

Activated Carbon Aided Alum Coagulation for

Removal of Textile Dye From Dye Water

By

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ABSTRACT

The processes of adsorption followed by coagulation was evaluated for the removal of three textile dyes (CIBACRON Yellow C5G, Remazol Blue RGB and Remazol Red RGB) from water in a laboratory-scale experiment. The adsorption efficiency of manufactured powdered activated carbon (Malbon R4) for three dye solutions was also investigated. Batch experiments showed that the adsorption of dyes increased with an increase in dye concentration and carbon dose. The right sequence of operation was identified for the combined treatment system. The results indicated that maximum percentage of dye removal by adsorption on Malbon R4 for the dyes achieved was 52.15-83.53 %. The maximum dye removal efficiencies for 20 mg/l and 50 mg/l of dye concentration (for three dyes) with adsorption followed by coagulation were 96.16-99.78% and 96.71-99.60 %, respectively. The combined adsorption-coagulation process has the capability of near complete dye removal. More research should be done with different types of activated carbons and coagulants for removal of dye from dye wastewater.

ABSTRAK

Penyingkiran tiga jenis celupan tekstil (CIBACRON Yellow C5G, Remazol Blue RGB and Remazol Red RGB) dari air dengan eksperimen dalam skala makmal telah dinilai melalui proses penyerapan diikuti pengentalan. Pemeriksaan tentang keberkesanan penyerapan oleh serbuk karbon diaktifkan (powdered activated carbon, Malbon R4) terhadap ketiga-tiga jenis celupan juga telah dijalankan. Eksperiment yang telah dijalankan menunjukkan peningkatan penyerapan dengan peningkatan kepekatan celupan dan karbon. Urutan operasi yang tepat bagi sistem rawatan bergabung telah dikenalpasti. Keputusan menunjukkan bahawa penyingkiran celupan maksimum dalam peratusan oleh penyerapan karbon mencapai 52.15-83.53 %. Penyingkiran celupan maksimum untuk ketiga-tiga celupan dengan kepekatan 20 mg/l dan 50 mg/l dengan proses penyerapan diikuti pengentalan adalah masing-masing 96.16-99.78 % dan 96.71-99.60 %. Proses bergabung penyerapan-pengentalan berkemampuan untuk menyingkirkan hampir kesemua celupan dalam air. Penyelidikan yang lebih harus dilakukan bagi jenis karbon dan pengental yang berlainan dalam penyingkiran celupan dalam air sisa.

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CHAPTER 1

INTRODUCTION

According to Banat et al. (1996), most of the industries in the twenty-first century, such as dyestuffs, textile, paper and plastics, use dyes in order to colour their products and also consume substantial volumes of water. The amount of coloured wastewater they generate everyday is considerable. Public perception of water quality is greatly influenced by those coloured wastewater. Colour is the first contaminant to be recognized in wastewater (Banat et al., 1996). Even very small amounts of dyes present in water (less than 1 ppm for some dyes), the visibility of these dyes are high and undesirable (Robinson et al., 2001; Banat et al., 1996).

There are over 100,000 commercially available dyes and more than 7×10^5 tone are produced annually (Pearce et al., 2003; McMullan et al., 2001). The synthetic dyes are common water pollutants because of their good solubility. Due to that, they may frequently be found in industrial wastewater. An indication of the scale of the problem is given by the fact that two per cent of dyes that are produced are discharged directly in aqueous effluent (Pearce et al., 2003; Robinson et al., 2001). Many of these dyes are toxic and even carcinogenic and this poses a serious hazard to aquatic living organisms. Due to increasingly stringent restrictions on the organic content of industrial effluents, it is necessary to eliminate dyes from wastewater before it is discharged. (O'Neill et al., 1999; Vandevivere et al., 1998). However, wastewater containing dyes is very difficult to treat, since the dyes are recalcitrant organic molecules, resistant to aerobic digestion, and are stable to light, heat and oxidizing agents (Sun and Yang, 2003; Ravi Kumar et al., 1998).

The present study was undertaken to assess the effectiveness of powdered activated carbon aided alum coagulation in treatment of dye wastewater.

1.1 Importance of the Study

Due to the increased of population, theoretically the number of industry will raise up rapidly especially the dye industry. In the 21st century, consumer products focus not only on quantity but also on its look (packing, decoration and advertisement)-all of those can be done with dye or colouring. Therefore, the industry will release large quantity of wastewater consisting of different types of dyes and this may necessitate complicated wastewater treatment.

The first and foremost importance of this study would be to ascertain the effectiveness of powdered activated carbon as adsorbent for dyes in water. By using the locally manufactured material, it was expected that treatment cost would be lower, thus be an alternative to the existing treatment method. Consequently, it will develop as a more economical method for treatment. Powdered activated carbon aided alum coagulation not only help in reducing the amount of alum used, but also reduce the cost for aluminium sulphate. As we know, powdered activated carbon is a common commercial product that can be obtained easily. In addition, powdered activated carbon does not give any significant impact to the pH of the water.

