COAGULATION OF TURBID WATER BY CHITOSAN AND ALUM

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I hereby declare that this dissertation is based on m original work, except for quotations and summaries each of which have been fully acknowledged

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ABSTRACT

Coagulation efficiency of a biopolymer (i.e. chitosan) was investigated at different coagulant dosage, initial turbidity, mixing time and pH conditions using kaolin suspension as the test water. For comparison, a similar experiment was carried out using alum as the coagulant. The final turbidity was measured in each experiment using a turbidity meter. The results showed that chitosan was a more effective coagulant at low dosage compared to alum. Efficiency of turbidity removal increases as mixing time increased while alum, efficiency was not effect significantly affected. Both alum and chitosan efficiency increased as initial turbidity increased until a certain specific optimum level. Chitosan showed higher efficiency in alkaline condition compared to alum. The optimum pH for chitosan was in the range between pH 7-8.

PROSES PENGGUMPALAN DALAM AIR TURBID MENGGUNAKAN CHITOSAN DAN ALUM

ABSTRAK

Kesan kuantiti pengumpal, turbiditi awal, masa pengacauan dan pH telah dikaji dalam keberkesanan pengurangan turbiditi air melalui proses pengumpalan dengan menggunakan kitosan sebagai pengumpal dan larutan kaolin sebagai turbidit sampel air keruh. Untuk perbandingan, setiap eksperimen ini diulangi dengan menggunakan alum sebagai pengumpal. Turbiditi akhir telah diukur pada akhir eksperimen dengan menggunakan meter turbidit. Kitosan didapati lebih efektif berbanding alum pada dos yang rendah. Keberkesanan kitosan untuk mengurangkan turbiditi meningkat apabila masa pengacauan meningkat sementara keberkesanan alum tidak banyak dipengaruhi. Dari segi kepekatan turbiditi awal meningkat sehingga ke tahap optimum. Kitosan adalah lebih efektif dalam larutan beralkali berbanding alum dan pH optimum bagi kitosan adalah dalam julat 7 hingga 8.

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LIST OF SYMBOLS

%	percentage
^oC	degree Celsius
^oF	degree Fahrenheit
M	molar
pH	concentration of ion hydrogen by negative logarithma in mol sedimetracube
w/w	weight percent
mL	milliliter
L	liter
min	minutes
g	gram
s	seconds
CL^-	chlorine ion
H^+	hydrogen
$\pm$	plus minus
HCL	acid hydrochloric
NaOH	sodium hydroxide
NTU	nephelometric turbidity meter
JTU	Jackson turbidity unit
FTU	formazin turbidity unit
APHA	American Public Health Association

CHAPTER 1

INTRODUCTION

1.1 Introduction.

Turbid water is a typical problem faced by water treatment plants when producing potable water from river water. The water treatment process generally involves 4 stages namely aeration, sedimentation, filtration, and disinfection (James and Brian, 1989). The sedimentation stage involves coagulation process to destabilize colloidal impurities by producing large floc which subsequently separate from the dissolve phased. The process is generally expedited using chemical coagulants. Alum or aluminum sulphate is the most widely used coagulant in water treatment because of its proven performance, cost effectiveness, relative ease handling and availability (Kawamura,1991). Synthetic polymer also are available such as aluminum chiorhydroxidde, polyacrylamide, poly(acrylic acid) which reacts as a coagulant in water treatment. Synthetic polymers are used alone or combined with alum under certain condition.

The use of conventional coagulants has some disadvantages. The use of alum decreases the alkalinity of water due to the strong pH dependence for effective coagulation. Alum also causes secondary pollution in the sludge disposal which complicates handling and disposal procedures, and has raised public health concerns owing to the amount of aluminium remaining in the treated water (Huang and Chen, 1996).

Alum coagulation produces significant alum sludge and increase the alkalinity of the water. Alum floc is generally much weaker in cold-water flocculation. To minimize these problems, synthetic polymer is the latest development in physical-chemical water treatment. The coagulation of negatively charge solids with polymers has already received extensive attention (Kawamura, 1991). However, it is contended that the residual polyacrylamide in treated water may cause neurological disorder in human. Synthetic polymers form large and strong floc but usually do not produce a clear supernatant, because they generally incapable of enmeshing all of the colloid particles in raw water. Unit cost for polymers is much higher than for alum and most of them are not readily biodegradable. In addition, there is some uncertainty about their long range toxicity, carcinogenicity, and mutagenicity for humans (Kawamura, 1991).

