Coagulant from *Leucaena leucocephala* for Chromium Removal

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Abstract. This research investigated the effectiveness of *leucaena leucocephala* as a natural coagulant for chromium removal. *Leucaena leucocephala* is a permanent non-climbing shrub tree which is wild and abundant in Malaysia and commonly known as petai belalang. Coagulation experiment using jar test were performed where the effect of coagulant dosage and pH were examined. The parameters investigated were suspended solid (SS), chemical oxygen demand (COD), biological oxygen demand (BOD), turbidity and chromium content. The optimum of *leucaena leucocephala* coagulant dosage for removal of suspended solid, turbidity, COD, BOD and Chromium is at range 400-600 mg/L which yielded 45, 31.4, 38.5, 27.5 and 4.05% removal respectively. While the optimum pH is at pH 2-4 (acidic) which give 33.3, 26.8, 33.75, 31.4 and 14.06% removal of suspended solid, COD, BOD, turbidity and chromium content respectively. It is concluded that the *leucaena leucocephala* showed tremendous potential for chromium removal.

1. Introduction

The present of dye in wastewater are one of the serious problems faced by many industries in all over the world. Chromium can be categorized as dangerous wastes and toxic (B3) [1]. Coagulation process has been proven to be among the most effective way to remove heavy metal while aluminum salt is the main and widely used coagulant [2]. However, usage of these chemicals has several disadvantages such as relatively high costs; give harmful effects on human health, produced large volumes of sludge as well as the fact that they considerably affect pH of the treated water [3]. Thus, there is an increasing need for other environmentally acceptable and economically viable alternatives to replace the chemical-based coagulants. Plant-based coagulants could be promising alternatives as they are more cost effective, produce less voluminous sludge, highly biodegradable, non-toxic and do not alter the pH of the water under treatment [4]. Four types of plants which have been extensively used as natural coagulants are Moringa oleifera[5], nirmali seeds [6], tannin[7] and cactus [8]. This research focused on the preparation of coagulant from *leucaena leucocephala* using acid hydrolysis at 6 M of hydrochloric acid for treatment of dye wastewater. *Leucaena leucocephala* is preferable since it is abundant, wild, easy to find and naturally grown in Malaysia. The objectives of this study are to prepare coagulant from *leucaena leucocephala* using acid hydrolysis at 6 M of hydrochloric acid and determine the coagulant performance using chromium with jar test apparatus.
2. Methodology

2.1. Material
The leucaena leucocephala pods were collected at Seksyen U12 Shah Alam. Samples were dried in an oven at temperature of 60 °C for 24 hours. Dried leucaena leucocephala were then grinded and soaked in ethanol solution to removes chlorophyll.

2.2. Acid Hydrolysis
10 g of leucaena leucocephala was added in the 100 mL of 6 M of hydrochloric acid solution. The mixture were stirred for 1 hour and being filtered using vacuum filtration equipment. The grinded LL in was then washed using distilled water until reach pH 7 and being dried in an oven until all moisture will be removed.

2.3. Preparation of standard Chromium (VI) solution
Standard Chromium (VI) solution was prepared by dissolving 0.2829 g of Potassium dichromate crystals in distilled water and making up to 100 mL. Exactly 100 mL of this solution was transferred into a 1 L volumetric flask and diluted using distilled water to get a solution containing 0.1 mg of Chromium (VI) ions per cm³ (100 ppm or 1.923 mmol per litre).

2.4. Coagulation Jar Test Experiments
Jar Test equipment consists of six glass beakers each with a powered paddle which stirs the contents of the beaker. All tests were conducted at room temperature. 500 mL of standard chromium (VI) solution was poured into each of the six beakers. The desired amount of coagulant was added to the suspension and stirred at rapid mixing (120 rpm) for 1 minute. The speed of stirrer was reduced to slow mixing (30 rpm) for 20 minutes to keep flocs particles uniformly suspended. The paddles were then withdrawn and settling of flocs particles was observed and recorded. The mixture was left for 1 hour and then the supernatant was collected to be used in the determination of the suspended solid (SS), chemical oxygen demand (COD), biological oxygen demand (BOD), turbidity and Chromium content using the standard method.

2.5. Analytical Analysis
Suspended solid (SS) test was carried out with the aid of vacuum filtration apparatus. The initial weight of filter paper was recorded after drying in the oven at 100-105 °C for an hour. A 10 mL of the water sample was filtered through a filter paper. The residue was dried to constant weight at 100 °C - 105 °C for 1 hour. The filter paper was then cooled in dessicator before weighing. The total suspended solid content was calculated by using the equation 1;

\[
\text{Suspended solid} = \frac{(A - B) \times 10^6}{C}
\]

Where A is weight of disk + remaining solid (g), B is weight of empty disk (g), and C is volume of sample (mL)

