome Instruments) and X-Ray Fluorescence (Bruker S4 EXPLORER X-Ray Fluorescence) Spectroscopy for chemical composition of AD. The surface area of dross is 10.06 m²/g.

2.2 Preparation of congo red dye solution

1g of Congo Red dye was dissolved in 1 L of distilled water to produce 1000 mg/L of stock solution. Four different concentrations 20, 40, 70 and 100 ppm were prepared by diluting the stock solution.

2.3 Adsorption Studies

The study was performed in batch process. The effect of adsorbent mass, pH and initial concentration of congo red solution were carried out to investigate the adsorption efficiency of AD. The adsorbent mass varied in the range of 0.1 to 1.0 gram, and pH was observed at pH 6, 8 and 9. The initial concentrations of congo red solution were 20, 40, 70 and 100 ppm. The mixture was stirred using orbital shaker at 200 rpm at room temperature until 180 minutes. After that, the final concentration of congo red was analysed using UV-Vis Spectrometer (Shimadzu, UV-1800) at 500 nm wavelength absorbance. The amount of congo red adsorbed by aluminium dross was calculated according to equation 1:

$$q = \frac{C_o - C_e}{m} V \quad (1)$$

q (mg/g) = amount of congo red adsorbed per unit gram of aluminium dross; C_o and C_e (mg/l) is the initial and final concentration of congo red; V (l) is the solution volume and m (g) is the dosage of aluminium dross.

3. Results and Discussion

3.1 Scanning Electron Microscopic (SEM) image of aluminium dross

Figure 1 shows the microstructure of raw aluminium dross and the dross has irregular shape, and there is no voids or cavities observed in the image indicates that, the particles are well dispersed.

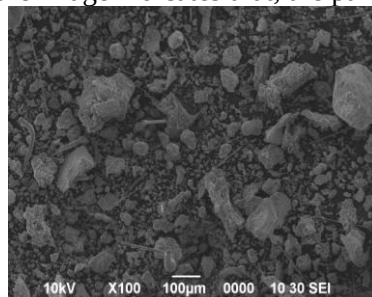


Figure 1. SEM image of Aluminium Dross

3.2 Chemical composition of aluminium dross

The chemical composition of aluminium dross has the highest content of Al_2O_3 with 89.80%, followed by SiO_2 with 1.20% and small amounts in between of 0.01 to 0.2% of Fe_2O_3 , MgO , SO_3 , CaO , Cr_2O_3 , TiO_2 and Na_2O .

3.3 Effect of adsorbent mass, pH and concentration on the adsorption of congo red

Figure 1, 2 show the percentage of congo red removal by aluminum dross at different adsorbent mass for the dye concentrations of 20, 40, 70 and 100 ppm and for pH 6, 8 and 9, respectively. In general, the removal curves are single, smooth and continuous leading to saturation.

For the effect of adsorbent mass, all curves showed the increment in the percentage removal of dye as adsorbent mass increased. This is due to increase in adsorption surface area of the adsorbent and the availability of adsorption sites [2], [14]-[15]. Besides, it was observed that 1.0 g has the highest per cent of removal, approximately 80% and above for all dye concentration for pH 6, 8 and 9. On the other hand, 0.4 g was a good enough to remove all congo red dye, approximately 100% from solution for 20 and 40 ppm of dye concentration at pH 9.

As the pH of the system increased the per cent dye removal increased. The per cent removal almost has the same values for lower adsorbent mass, masses from 0.1 to 0.4 g for 40, 70 and 100 ppm. The highest percentage of adsorption occurred at pH 9 for all different dye concentrations and at different adsorbent mass. Thus the highest efficiency of dye removal was achieved when carried out with aluminum dross at pH 9.

The removal of dye depends on the concentration of dye, Figure 2 (a,b,c), exhibited the same curve trends which is when dye concentration value increased, per cent dye removal decreased at same adsorbent mass. This can be explained by the limited number of available active sites on the surface of adsorbent to accommodate higher concentration of congo red [16].

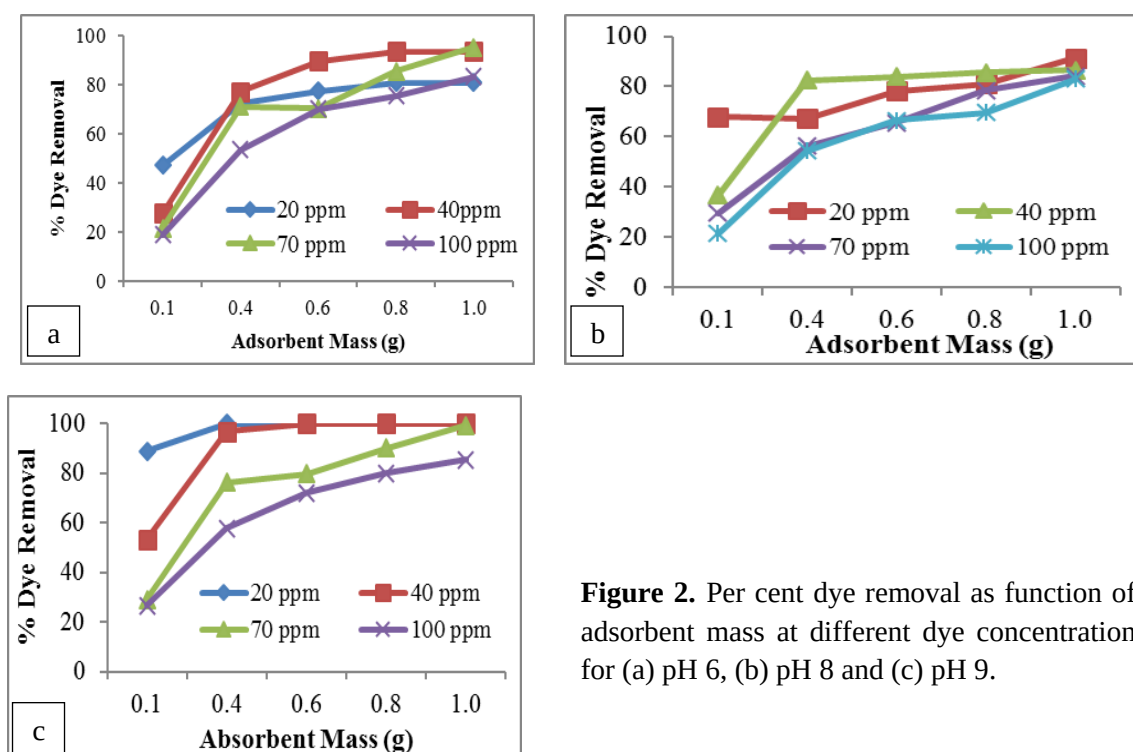


Figure 2. Per cent dye removal as function of adsorbent mass at different dye concentration for (a) pH 6, (b) pH 8 and (c) pH 9.

4. Conclusion

From the results presented, complete removal of dye can be achieved by using appropriate adsorbent mass and pH for the wastewater. Overall, 0.1 g of adsorbent mass provides significant impact on the per cent dye removal when it was carried out at low dye concentration, 20 ppm and at higher pH which is pH 9. In contrast, waste water with lower pH, at higher dye concentration, need more amount of adsorbent mass to successfully removing dye from waste water. Thus, it can be concluded that aluminium dross without having any treatment can be effectively used for the adsorption of congo red in wastewater industries. The kinetic and physicochemical of AD can be further explored for better understanding on the performance of AD as adsorbent in wastewater treatment.

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6. References

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