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Removal of color, turbidity, UV_{254} in treated wastewater of sugar factory by aluminum and iron based coagulants

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Abstract

This study aimed to compare of four coagulants (alum, polyalumina chloride (PACl), ferric chloride ($FeCl_3$), and ferric sulfate ($Fe_2(SO_4)_3$)) efficiency for removing turbidity, color, and ultraviolet absorbance at 254 nm (UV_{254}) of treated wastewater of sugar. Effect of pH (5, 6, 7, 8, and 9) was investigated under coagulants dose of 500 mg/L. The result showed that pH of 6 is appropriate for coagulation. $FeCl_3$ was the best coagulant effectively removed turbidity, color, UV_{254} by 66%, 63%, and 70%, respectively (pH 6). PACl provided lowest removal and was not effective for UV_{254} removal.

Keywords: Coagulation, Color, Sugar factory, Treated effluent, UV_{254}

1. Introduction

During the past couple years, Thailand experience serious drought previous and short of fresh water for domestic and industrial uses [1]. Therefore, recycle of the wastewater could be considered an option for several businesses. Sugar industries use lots of water in the process (250 m^3/ton of raw sugar) [2]. However, effluent wastewater after treatment still has yellowish color from melanoidins. As a result the treated effluent becomes objectionable for reuse. Coagulation by aluminum or iron salts is one simple and conventional alternative to removal color or organics from wastewater for reuse purpose. Previous studies reported successful use of coagulation to remove color from molasses wastewater [3-4]. However, in this particular effluent wastewater there is lack of information of which type of coagulants could provide the best color removal. This research aimed to compare the removal of turbidity, color, and ultraviolet absorbance at 254 nm (UV_{254}) (unsaturated carbon surrogate) of treated effluent wastewater from sugar factory.

2. Materials and methods

2.1. Treated effluent wastewater

Treated effluent wastewater was collected from a biological wastewater treatment plantat a sugar factory, Chaiyaphum Province, Thailand (Dec 10, 2015). Wastewater plant employs anaerobic and aerobic processes to remove organic in wastewater. The sample was stored in refrigerator at 4°C before use in experiment. The apparent of water sample is clear, and yellow in color. Other characteristics of water sample are shown in Table 1.

Table 1 Characteristics of treated effluent wastewater of sugar factory

Parameter	Value	Unit
pH	8.19	-
COD	126	mg/L
BOD	13.6	mg/L
Color	125	Pt-Co
Turbidity	11.2	NTU
Alkalinity	994	mg/L
UV_{254}	0.825	cm^{-1}

2.2. Coagulation experiment

Coagulation experiment was carried out using a laboratory jar test apparatus. Four coagulants ($Al_2(SO_4)_3.18H_2O$), polyaluminium chloride (PACl), ferric chloride ($FeCl_3.6H_2O$), and ferric sulfate ($Fe_2(SO_4)_3.7H_2O$)were used in the experiment. Stock solution of 50 g/L of each coagulant was prepared with deionized (DI) water. For each jar, 1 L of samples was poured into 1-L beaker. The pH was adjusted to desired values (5-9) using concentrated H_2SO_4 or NaOH. Coagulants of 500 mg/L were added to each beaker. The samples were rapid mixing for 1 min at 150 rpm followed by slow mixing for 20 min at 30 rpm and then settled for 1 hr.

2.3. Analyses

The pH value was measured with a bench-scale pH meter.Turbidity was directly read on a turbidity meter in nephelometry turbidity unit, NTU. Color was measured with spectrophotometer (DR6000, HACH, USA) at 455 nm wavelength in Platinum-Cobalt unit (Pt-Co). UV_{254},

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indicator of unsaturated/aromatic carbon, was measured by spectrophotometer (DR6000, HACH, USA) (APHA et al., 2005). Other analyses such as alkalinity, biochemical oxygen demand (BOD), and chemical oxygen demand (COD) were performed according to standard methods [5].

3. Results

3.1 Turbidity removal

Turbidity removal by Al^{3+} and Fe^{3+} based coagulants is shown in Figure 1. The effect of pH was investigated in the range of 5 to 9 and fixed coagulants concentration at 500 mg/L. Among coagulants, alum, $FeCl_3$ and $Fe_2(SO_4)_3$ yielded about similar result from pH 7-9 (60-70 % removal). On the other hand PACl provided lowest turbidity removal in most pHs (Best condition was only 30 % at pH 7). The pH suitable for precipitate turbidity of treated effluent wastewater was ranged from 7-9.

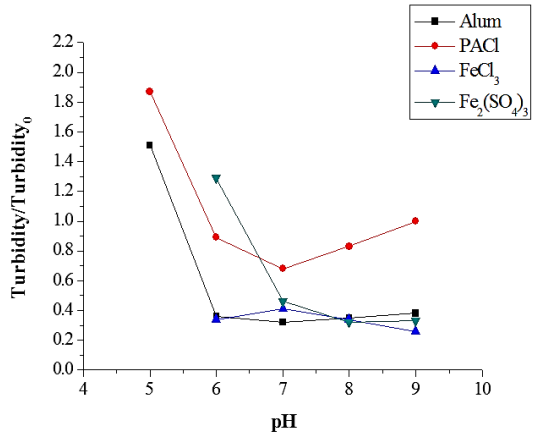


Figure 1 Effect of pH on normalized turbidity

3.2 Color removal

Figure 2 and Figure 3 presents the color removal of treated effluent water of four coagulants. Solution pHs of 6 provided better performance for color removal. $FeCl_3$ gave the best color removal by 63% at pH 6 while $Fe_2(SO_4)_3$ cause color to be higher than the initial value while PACl provided the least removal among coagulants (except for pH 6). The increasing of color over the initial value might due to the complexation of Fe-NOM and Al-NOM and then increase its colloidal stability.