Many of the chemicals used in water and wastewater treatment are also associated with human health and environmental problems (Crapper et al., 1973; Christopher et al., 1995; Kaggwa et al., 2001) and a number of them have been regulated for use in water treatment. Aluminium sulphate (alum) is a well known industrial chemical which is available in both solid and liquid forms. It occurs naturally as the mineral alunogenite and

has been developed to significantly enhance the treatment of water, wastewater, industrial effluent and process water in the paper, food, dairy, oil, textile and chemical industries. Although alum was widely used as coagulant in water treatment in most countries from decades ago, it might pose a health risk to the user if the quantity is too much. There is equally good evidence that aluminum exposure is not a risk factor as there is evidence that it is a risk factor (Harrison et al., 1998). The aluminium residual in the water after treatment may cause Alzheimer's disease which is a progressive brain disorder that gradually destroys a person's memory and ability to learn, reason, make judgments, communicate and carry out daily activities. As Alzheimer's disease progresses, individuals may also experience changes in personality and behavior, such as anxiety, suspiciousness or agitation, as well as delusions or hallucinations. Besides, alum also lowers the pH of the water, thus increasing the acidity of water and extra processes need to be done on the water. Therefore, by researching alternative method using powdered activated carbon aided alum coagulation may help in developing an economical, healthier and environmentally friendly method of treatment.

1.2 Objectives of the Study

- a) To evaluate the efficiency of aluminium sulphate as coagulant in treating water containing textile dye.
- b) To determine the optimum dosage of powdered activated carbon as adsorbent for the textile dyes in dye water.
- c) To determine the optimum dosage of powdered activated carbon in treating different dye such as CIBACRON Yellow C5G, Remazol Blue RGB and Remazol Red RGB.

- d) To determine the optimum dosage of powdered activated carbon in treating different concentrations of dye solutions (20 mg/l and 50 mg/l).
- e) To determine the efficiency of powdered activated carbon aided alum coagulation in treating the different dye solutions and different concentrations of dye solutions.

1.3 Scope of the Study

This main focus of the study is on laboratory work, called batch clarification test (jar test). By doing the test on different concentrations of dyes with sedimentation and filtration, the optimum dosage of powdered activated carbon as adsorbent and alum as coagulant will be obtained. On the other hand, optimum amount of powdered activated carbon needed to be determined precisely. This is because the results will be used to compare with results from other dye solutions. The pH will be measured before and after the test and recorded to check the change in pH with and without alum as coagulant. The measured parameter in the study is absorbance dye concentration.

CHAPTER 2

LITERATURE REVIEW

2.1 General

Colour is one of the characteristics of an effluent, which is easily detected and readily traced back to its source. Most of the dyes are stable to biological degradation. Dye wastewaters are often objectionable on aesthetic grounds. Dye affects the nature of water by inhibiting sunlight penetration, thus reducing photosynthetic action. Some dyes are carcinogenic and mutagenic. Therefore, there is considerable need to treat dye wastewater prior to discharge. Once the dye has contaminated the water, its removal by conventional wastewater treatment methods is particularly difficult because many of the dyes are stable to light and oxidizing agents, and are resistant to aerobic bio-oxidation. The removal of dyes in an economical fashion remains an important problem. The removal of colour from waste water is often more important than the removal of soluble colourless organics which normally contribute to the major BOD load.

Adsorption has been shown to be a good method of color contaminant removal. It overcomes the problem of the treatment techniques by taking advantage of an adsorbent's surface having an affinity for a particular molecular or ionic species coming into contact with it. A further benefit is that adsorption can be very simple and offers sludge free operation. The evaluation of activated carbon for color removal has been extensive and effluent treatment systems using activated carbon have been successful (Kadirvelu et al., 2005).

2.2 Textile Dyes (<http://www.pburch.net/dyeing/FAQ/typesofdyes.shtml>;
<http://www.pburch.net/dyeing/aboutdyes.shtml>)

Different types of fiber require different types of dyes. Cotton, rayon, linen, tencel, and hemp are all cellulose fibers, and thus require the same classes of dyes: fiber-reactive dyes, vat dyes, azoic or naphthol dyes, and direct dyes. Wool, mohair and angora are protein fibers, and require completely different dyes, the most important of which for the home dyer is the group called acid dyes. Silk is a special case because it can be dyed with fiber reactive dyes like cotton, or acid dyes like wool. Synthetic fibers use entirely different types of dye, depending on the type of synthetic fiber, in most cases, the home dyer will be better off using a high-quality fabric paint rather than dye on synthetic fibers.

2.2.1 Dyes for Cellulose Fibers

These are used to dye T-shirt. Cellulose fibers include cotton, linen, rayon, hemp, ramie and tencel. Fiber-reactive dye is one of the best choice for cellulose fibers. These dyes will handle just about any type of fabric along with paper, wood, and most natural substances. They are in powdered form, and depending on decision to apply them, they need to be mixed with soda ash and urea. The most popular way of using these dyes is by tub or vat dyeing.

Besides that, there are direct dyes which can also be called as hot water dyes or less washfast. They are azo dyes, and used with sodium salts, fixing agents and metallic (chrome and copper) compounds generally on cotton-wool, or cotton-silk combinations.

Vat dyes use a more complex method. These dyes are impregnated into fiber under reducing conditions and reoxidized to an insoluble color.