Reactor digestion method was used to determine chemical oxygen demand (COD). 2 mL of each sample was added into COD digestion reagent vials and was inverted gently to mix the contents. It then was placed in the preheat COD reactor. The vials were heated for 2 hours at 150°C. Then, the sample vials were cooled at room temperature for about 20 minutes before the samples were analyzed by using spectrophotometer. The biological oxygen demand (BOD) test was carried out using dilution method. The dilution method is conducted by placing 50 mL of sample into bottles and filling the bottles with dilution water. The bottles are sealed and allowed to stand for 5 days at a controlled temperature of 20°C. At the end of the five-day period, the remaining dissolved oxygen is measured. The difference between the final and initial reading of dissolved oxygen was the BOD reading. Turbidity test was performed using portable turbidimeter with measurement in nephelometric turbidity unit NTU. This turbidimeter can measure turbidity from 0.001 to 1000 NTU in automatic range mode with automatic decimal point. The measurement is based on the light-transmitting properties.
Chromium (Cr) content was analyzed using Atomic Absorption Spectroscopy (AAS). 20 mL of water sample was placed into sample bottles and labeled to be analyzed by atomic absorption spectroscopy (AAS).

3. Results and discussion

3.1. The effects of coagulant dosage

Study on the effect of coagulant dosage is important for economic purpose. This is because excessive use of coagulant can be prevented during treatment of dye wastewater. The effect of coagulant dosage was studied in the range from 200 mg/L to 800 mg/L. Based on the results, the highest recorded suspended solid (SS), turbidity, chemical oxygen demand (COD), Chromium content and biological oxygen demand (BOD) removal percentages of *leucaena leucocephala* were observed at dosages range from (400-600 mg/L) at 45, 31.4, 38.5 and 27.5 % respectively. Figure 1 below shows the effect of coagulant dosage on the removal of suspended solid, turbidity, COD, BOD and Chromium content.

![Figure 1: Effect of coagulant dosage](image)

The percentage removal of COD and BOD was decreased in the range from 500 mg/L to 800 mg/L of coagulant dosage. This trend of graph is similar with the previous study which used *dragon fruit foliage* as the plant-based coagulant to treat concentrated latex effluent [9]. This is because the use of natural coagulants may increase the organic contents in solution resulting in increased of microbial activity. This will cause BOD concentration to increase and subsequently contributes to the increased of COD concentration [10]. The percentages of suspended solid and turbidity removal starts to decrease at coagulant dosage 600 mg/L. Similar behavior was observed when chitosan was studied to coagulate bentonite. The turbidity of the treated water started to deteriorate at increased coagulant dosage. This is because the main effect of coagulation was depending on the molecular weight of the coagulant [11]. Concentration of the chromium content in the solution was increased as the coagulant dosage increased. This may be due to the presence of heavy metal content in *leucaena leucocephala* pods. This is possible due to the geographical position of *leucaena leucocephala* [12].

3.2. The effects of pH

The effect of pH was studied in the range from 1-8. The highest recorded suspended solid, turbidity, COD, BOD and chromium removal percentages were observed at pH 2-4 (acidic) at 33.3, 31.5, 26.8, 33.75 and 14.06% respectively.
Figure 2 show that *leucaena leucocephala* have an excellent removal in the acidic solution. This is in agreement with the previous study that found *jatropha cursas seeds* coagulant is efficient under acidic conditions with turbidity removal of 99.4% at pH 3 [13]. *C. obtusifolia gum* as coagulant also showed higher coagulation activity at pH 3 to 5 with maximum total suspended solid (TTS) and COD removals of 89.9 and 33.9% respectively [14].

![Figure 2 Effect of pH](image)

The proposed coagulation mechanism involved could be adsorption with interparticle bridging. Thus, the charge of the coagulant in the solution did not play an important role for this mechanism. Natural polymers and organic colloids such as *leucaena leucocephala* are generally non-ionic and functioning as effective bridging coagulant in acidic solution [13],[14].Moreover, it can be seen that the percentages removal is decreasing at pH neutral. A similar observation is seen from the previous findings where the lowest turbidity, COD and suspended solid removal is in the pH range 6-8 using chitosan to treat concentrated latex effluent [10]. It appeared that SS removal percentages were consistently lower at pH neutral are caused by solution neutrality as opposed to acidic and basic where the elevated concentration of either H+ or OH− causes more electrostatic interactions between the coagulant and chemical species in the effluent and thus promotes coagulation [10].

### 4. Conclusion

The optimum coagulant dosage for removal of suspended solid, turbidity, COD, BOD and Chromium is at range 400-600 mg/L which yielded 45, 31.4, 38.5, 27.5 and 4.05% removal respectively. The optimum pH is at pH 2-4 (acidic) with 33.3, 26.8, 33.75, 31.4 and 14.06% removal of suspended solid, COD, BOD, turbidity and chromium content respectively. As such, it could be concluded that the *leucaena leucocephala* showed remarkable potential as natural coagulant for water treatment purposes.

### Acknowledgment

The authors wish to acknowledge to Research Management Centre for financial support under Research Acculturation Grant Scheme (RAGS) for funding project 600-RMI/RAGS 5/3 (19/2014) by Universiti Teknologi MARA (UiTM).

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