POTENTIAL STUDY OF SILK SERICIN AS COAGULANT AID FOR REMOVAL OF SYNTHETIC TURBID WATER

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INTRODUCTION

Water supply system has a main purpose on the improvement of water quality to ensure the health issue on daily consumptions. Water quality improvement procedure simply begins with instability of colloids using coagulants followed by flocculation and then turbidity removal by sedimentation [1]. Coagulants widely used in water supply include alum, ferric chloride, and ferrous sulfate. However, these coagulants are relatively expensive and yield low removal efficiency at low level turbidity. In order to improve the turbidity removal efficiency, both synthetic and natural coagulant aids must be exploited. Regarding the application of synthetic polymers, the presence of residual monomers is undesirable because of their neurotoxicity and strong carcinogenic properties [2].

In recent years there has been considerable interest in the development of usage of natural coagulants which can be produced or extracted from microorganisms, animal or plant tissues. These coagulants should be biodegradable and are presumed to be safe for human health. In addition, natural coagulants produce readily biodegradable and less voluminous sludge that amounts only 20-30% that of alum treated counterpart [3].

Several papers suggested that proteins are the coagulation active components in plant extracts. Among them, silk is a natural biopolymer produced by silkworms during the formation of their cocoon. Silk cocoon consists of two natural macromolecular proteins; fibroin and sericin. In which sericin constitutes of about 25-30% protein [4]. This important property indicates that sericin has the tendency of utilization as coagulant aid. Therefore, the main objective of this research is to investigate economical and natural coagulant aid that could be applied in water supply system.

MATERIALS AND METHODS

Preparation of silk degumming

Silk sericin used as coagulant aid in this study was extracted from silk cocoons by boiling them with 0.5% (w/w) Na_2CO_3 solution at 90°C for 60 minutes [4]. Then the sericin solution with light yellow color as shown in Figure 1 was separated from silk fibroin and and kept in a refrigerator at 4 °C for further use.

Figure 1 Silk sericin solution

Preparation of synthetic turbid water
Synthetic turbid water with the initial turbidity of about 50 NTU, 75 NTU, and 100 NTU, was prepared by adding kaolin of approximately 0.83 g, 1.26 g, and 1.687 g, respectively, into 12 liters of distilled water. The stock solution was then kept at ambient conditions for coagulation tests [5].

Coagulation test
Two sets of experiment were conducted to study turbidity removal efficiency of synthetic turbid water with and without coagulant aid. The first set of experiment was divided into 3 subsets to investigate the optimum dosage of alum without addition of coagulant aid at initial turbidity of around 50 NTU, 75 NTU, and 100 NTU. Six different dosages of 5% alum solution ($Al_2(SO_4)_3 18H_2O$) were added into the synthetic turbid water yielding the concentrations of 0 mg/L, 20 mg/L, 60 mg/L, 80 mg/L, and 100 mg/L. The pH of the synthetic turbid water in each beaker was adjusted to the value of about 7 using 5% $NaHCO_3$. The solution in each beaker was then mixed with a speed of 100 rpm for 1 minute and followed by mixing with a speed 30 rpm for 30 minutes. After mixing, the suspensions were left for 30 minutes sedimentation [1]. After that, the clarified samples were collected from the top of the beakers and measured for the residual turbidity using the HACH 2100P turbidity meter. The second set of experiment was also divided into 3 subsets and carried out using similar procedures as described above. However, 0.01 mL of the silk sericin, an economical and natural polymer, was promptly added into each beaker after the addition of alum except for the blank one. Each experiment was duplicated.

RESULTS AND DISCUSSION

Tables 1 to 3 compare results of coagulation test without and with coagulant aid at synthetic turbidity of 50 NTU, 75 NTU, and 100 NTU, respectively. As seen from these tables, the turbidity removal efficiency increased with increases in alum dosage. However, without addition of coagulant aid, the optimum removal efficiency was received at alum dosage of 80 mg/L. Whereas; the optimum removal efficiency was obtained at alum dosage of 60 mg/L with addition of silk sericin. From Table 1, the maximum removal efficiencies of 90% and 95% were received without and with coagulant aid, respectively. From Tables 2 and 3, the highest removal efficiencies of 93% were obtained without coagulant aid. When adding silk sericin, slight increases in removal efficiency were observed. The results indicated that, when adding silk sericin as coagulant aid, not only the turbidity removal efficiency could be improved but the amount of alum utilization could be reduced also. Furthermore, the different morphology of floc formation could be observed as shown in Figure 2. As seen from the figure, the larger floc was formed and settled out of the solution with the addition of silk sericin. Therefore, it could be concluded that silk sericin extracted from silk cocoon can be applied as an alternative material as natural coagulant aid. Since it can be readily prepared and costs much cheaper than the synthetic polymer. After all, silk cocoons, agricultural waste, can be easily collected in the northeast and central of Thailand. However, it has been reported that addition of natural coagulant aid can cause an increase in organic matter in water [5]. Since the organic matter in water might consume additonal chlorine in water supply system and can acts as a precursor of byproducts during the disinfection process. Therefore, the study of impact of natural coagulant aid on organic matter content in water should be further investigated.