Naphthol dyes are less available because they are more hazardous and all purpose dyes (hot water dye, less washfast) are also dyes for cellulose fibers.

2.2.2 Dyes for Protein Fiber

Protein fibers include all fibers made by animals: wool, angora, mohair, cashmere as well as silk. Silk is the only non-hair animal fiber, and can be dyed like wool or like cellulose fibers. The high-pH recipes used for most cellulose dyes will ruin animal hair fibers. Dyes that can be used for protein fibers include acid dyes, natural dyes (these work better on wool than on cotton), lanaset or sabraset dyes and vat dyes.

Acid dyes are used for coloring animal fibers via acidified solution (containing sulfuric acid, acetic acid, sodium sulfate and surfactants) in combination with amphoteric protein. Acid dyes can also be used for food coloring. Besides that, acid dyes include shot dyes, reactive dyes and all purpose dyes.

'Soy silk' is a new plant fiber, but, because it is made from soybean protein, reportedly as a byproduct of the tofu industry, it should be dyed like animal fibers instead.

2.2.3 Dyes for Synthetic Fibers

There are some common synthetic fibers such as polyester, nylon, acetate, acrylic, ingeo and polypropylene. Dyes that normally use for these fabrics are disperse dyes and pigment dyes.

2.2.4 Dyeing Blends

Most cotton/polyester blends are best dyed as for cotton, using fiber reactive dyes, leaving the polyester undyed. Cotton or nylon blends may be dyed with all-purpose

dye, first with soda ash at room temperature to dye the cotton and then in hot water with vinegar to dye the nylon.

2.2.5 Fabric Paints

Pigments that are not naturally attracted to fibers may be mixed with a glue-like binder to attach them to the fiber. "Pigment dyes" are not dyes at all, but a type of fabric paint.

2.3 Pollution by Textile Wastewater

Color removal from textile wastewater has been the target of great attention in the last few years not only because of its toxicity but mainly due to its visibility (ICI Watercare, 1991). When improperly handled and disposed of textile wastewater imperils both human health and the environment. Human exposures (occupational and non-occupational) to textile wastewater have led to health effects ranging from headaches, nausea, lung and skin irritations, to serious ailments like congenital malformations (Goldman et al., 1985, Griffith et al., 1989, Shinka et al., 1991, Morikawa et al., 1997).

The textile industry is very chemical-intensive and wastewater from textile-processing contains huge residues from different textile dyeing and finishing operations (Easton, 1995). Of particular concern are dyestuffs which are often major sources of heavy metals, salt, adsorbable organic halogens (AOX) and colour in dyehouse effluent (Reife, 1993, Smith, 1996), sizing agents which have high BOD and COD levels, and anionic/non-ionic surfactants most of which are still of poorly biodegradable nature (Vandevivere et al., 1998). Other potential sources of "recalcitrance" and toxicity in dyehouse effluent are different types of speciality chemicals that are applied to impart the finished product with

specific properties or to facilitate certain process stages in the production line. Though less attention has been paid to their fate and toxicity until only recently, dye carriers and antimicrobial finishing agents (biocides) have both been identified as one of the major groups of pollutants in dyehouse effluent (Park and Shore, 1984), and their characterization and proper management is becoming a challenging responsibility for the textile manufacturer (US E. P. A., 1997b).

2.4 Treatment of Dye Wastewater

Both coagulation and adsorption processes have individually proven to be highly effective in the decolourization (Vandevivere et al., 1998, Choy et al., 1999, Sankar et al., 1999, Papic et al., 2000, Robinson et al., 2001, Kim et al., 2004, Papic et al., 2004). However, the reported performances of the processes have varied depending on the nature of dye, adsorbent or coagulant used and the operation conditions. Recently, it is becoming more and more evident that the use of combined processes is able to overcome the disadvantages of individual unit operations and enhance the overall treatment performance (Kim et al., 2003 Papic et al., 2004).

Jar-test is one of the conventional ways to carry out the process of coagulation and flocculation in the laboratory. In order to determine the optimum dosages and the pH condition, Golob et al., (2005) carried out jar-tests at various reaction conditions (concentration of coagulant 0.01-0.4 g/L, concentration of flocculant 1-5 mL/L, pH 6-9). All solutions were stirred for 2 min at 100 rpm and after the coagulant (alum) and flocculant was added, it was stirred for 20 min at 20 rpm, and then 30-150 min was allowed for settling. The pH value was adjusted to the desired value with acid or alkali

before the coagulant and flocculant was added. The supernatant was separated from the precipitate by filtration through a filter paper or through a sand filter (Golob et al., 2005).

Amongst the numerous techniques of dye removal, adsorption is the procedure of choice and gives the best result as it can be used to remove different types of coloring materials (Derbyshire et al., 2001, Ho et al., 2003, Jain et al., 2003). Several researchers have studied the use of alternative materials that, although less efficient, involve lower costs. Among the studied alternative materials are agricultural, forest and animal by-products such as peat (Coupal et al., 1976), wheat bran, sawdust, tree barks (Michelsen et al., 1992), chitin and others (Laszlo, 1994) and cellulose fibers of eucalyptus bark (Morais et al., 1998).