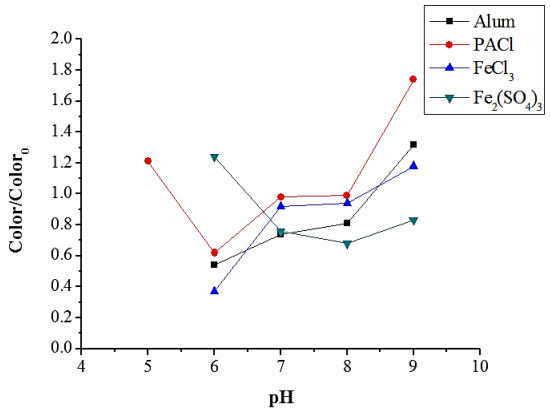
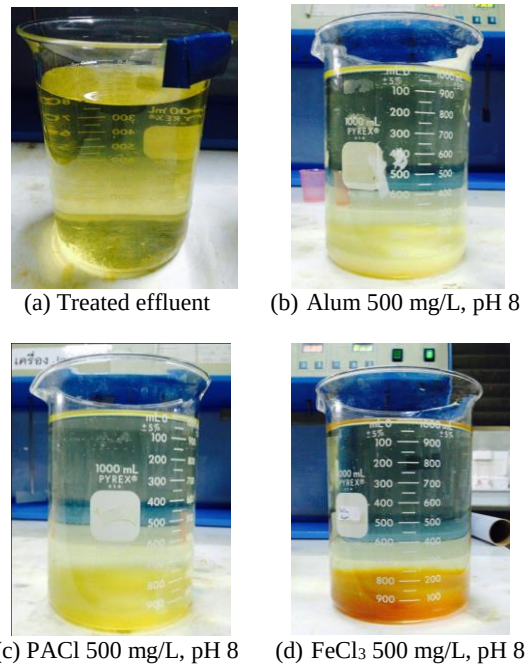


Figure 2 Effect of pH on normalized color

3.3 UV_{254} removal

Ultraviolet absorbance is a surrogate parameter for determining the unsaturated carbon (C=C, C≡C) or aromatic structures in the water. This constituent is typically chromophore. As a result it caused color. Removal of UV_{254} is shown in Figure 4. The results show that UV_{254} can be removed the best at pH of 6. The increasing of pH tended to decrease the removal efficiencies. Similar to in previous section, FeCl3 is the best coagulant to remove UV_{254} while PACl provided the least removal among coagulants. Note that for pHs 8 to 9, UV_{254} values of water treated by PACl were higher than that of raw wastewater. This was due to the structure of chromophores changed as pH increased causing to absorb more UV at 254 nm.



(a) Treated effluent (b) Alum 500 mg/L, pH 8

(c) PACl 500 mg/L, pH 8 (d) $FeCl_3$ 500 mg/L, pH 8

Figure 3 Color of (a) treated effluent and after coagulation by (b) alum, (c) PACl, and (d) $FeCl_3$

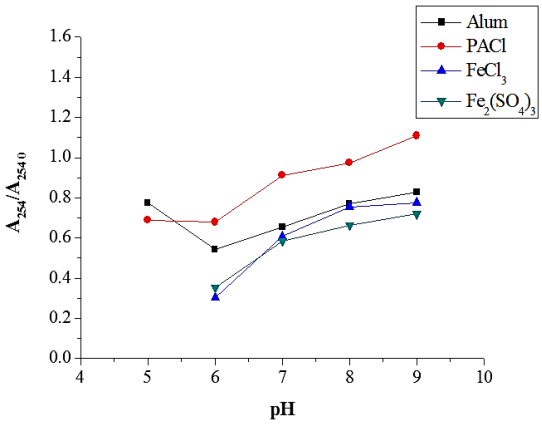


Figure 4 Effect of pH on normalized UV absorbance at 254 nm (A_{254})

4. Discussion

From the jar test results of four types of coagulants, $FeCl_3$ had the best efficiencies to remove turbidity, color, and

UV254 of treated wastewater of sugar factory. Only PACl provided the least removal compared to other coagulants. pH had a great impact the removal of turbidity, color, and UV_{254}. It seems that the appropriate pH for coagulation 6 while lowering the pH or increasing pH beyond this range could reduce efficiencies. This was due to the dissolution of the complex of alum or iron base salts [6].

5. Conclusion

The finding of this work showed that turbidity, color, and UV_{254} were effectively removed at coagulant doses of 500 mg/L. As color is the most concerned of this type of wastewater, pH range suitable for adding coagulants was 6. Future study for the effect of coagulant dosage and cost of chemicals need to be performed for practical uses.

6. Acknowledgement

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