Table 1: Turbidity removal efficiencies of synthetic turbid water at 50 NTU using alum and alum with 0.01 mL of silk sericin.

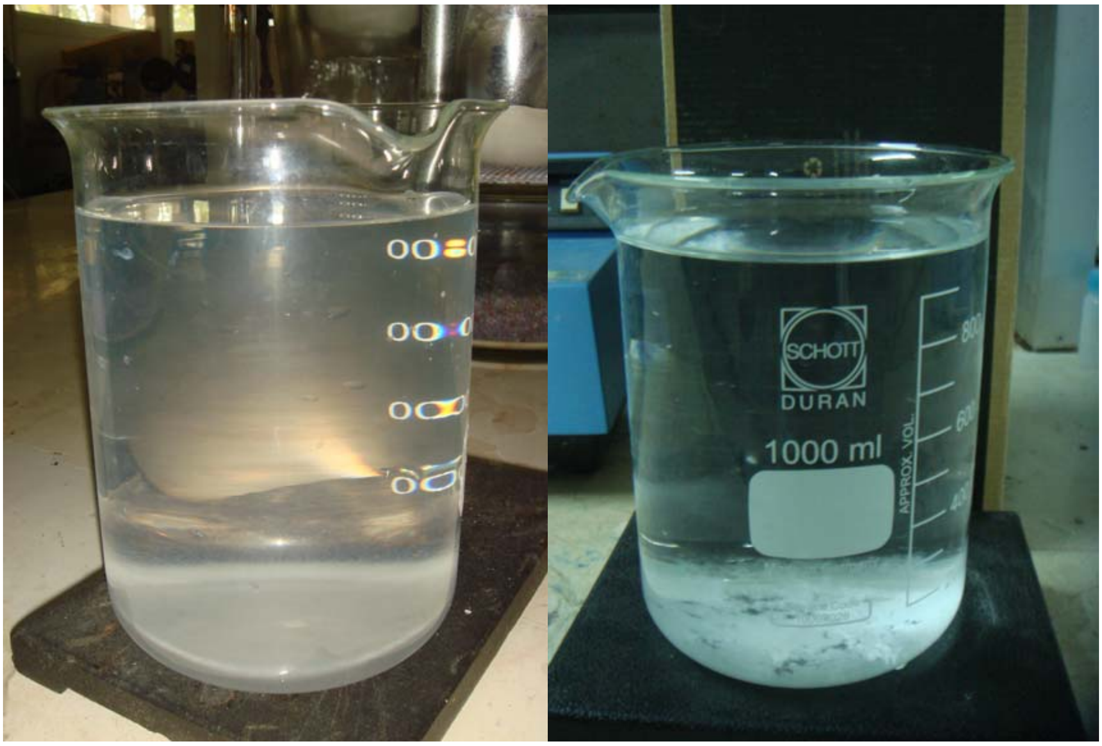
Sample No.	Alum concentration (mg/L)	% Removal Efficiency	Alum concentration (mg/L) + 0.01 mL silk sericin	% Removal Efficiency
1	0	29 ±1	0	40 ±2
2	20	35 ±5	20	60 ±3
3	40	58 ±2	40	77 ±3
4	60	78 ±3	60	95 ±0
5	80	94 ±2	80	91 ±2
6	100	88 ±2	100	85 ±3

Table 2: Turbidity removal efficiencies of synthetic turbid water at 75 NTU using alum and alum with 0.01 mL of silk sericin.

Sample No.	Alum concentration (mg/L)	% Removal Efficiency	Alum concentration (mg/L) + 0.01 mL silk sericin	% Removal Efficiency
1	0	37 ±4	0	52 ±2
2	20	52 ±2	20	69 ±3
3	40	56 ±2	40	68 ±0
4	60	73 ±2	60	94 ±0
5	80	94 ±1	80	85 ±2
6	100	86 ±1	100	60 ±0

Table 3: Turbidity removal efficiencies of synthetic turbid water at 100 NTU using alum and alum with 0.01 mL of silk sericin.

Sample No.	Alum concentration (mg/L)	% Removal Efficiency	Alum concentration (mg/L) + 0.01 mL silk sericin	% Removal Efficiency
1	0	32 ±4	0	57 ±4
2	20	61 ±1	20	74 ±1
3	40	73 ±0	40	77 ±2
4	60	90 ±1	60	93 ±2
5	80	93 ±0	80	82 ±2
6	100	74 ±2	100	68 ±2



a) without coagulant aid b) with coagulant aid

Figure. 2 Morphology of floc formation without and with coagulant aid.

CONCLUSION

The maximum turbidity removal efficiencies of the synthetic turbid water at 50 NTU, 75 NTU, and 100 NTU were in the range of 90-93% when using alum dosage of 80 mg/L without addition of silk sericin as coagulant aid. While, the highest turbidity removal efficiencies for all turbidities used in this study slightly increased to 93-95% when using alum dosage of 60 mg/L with addition of 0.01 mL of silk sericin. Furthermore, the different morphology of floc formation could be observed. Therefore, it could be concluded that silk sericin extracted from silk cocoon can be applied as an alternative material as natural coagulant aid. Since it can be readily prepared and costs much cheaper than the synthetic polymer.

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