The effectiveness of combined processes of adsorption and coagulation for complete removal of dyes has been investigated. The right sequence of operation was identified for the combined treatment system. Coagulation followed by adsorption was found to be more efficient than having adsorption prior to coagulation. There was a significant increase in adsorption capacity of powdered activated carbon for the combined process where coagulation was carried out prior to adsorption. The combined coagulation-adsorption process has the capability of complete dye removal and thus total decolourization, reduction in coagulant and adsorbent amounts and thereby produce less amount of sludge (Lee et al., 2005).

2.5 Coagulation and Flocculation

Processes of coagulation and flocculation are the conventional methods used to treat water and wastewater. In most of the treatment operation, these two processes are employed to separate colloidal suspended solids from wastewater. These two terms of

coagulation and flocculation are often used interchangeably, in fact they are two different processes.

Finely dispersed solids (colloids) suspended in water are stabilized by negative electric charges on the surface, and this may cause them to push each other. This phenomena prevents the colloids from colliding to form a larger masses or flocs. To form flocs that can settle faster and to assists in the removal of colloidal particles from suspension, chemical coagulation and flocculation are required. As mentioned, these processes are normally done in sequence because they are a combination of physical and chemical reactions. Coagulant as chemical are mixed with wastewater to promote the aggregation of the colloids into larger particles which could settle easily.

Coagulation is the process that neutralize the force which keeps the colloids apart. Coagulant with cation (cationic coagulant) provide positive charge to reduce the negative charges (zeta potential) of the colloids. To disperse the coagulants throughout the water, a rapid mixing phase is required while running the jar test. Meanwhile, coagulants should not be overdosed because this can cause a complete charge reversal and re-stabilize the colloids.

Flocculation is the action of chemicals to form bridges between the flocs and combine the particles into large agglomerates or clumps. Bridging is the process that occurs when segments of the polymer chain adsorb on different particles and help particles aggregate. In the process of flocculation, anionic chemical (flocculant) will react with positively charged particles, adsorbing on the particles and causing destabilization either by bridging or charge neutralization. In this process, it is essential that the flocculating agent be added by slow and gentle mixing to allow for contact between the small flocs and to agglomerate them into larger particles. The newly formed particles are weak and might

break up easily by the shear force while mixing by paddles. Therefore, the chemical used for flocculation should not be overdosed and if done so, problems of settling or clarification will occur. This is because the anionic chemical themselves are lighter than water and if the dosage is increased, the tendency of the floc to float will increase and will lead the floc continuing to float without settling. If the used dosage is just adequate, the suspended particles will flocculate into larger size, they can easily be removed from water by floatation and/or sedimentation, provided that a sufficient density difference exists between the flocculated particles and the water. The addition of a flocculant may not be needed since the particles formed by the coagulation reaction maybe sufficiently destabilized or of sufficient size to allow removal. The flocculation reaction affects the physical nature of the floc, making these particles less gelatinous, thereby easier to dewater and also increases the size of the floc particles to settle them faster (Peavy et al., 1985).

2.6 Mechanism of Coagulation and Flocculation

The mechanisms of coagulation include adsorption and charge neutralization, interparticle bridging, ionic layer compression and adsorption and entrapment in a flocculent mass (sweep coagulation).

For some particles, terminal settling velocities are very low due to their fine sizes. This shows that plain sedimentation may not be efficient in removing fine suspended particles. To speed up the settling velocities, the effective size of these particles should be increased. Agglomeration of particles into groups is the only way to increase the particles size. However, some particles have shown the properties that prevent agglomeration and they are known as stable when the particles do not agglomerate naturally. The stability of the colloidal suspensions depends on the large surface to volume ratio resulting from their

small size. The surface phenomena predominate over mass phenomenon. The accumulation of electrical charges at the particle surface is the most important surface phenomenon. In most surface waters, the colloidal particle is negatively charged.

Colloid will affect the ions contained in the water around the colloid. Colloids with negative charge naturally attract the positively charged ions each other as shown in Figure 2.1. A layer of cations will form around the colloid and will stick together. Other ions in the vicinity of the colloid arrange themselves as shown, with greater concentration of positive, or counter ions being closer to the colloidal surface. A net charge will produce from the arrangement procedures. The net charge should be strongest at the bound layer and will decrease exponentially with distance from the colloid (Peavy et al., 1985).

