EXTRACTION, CHARACTERIZATION AND APPLICATION OF CELLULOSE FROM PANDAN LEAVES AS GRAFTED FLOCCULANT FOR DYES TREATMENT

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Chemical)

Faculty of Chemical Engineering
Universiti Teknologi Malaysia

JANUARY 2014

This project I dedicated to my beloved mother, siblings, lecturers and fellow friends. Thanks for your support and prayers. Without all of you I will never be able to finish this project.

ACKNOWLEDGEMENTS

All praises to Allah swt for His blessings of health and opportunity given by Him to gain this treasure of knowledge. Challenges and experiences that I obtained during the entire process in order to accomplish this project have been valuable for me. Therefore, I would like to express my thanks and gratitude to all people that have been giving their assistance and supports throughout the completion of this project.

Firstly, I would like to grant my thanks and deep appreciation to my supervisor, Dr. Norzita binti Ngadi, for her constant advices, ideas, guidance and patient throughout the duration of my project. Besides that, I also would like to thank my co supervisor Assc. Prof. Dr. Ida Idayu binti Muhamad for sharing her knowledge, expertise and motivation.

I also want to express my thanks to the entire laboratory technician for his kind assistance and cooperation during the experiment.

I would like to express thousands appreciation to my beloved mother who always be there for me. Only Allah can repay you.

Lastly, to all my fellow friends and anyone who directly or indirectly contribute to this project, I really appreciate your support.
Thank you.

ABSTRACT

A new polyacrylamide grafted cellulose (PAM-g-cellulose) was successfully synthesised by using microwave assisted synthesis method. Cellulose was extracted from Pandan leaves by carrying out alkali and bleaching treatments. The determination of chemical composition was done which covers the percentage of lignin, hemicellulose and cellulose. Analysis of Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD) and Thermogravimetric (TGA) were conducted to the raw Pandan leaves and extracted cellulose. For grafting synthesis study, the highest grafting percentage was achieved at 170%. The best grafted sample (i.e. highest percentage) then was characterized using SEM and FTIR. The PAM was successfully grafted onto the backbone of cellulose as confirmed by SEM and FTIR results. The grafting mechanism involved a synergism of microwave radiation and ceric ammonium nitrate (CAN) as chemical free radical initiator to initiate the free radical grafting reaction. The flocculation studies of the developed grafted copolymers have been evaluated in synthetic dye (Reactive Black 5 (RB5)) suspension. Response surface methodology (RSM) and Box-Behnken design (BBD) were employed to explore the relationship of process variables (i.e. initial dye concentration, flocculant dosage and pH) on percentage reduction of initial dye concentration and COD level of RB5 dye as well as to find the optimum process condition. The flocculant dosage and pH were the most significant factors in affecting the degree of flocculation efficiency. The optimum condition for reduction of initial dye concentration and COD were achieved at initial dye concentration of 0.03 g/l, flocculant dosage of 0.06 g and pH 11.72. Under this condition, the reduction of initial dye concentration and COD were 23.51% and 54.24%, respectively.

ABSTRAK

Gabungan antara poliakrilamida dan selulosa (PAM-g-selulosa) telah berjaya disintesis dengan menggunakan kaedah yang dibantu oleh gelombang mikro. Selulosa telah diekstrak dari daun Pandan melalui rawatan alkali dan pelunturan. Komposisi kimia telah ditentukan yang merangkumi peratusan lignin, hemiselulosa dan selulosa. Analisis Pengimbas Mikroskop Elektron (SEM), Jelmaan Fourier Spektroskopi Inframerah (FTIR), Pembelauan X-Ray (XRD) dan Termogravimetri (TGA) telah dijalankan terhadap daun Pandan dan selulosa yang telah diekstrak. Di dalam kajian mengenai sintesis gabungan, peratusan gabungan tertinggi dicapai adalah sebanyak 170%. Sampel gabungan yang terbaik (i.e. peratusan tertinggi) kemudian telah dicirikan menggunakan SEM dan FTIR. PAM telah berjaya digabungkan dengan selulosa seperti yang telah dibuktikan oleh keputusan SEM dan FTIR. Mekanisma gabungan melibatkan sinaran gelombang mikro dan serium ammonium nitrat (CAN) sebagai bahan kimia radikal bebas untuk memulakan tindakbalas gabungan. Gabungan yang terhasil ditunjukkan oleh SEM dan FTIR di mana kedua-duanya menunjukkan perubahan pada mikrograf dan spektra. Kajian pengelompokan telah dijalankan terhadap pewarna sintetik (Reactive Black 5 (RB5)). Kaedah respon permukaan (RSM) dan reka bentuk Box-Behnken (BBD) telah digunakan untuk mengkaji hubungan antara pembolehubah (kepekatan awal pewarna, dos flokulan dan pH) dengan peratusan penurunan kepekatan awal pewarna dan tahap COD pewarna RB5 serta untuk mencari keadaan optimum proses. Dos flokulan dan pH adalah faktor yang paling penting dalam mempengaruhi tahap kecekapan pengelompokan. Keadaan optimum untuk mengurangkan kepekatan awal pewarna dan COD dicapai apabila kepekatan awal pewarna adalah sebanyak 0.03 g/l, dos flokulan sebanyak 0.06 g dan pH 11.72. Dalam keadaan ini, pengurangan kepekatan awal pewarna dan COD adalah masing-masing 23.51% dan 54.24%.