As a consequence, there is a growing interest on the application of natural materials or natural coagulants as alternatives to inorganic salts and synthetic polyelectrolytes. Examples of natural coagulants that have been investigated are chitosan

(Divakaran and Pillai, 2001), sodium alginate (Kawamura, 1991), and *moringa oleifera* (Anselme and Narasiah, 1997). Natural coagulants are not harmful towards human health.

Chitosan (*N*-acetyl-d-glucosamine) is a natural cationic polymer obtained by deacetylation of chitin extracted from crustacean, arthropods, fungi and yeast (Divakaran, 2004). Chitosan has been recommended as a suitable coagulant resource material because of its excellent properties such as biodegradability, non-toxic, effective dosage range of coagulation for various colloid suspension, high molecular weight and do not cause any adverse to human health (Kawamura, 1991).

1.2 Objective of Study.

The objectives of this study are as follows:

1) To prepare chitosan using crab shells as the raw material.
2) To determine and compare the effectiveness of chitosan with alum as coagulant for treatment of turbid water

1.3 Scope of Study.

In this study, chitosan and alum will be used as coagulants. First, chitin will be extracted from crab shells, and chitosan is subsequently derived from the chitin obtained. The chitosan will be tested using kaolin suspension to represent turbid waters. The effects of coagulant dosage, initial turbidity, mixing time and pH value on coagulation efficiency will be investigated. The final turbidity of the suspension will be determined using a turbidity meter. Results obtained for chitosan will be compared to that for alum

CHAPTER 2

LITREATURE REVIEW

2.1 Turbid Water.

Water is said to be turbid when particles suspended in it restrict the transmission of light and give a cloudy or muddy appearance. Only small particles can remain suspended for significant periods of time. Comparatively, large and dense particles such as sand grains will sink rapidly. All particles denser than water will tend to sink unless there is a force operating to keep them suspended. Normally some level of motion of the water assists in suspending particles. Thus the duration of suspension depends on the intensity of the motion plus the size shape and density of the particles (Smethurst,1992).

According to the Environmental Protection Agency (EPA), turbidity is the cloudy appearance of water caused by the presence of suspended and colloidal matter. There are various parameters influencing the cloudiness of water. Some of these are phytoplankton, sediments from erosion, resuspended sediments, waste discharge, and algal growth.

Turbidity is considered as a good measure of the quality of water (James and Brian, 1989). Bentonite and kaolin suspension are commercialize turbid water use in coagulation studies as an alternative to natural turbid water (Divakaran, 2004).

Turbidity is measured in Nephelometric Turbidity Units (NTU), Jackson Turbidity Unit (JTU), Formazin Turbidity Unit (FTU), and American Public Health Association (APHA) units. The instrument used for measuring it is called nephelometer or turbidity meter, which measures the intensity of light scattered at 90 degrees as a beam of light passes through a water sample (James and Brian, 1989).

2.2 Coagulation Chemistry.

2.2.1 Basic Principles of Coagulation.

Coagulation method is widely used in water and wastewater treatments. It is well known for its capability of destabilizing the charge particle using chemical reagent or coagulants and causes the agglomeration of these particles. Agitation of suspension causes particle to come closer or even collide. These mechanisms are very important in forming flocs of suspended solid which could be easily settled and finally removed from the water following clarification or filtration process (Ahmad *et. al.*, 2006).

Settling velocity of a particle is the rate at which the sediment settles in still fluid. Settling is effected by the grain size. It is also sensitive to the shape (roundness and sphericity) and density of the grains as well as to the viscosity and density of the fluid (Anderson *et. al.,* 1996). For dilute suspensions, Stokes' Law predicts the settling velocity of small spheres in fluid, either air or water according to the following equation:

$$w = \frac{2(\rho_p - \rho_f) g r^2}{9\mu}$$

where w is the settling velocity, ρ is density (the subscripts p and f indicate particle and fluid respectively), g is the acceleration due to gravity, r is the radius of the particle and μ is the dynamic viscosity of the fluid. If the flow velocity is greater than the settling velocity, sediment will be transported downstream as suspended load. As there will always be a range of different particle sizes in the flow, some will have sufficiently large diameters that they settle on the water, but still move downstream. The settling rate increases as particle size increase (James, 1989).

2.2.2 Mechanism of Coagulation.

Chemical coagulation is one type of chemical treatment process. The mechanism of coagulation on turbidity removal can be categorize in two stages namely; Adsorption of reagent onto the particles and the formation of aggregate (Krasner and Amy, 1995). Adsorption is possible when the reagent and the surface are of opposite charge, resulting in non-specific electrostatic interaction (Huang and Chen, 1996). Aggregation of fine particles can be achieved by neutralization of charges or a reduction of the repulsion forces between particles. The overall electrical charge associated with particles and organic matter in water is usually negative. Consequently, positively charged coagulants are added to neutralize the electrical charge (Edzwald, 1993).