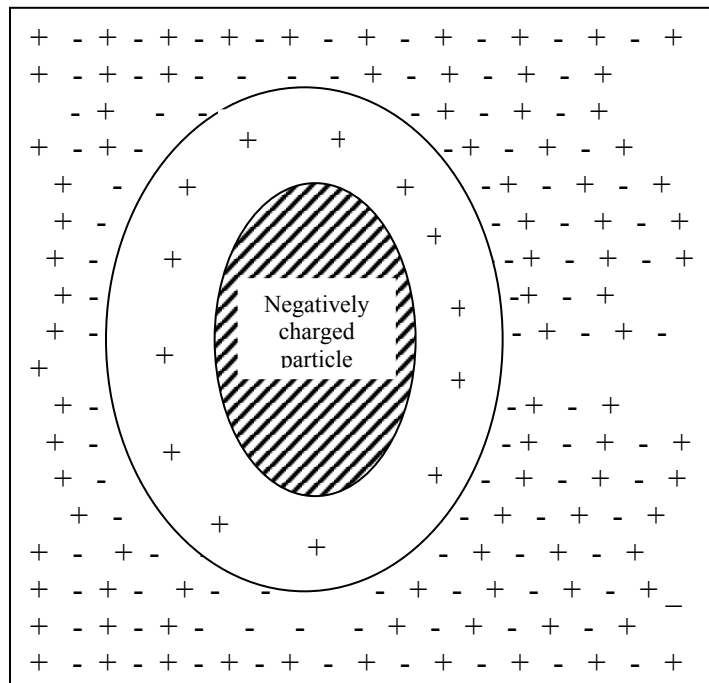


Figure 2.1 A negatively charged colloid with a possible configuration of ions around it.

When two colloids come close to each other, actually two forces are acting on them. The first force called the van der Waals force is an attraction force and is inversely proportional to the sixth power of the distance between particles. It also decays exponentially with distance. The second is the electrostatic potential which is created by the “halo” of counter ions surrounding each colloid and reacts to repulse the particles. However, van der Waals force decreases more rapidly than the electrostatic force, but it is strong at closer distances. The sum of the two forces, the net force, as they relate to one colloid in close proximity to another, is repulsive at greater distances and becomes attractive only after passing through a maximum net repulsive force, called the energy barrier at some distance x between the colloids (Figure 2.2). The energy barrier needs to be overcome for agglomeration to occur. For colloidal particles to overcome the energy barrier, Brownian motion may provide enough momentum. To move the larger particles across the energy barrier, mechanical agitation of the water may impart enough momentum to them. These processes are too slow and neither results in agglomeration of medium-sized colloids. The colloids are chemically coagulated into clusters, or flocs, which are large enough to be removed by settling. The accomplishment of chemical coagulation is normally done by adding some trivalent metallic salts such as aluminium sulphate or ferric chloride (Peavy et al., 1985).

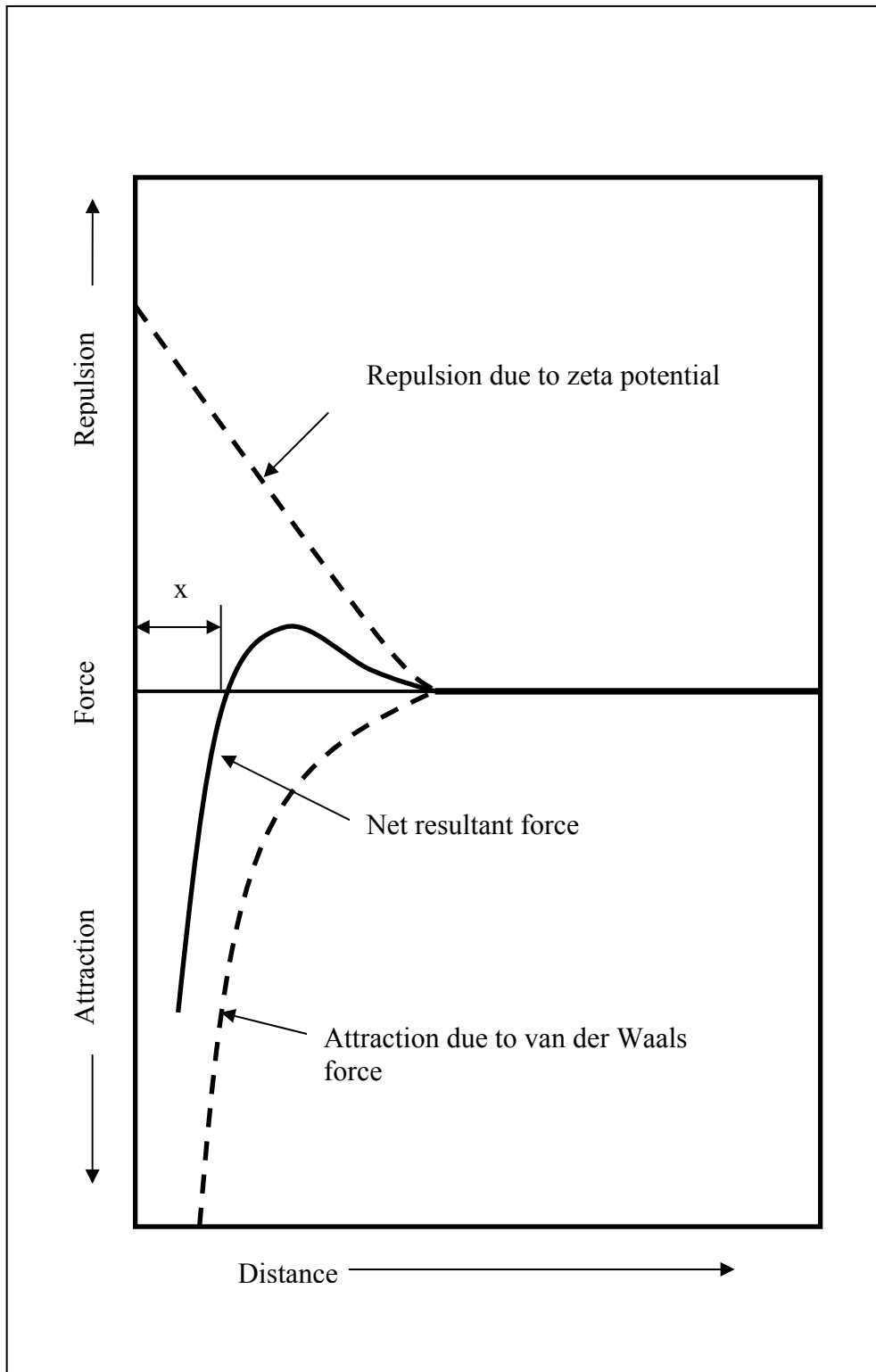
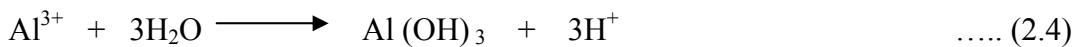
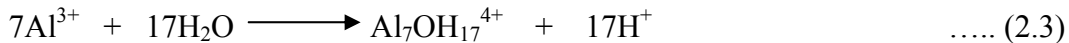