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LIST OF ABBREVIATIONS

AM	-	Acrylamide
Ag	-	Agar
ANOVA	-	Analysis of variance
AGU	-	Anhydroglucose
AOX	-	Alternative oxidase
BBD	-	Box-behnken design
BOD	-	Biological oxygen demand
CAN	-	Ceric ammonium nitrate
CCD	-	Central composite design
CMG	-	Carboxymethyl guar gum
CMS	-	Carboxymethylstarch
COD	-	Chemical oxygen demand
C.I.	-	Colour index
DF	-	Degree of freedom
EFB	-	Empty fruit bunch
EDA	-	Ethylene diamine
FTIR	-	Fourier transform infrared
g	-	Graft
GGI	-	Gum ghatti
H_2O_2	-	Hydrogen peroxide
Hyd.	-	Hydrolyzed
O_3	-	Ozone
MnO_4	-	Permanganate

PAM	-	Polyacrylamide
PAC	-	Poly (aluminium chloride)
Psy	-	Psyllium
RB5	-	Reactive black 5
RBF	-	Round bottom flask
RSM	-	Response surface methodology
SEM	-	Scanning electron microscopy
SAG	-	Sodium alginate
$NaClO_2$	-	Sodium chlorite
NaOH	-	Sodium hydroxide
NaOCl	-	Sodium hypochloride
St	-	Starch
TAM	-	Tamarindus indica mucilage
TAPPI	-	Technical Association of Pulp and Paper Industry
TDS	-	Total Dissolve solid
TGA	-	Thermogravimetric analysis
TSS	-	Total Suspended solid
TKP	-	Tamarind kernel polysaccharide
UV/Vis		Ultraviolet-visible
XRD		X-ray diffraction

LIST OF SYMBOLS

θ	-	Angle
%G	-	Grafting percentage
$-SO_2-CH_2CH_2-SO_3-$	-	Sulphatoethylsulphone
-N=N-	-	Two nitrogen atoms
λ	-	Wavelength

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Textile industry is one of the largest water and chemicals consumer industries in Malaysia (Kumar *et al*., 2011; Subki and Hashim, 2011). Textile industry in Malaysia is concentrated mainly in the states of Johor, Penang and Selangor (Muyibi *et al*., 2008). Generally, textile wastewater is characterized with high in colour, biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolve solid (TDS), total suspended solid (TSS), pH and temperature (Oke *et al*., 2006). Although most of the textile factories are equipped with treatment facilities, the problems still persist since all the available treatment methods have own positive k4and negative aspects. Reife and Freeman (1996) stated that, the details of the wastewater characterization are important step in selecting wastewater treatment methodologies.

The discharge of textile wastewater contains various pollutants such as sulphur, salts, toxicants, degradable organics and colour. These pollutants are generated during various stages of textile manufacturing process. The processes include, desizing, scouring, bleaching, mercerizing, dying, printing and finishing (Verma *et al*., 2012). These processes led to the alteration of chemical structure in the discharge effluents which then result in the toxicity of the wastewater (Koyuncu, 2003; Ahmad and Puasa, 2007).

The important material used in textile industry is dyes. Dyes are materials that impart appearance of the fabrics. Dyes give a good attraction to the fabrics through the colours that being created. At the same time, dyes are the biggest contributor of the highly toxic discharge of textile wastewater. This important material further is in charge of all the characteristics of textile wastewater. Dyes can give a high negative impact towards textile wastewater characteristics such as chemical oxygen demand (COD), suspended solids, colour and pH. Those characteristics are significant in evaluating textile wastewater quality (Chung *et al*., 1992; Tufekcu *et al*., 2007; Saratale *et al*., 2011). Dyes are considered as xenobiotic compounds that are very recalcitrant to biodegradation. Besides that, the absorption of light due to textile dyes creates problem to photosynthetic aquatic plants and algae. The reduction of photosynthesis deteriorates the water quality and lowers the gas solubility mainly in aqueous ecosystem (Anjaneyulu *et al*., 2005; Saeed *et al*., 2010).

There are several technologies that have been developed in solving textile wastewater problems. The technologies include physical, chemical and biological treatment methods. However, the requirements for every treatment process are for it to be efficient, simple, low cost and environmentally friendly. Therefore, every limitation of the readily available processes is extensively worked on in order to provide some improvement. There are various continuing researches carried out to develop new technologies of textile wastewater.