Effective coagulation/flocculation can remove particles over a wide range of particle sizes. Most inorganic salt ions, such as Al^{3+} or Fe^{3+}, have ability to compress the electrical double layer which related to the valence of the ionic charge of the ion itself. When coagulation corresponds to minimum stability, the suspended particle does not carry a charge in relation to the suspending medium causes zeta potential to be zero (AWWA,1989). The surface has a negative charge, which positive ions will be attracted to and form a bound layer of positive ions (Fig. 2.1) All particles carry an electrical charge on their surfaces, the sign and intensity of which depend on the nature of the surface and on the chemistry of the aqueous suspending medium (Gregor *et. al.*, 1997).

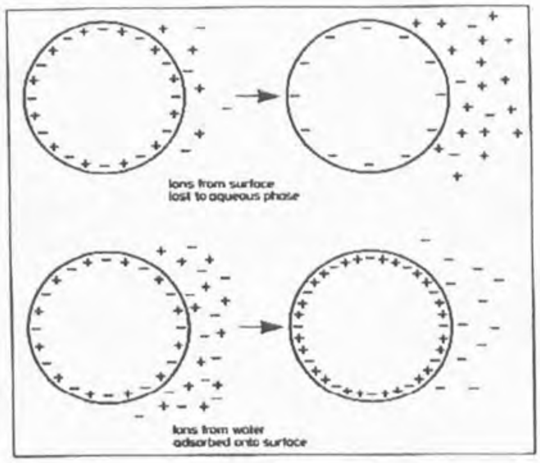

Fig. 2.1. The overall electrical charge associated with particle (Parazak *et. al.*, 1988)

Bridging is considered to be a consequence of the adsorption of the segments of flocculants macromolecules onto the surfaces of more than one particle through flocculation process (Parazak *et. al*., 1988). Requirements of bridging flocculants are that they be strongly adsorbed onto the particles, and that they are capable of holding on the gap between the particles. Synthetic polymers of high molecular weight are long enough for one end to adsorb onto one particle and the other end onto a second particle forming a three-dimensional matrix (Fig. 2.2). Generally, the higher the molecular weight, the better the flocculants reacts in a polymer bringing (Sonntag, 1993).

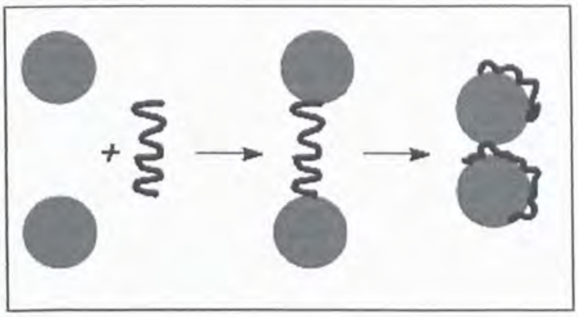

Fig. 2.2. Polymer attaches to two particles simultaneously by both ends through electrostatic attraction (Franceschia *et. al*., 2002).

Most bridging flocculants therefore, carry either a positive (cationic) or a negative (anionic) charge. These charges serve two principles; they provide a means of adsorption onto the particle surface by electrostatic attraction. It also causes the polymer molecule to extend and uncoil due to charge repulsion along the length of the polymer chain (Fig. 2.3). Hence, the molecule will be more nearly linear and can therefore accommodate more particles (Ahmad *et. al*., 2006).

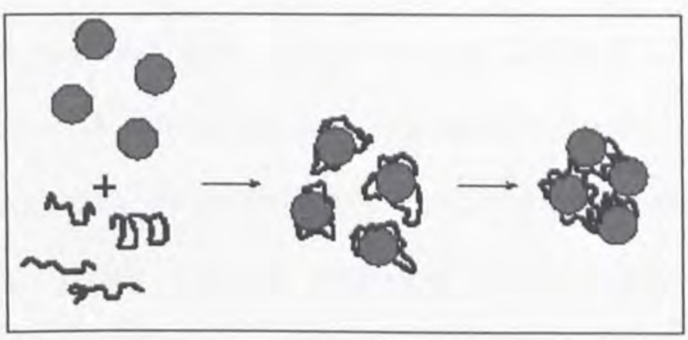

Fig. 2.3 Polymer chain that accommodate more particles through charge repulsion (Franceschia *et. al.,* 2002).

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