Figure 2.2 Colloidal interparticulate forces versus distance

2.6.1 Adsorption and Charge Neutralization

Aluminium sulphate will ionize and form sulphate ions (SO_4^{2-}) and aluminium cations (Al^{3+}) when mixed with water. Al^{3+} cations will react with water and form a variety of aquometallic ions and hydrogen.



The aquometallic ions become a part of the ionic cloud surrounding the colloid and because they have a great affinity for surfaces, they are adsorbed to the surface of the colloid to neutralize the surface charge. The ionic cloud disappears and the electrostatic potential dissipates once the surface charge has been neutralized. Overdosing with coagulant can re-stabilize the suspension if enough of ions formed are adsorbed, the charges on the particles become reversed and the ionic clouds reform, with negative ions being the counter ions.

2.6.2 Interparticle Bridging

When aluminium or ferric salts dissociate in water, large molecules may be formed. Instead of or in addition to metallic coagulants, synthetic polymers (polyelectrolyte) also may be used. The polymers might be linear or branched and are highly surface reactive. Thus, several colloids may become attached to one polymer and several of the polymer-colloid groups may become enmeshed, resulting in a settleable mass. In addition to the adsorption forces, charges on the polymer may assist in the coagulation process. Synthetic polymers may carry positive or negative charges or may be

neutral, while metallic polymers formed by the addition of aluminium or ferric salts are positively charge.

2.6.3 Ionic Layer Compression

In water, ions have an effect on the decay function of the electrostatic potential. A high ionic concentration compresses the layers composed predominantly of counter ions toward the surface of the colloid. No energy barrier will exist if the layer is sufficiently compressed, the van der Waals force will predominate and the net force will be attractive. However, the coagulant would not be able to increase the ionic concentration sufficiently to affect ionic layer compression at the concentration that is normally used in water treatment.

2.6.4 Sweep Coagulation

Aluminum hydroxide $[Al(OH)_3]$ will be formed as last product of the hydrolysis. It forms in amorphous, gelatinous flocs that are heavier than water and settle by gravity. Colloids may become entrapped in a floc as it is formed or enmeshed by its sticky surface as the flocs settle. Thus, the colloids are swept away from the suspension (Peavy et al., 1985).

2.7 Activated Carbon as Adsorbent

There are many conventional treatment technologies available for the removal of dye from water including biological and chemical oxidation, chemical coagulation, foam flotation, electrolysis, biodegradation, advanced oxidation, photocatalysis and adsorption. Due to the complex structure, molecular size and nature, conventional biological processes

are less efficient in degrading synthetic dyes. The cell uptake was shown to be inversely proportional to the number of sulfonate groups. Advanced oxidation processes ($\text{H}_2\text{O}_2/\text{UV}$, O_3) have the potential to eliminate organic carbons in wastewater; however, they are too expensive and complex apart from being effective only for very low concentrations of organic dye wastes. Both coagulation and adsorption processes have individually proven to be highly effective in the decolourization. The reported performances of the processes have varied depending on the nature of dye, absorbent or coagulant used and the operation conditions. (Lee et al., 2005).

The advantages of adsorption process are the amount of sludge produced is lesser than other method and complete removal of dyes even from dilute solutions. Activated carbon is the most widely used absorbent. The wide usefulness of activated carbon is a result of its chemical and mechanical stability, high adsorption capacity and high degree of surface reactivity (Attia et al., 2004). Besides that, adsorption is considered an attractive option in treating such wastewaters. Absorbent-grade activated carbon is cost-prohibitive and both regeneration and disposal of the used carbon are often very difficult. Consequently, many investigators have studied the feasibility of using low cost substances (Mall et al., 1996).

Adsorption methods have been invariably successful to decolourise textile effluents, but this application is limited by the high cost of adsorbents. The carbon derived from agricultural wastes is gaining importance as it is inexpensive and perfectly suitable for the removal of organic and inorganic contaminants from wastewater. Some of the materials used with varying success include saw dust, rice husk, rice shells, peanut shells, cotton seed shell, myrobalan, rubber seed coat, cashewnut sheath, palm seed coat, palm

tree flower, pongam seed coat, cornelian cherry, apricot stone, almond shell, oak wood waste, corn hulls, corn stover and cotton stalks (Santhy et al., 2005).

Once the dye has contaminated the water, it is not easy to remove by using the conventional wastewater treatment methods. The problem are due to some dyes are stable to light and oxidizing agents, and are resistant to aerobic bio-oxidation.

The removal of dyes in an economical fashion remains an important problem. Adsorption has been shown to be a good method of color contaminant removal. It overcomes the problem of the treatment techniques by taking advantage of an adsorbent's surface having an affinity for a particular molecular or ionic species coming into contact with it. A further benefit is that adsorption can be very simple and offers sludge free operation. The evaluation of activated carbon for color removal has been extensive and effluent treatment systems using activated carbon have been successful (Kadirvelu et al., 2005).

Full decolourization is not possible by the process of coagulation-flocculation. The limitations of coagulation-flocculation are that it is not always effective and there are problems associated with sludge disposal. Thus, interest in coagulant recovery stems not only from the potential savings in chemical costs but also from substantial reductions in sludge volume. Some research has been conducted to show the feasibility of recycling the coagulants. Recently, there are some research on the removal of reactive dyes from wastewater by the combination of Al(III) coagulation and activated carbon adsorption. Although some low cost absorbent like those obtained from waste materials have an economic advantage, the effectiveness are much less than activated carbon. On the other hand, the purpose of combining both coagulation and adsorption processes is to lower the coagulant consumption using activated carbon and to achieve complete dye removal. This

approach offers a simple and economic “end-of-pipe” solution to the challenges set by new legislation covering dye wastewater discharges (Papić et al., 2004).

For example, the problem of colour removal from textile wastewater has been considered in Egypt in recent years to be of great importance because of the need to satisfy the increasing demand of water. Due to this, a national effort has been launched to deal with this problem using natural, local absorbents. Market research have been undertaken to determine whether cheap commercially available materials hold promise in the treatment of wastewater. In spite of the presence of a huge number of dyestuffs which are widely used in dyeing processes, little data are available on the removal of these dyes from textile effluents. In industrial wastewater, adsorption is used to remove organic materials such as color, phenols, detergents and other toxic or non biodegradable. The cost of powdered activated carbon (PAC) itself is the most important component to consider, therefore, searching for cheap sources or substitute with PAC is a must (Al-Sarawy et al., 2005).

CHAPTER 3

METHODOLOGY

3.1 General

The flowchart below shows the summarized methodology for this project.

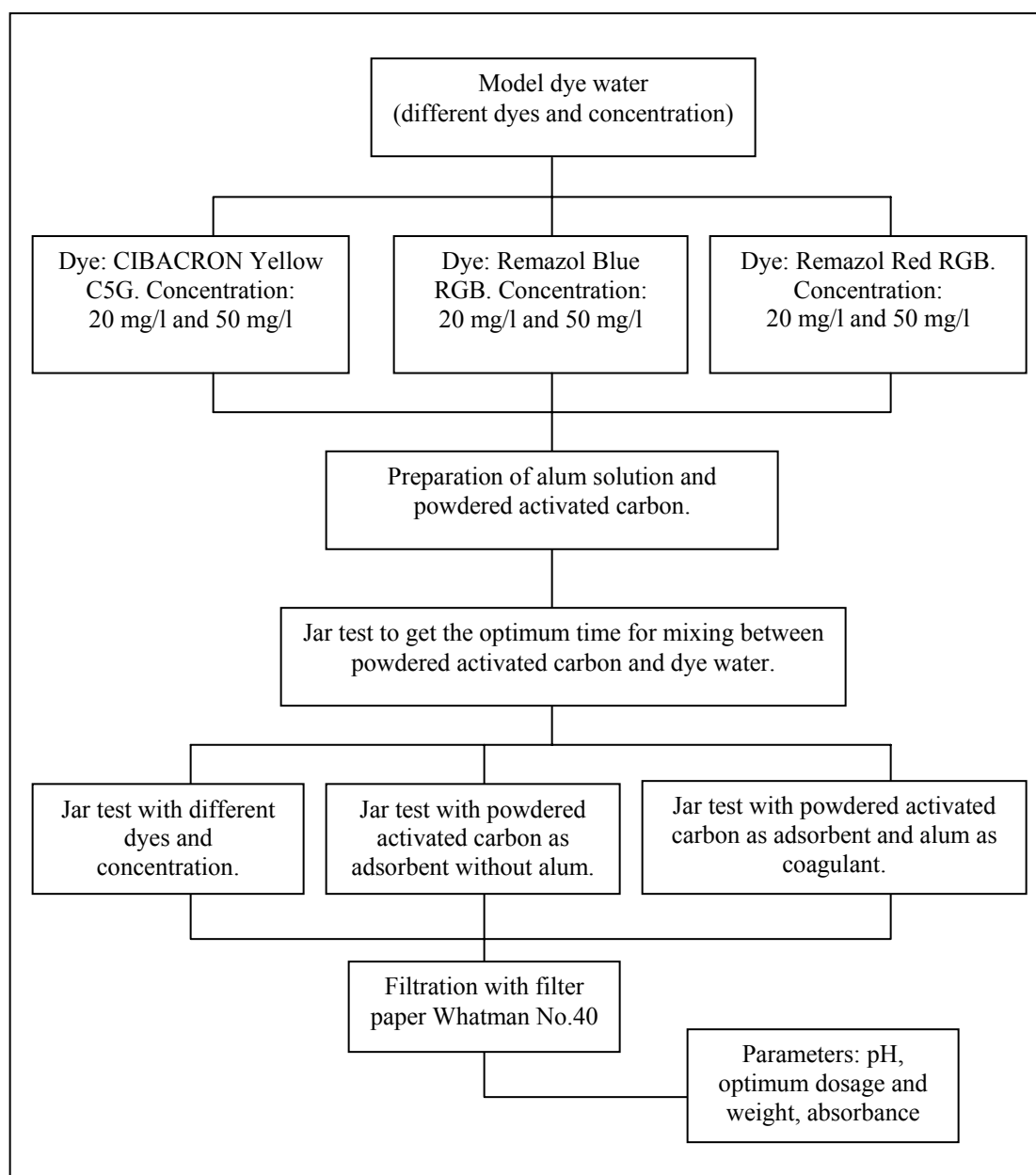


Figure 3.1 Flowchart for the adsorption coagulation test

3.2 Preparation Phase

As starting point for this project, desk study is very important and it is the first step to gather basic idea. Through some related journals, it is useful in completing the literature review. Through the literature review, the overall idea of this project is known and this contributed to successful laboratory work. Besides that, there are also several preparation needed before continuing the other phases.

3.3 Material Used

There are two main manufactured materials used in this lab test. There are plenty of types of dye and most of them come in liquid or powder form. In this project, dyes with code CIBACRON Yellow C5G, Remazol Blue RGB and Remazol Red RGB from Ciba Specialty Chemicals were used. These dyes are soluble in water and sensitive to heat (40 °C).

Another material used for adsorption is powdered activated carbon. The powder is manufactured by Century Chemical Works and given name Malbon R4. Malbon activated carbon is produced through steam activation, using carefully selected sawdust charcoal from various tropical wood species as the base material. Several advantages such as flexibility and economy are apparent in Malbon activated carbon. Besides that, it provided effective purification in terms of removing unwanted colours, odour or other impurities from liquids or solutions. Therefore, it is suitable for use as adsorbent in commercial treatment plan.

The dye water sample used in the laboratory test is prepared with known concentration. In this test, 10 g/l for all three types of dye solution were prepared and stored in a refrigerator. 2.5 gram of dye powder was weighed and poured into a 250 ml

volumetric flask. . Distilled water was added for about half of the volume of the volumetric flask and well shaken. Additional distilled water was added exactly up to the mark of 250 ml. The dyes were soluble in water. Therefore, settlement should not occur during the storage period. The advantages of this preparation are minimizing the errors during weighing and time saving. With this solution, every 1 ml consisted of 10 mg of pure dye. Therefore, work became easier in preparing the others concentration of dye solution.

Aluminium sulphate also well known as alum is widely used as coagulant in most of the existing treatment plant. Solution with the concentration 10 g/l was prepared and stored in a reagent bottle. 5 gram of alum was weighed and poured into the 500 ml volumetric flask. Distilled water was added for about half of the volume of the volumetric flask and well shaken. Additional distilled water was added exactly up to the mark of 500 ml.

3.4 Jar Test

Jar test is the most widely use method for evaluating and optimizing the coagulation-flocculation processes (Kawamura 1991). This test involved rapid mixing, slow mixing and sedimentation. Glass beakers of 1 liter capacity, filled with the model dye water were used. The apparatus allowed six beakers to be agitated simultaneously, and rotational speed could be varied between 0 and 350 rotations per minute (RPM). A jar test simulates the coagulation and flocculation processes that encourage the removal of suspended colloids and organic matter which can lead to turbidity, absorbance, odor and taste problems.

The jar tester (Figure 3.2) made with six paddles to stir the solutions of six 1 liter beakers. The first beaker from left acts as a control while the operating conditions can be

varied among the other five beakers. Mixing speed in all of the beakers was controlled by an RPM gauge set at the right of the device.



Figure 3.2 Jar Tester model CZ150

All six beakers were started with rapid mixing at 350 RPM and different quantities of Malbon R4 and this mixing lasted for not more than 5 minutes and timed with a stopwatch. This was followed by another rapid mixing with different alum dosages into each beaker. The duration of this rapid mixing was timed with a stopwatch. After rapid mixing, the slow mixing was quickly established and its duration was again timed with the stopwatch. After slow mixing, all six paddles were pulled up carefully and beakers were let for the sedimentation. In this test, the intensity and duration of second rapid mixing were fixed respectively at 350 RPM for 1 minute and 50 RPM for 20 minutes in the case of slow