1.2 Problem Statement

Textile wastewater contains a wide range of dyes which give rise to serious problems to the environment and human life. Dyes contribute to the negative characteristics of textile wastewater such as high in BOD, COD, colour, TSS and etc. Among all dyes treatment in textile wastewater such as adsorption, oxidation, coagulation and/or flocculation, biosorption and membrane technologies, flocculation process is in demand because of its effectiveness and economical characteristics.

In flocculation process, flocculant is the important chemical used to increase the flocculation efficiency. There are two categories of flocculants which are inorganic and polymeric. Inorganic flocculants are needed in large dosage and thus the production of sludge is high. In comparison, polymeric flocculants are extensively used because the dosage and the production of sludge are less than inorganic flocculant.

Apart from that, polymeric flocculants can be further classified into natural and synthetic. Natural flocculants are low in cost and have good biodegradability. However, the biodegradability of these flocculants limits their storage life and flocculation performance. Synthetic flocculants on the other hand, has high efficiency in flocculation process. But still, the biggest limitations of these flocculants are on their shear degradability that can be considered to be hazardous to the environment and human health.

Another class of polymeric flocculants which are grafted copolymers flocculant have been synthesized by a number of researchers, which combine the advantages between natural and synthetic flocculants. Besides that, the disadvantages of both types can be diminished or fully terminated. Grafted copolymers flocculant has been claimed that can increase the flocculation efficiency besides being professed as eco-friendly flocculant technology.

This flocculant has been studied by many researchers by means of finding the best grafted flocculant in order to solve wastewater problems. The findings were led to various treatment performances. The performance was based on the type of the wastewater and also the materials used (natural and synthetic) to synthesize the grafted flocculant. Therefore, it is necessary to choose the suitable materials to achieve a good flocculation performance.

This study was aimed to synthesize a new grafted copolymers flocculant with high flocculation efficiency in treating textile wastewater. The flocculant was synthesized by grafting cellulose derived from Pandan leaves and polyacrylamide (PAM). Cellulose has been extracted from several other sources. Extracted cellulose from Pandan leaves was targeted as excellent natural polymer to be grafted with PAM. The effectiveness of this synthesized flocculant was investigated for the first time in treating Reactive Black 5 (RB5) dye. The flocculation efficiency was defined through percentage reduction of initial dye concentration and COD level.

1.3 Hypothesis

The hypothesis for this research is that new grafted copolymers flocculant is more superior compared to inorganic flocculants and solely natural and synthetic polymeric flocculants in treating textile wastewater. This grafted copolymers flocculant has the advantages from both natural and synthetic polymer flocculants because of the extent of the attachment of both materials onto their backbone. Moreover, the findings will provide an alternative for a low cost, environmentally friendly textile wastewater treatment.

1.4 Objectives

This study aims to achieve the following objectives:

i. To extract cellulose from Pandan leaves (*Pandanus amaryllifolius* Roxb.)
ii. To synthesize and characterize the polyacrylamide grafted cellulose (PAM-g-cellulose)
iii. To investigate the effectiveness of synthesized polyacrylamide grafted cellulose (PAM-g-cellulose) as a flocculant for Reactive Black 5 (RB5) dye in textile wastewater

1.5 Scope

In order to achieve the objectives, specific scopes have been set which limit the range of the study. This study was firstly, emphasized on extraction of cellulose from Pandan leaves (*Pandanus amaryllifolius* Roxb.). The cellulose was extracted using chemical treatment method which was alkali treatment and bleaching. After that, the extracted Pandan leaves were characterized by means of chemical composition (using TAPPI method), morphology (using SEM analysis), functional group (using FTIR spectroscopy analysis), crystalinity (using XRD analysis) and thermal stability (using TGA).

The second part of the study covers the synthesis of grafted copolymers flocculant. This part was carried out by grafting the polyacrylamide (PAM) with the extracted cellulose using microwave assisted method. The best grade of grafted copolymers (higher percentage grafting (%G)) then was characterized using SEM analysis and FTIR spectroscopy. Further, the mechanism of the developed flocculant was also investigated in this study.

The performance of the grafted copolymers (PAM-g-cellulose) as a flocculant was tested in flocculation process using a standard jar test. For jar test conditions, the mixing rate was fixed at 200 rpm for rapid mixing (3 minutes) and 30 rpm for slow mixing (30 minutes). The supernatant after the flocculation process was allowed to settle for 30 minutes. Three independent variables including initial dye concentration (g/l), flocculant dosage (g) and pH of the wastewater were used. The numerical values for all three variables have been specified through response surface methodology (RSM) method.

In order to produce the experimental design specifying all conditions, STATISTICA software version 8.0 was used. The range for the initial dye concentration is 0.025 to 0.1g/l, 0.02 to 0.1g for dosage of flocculant and 3 to 11 for pH. The fixed conditions and the ranges were selected according to the preliminary studies done and from several literature reviews from previous works. The treated wastewater was analyzed for percentage reduction of initial dye concentration and chemical oxygen demand (COD). To distinguish the superiority of the grafted copolymers flocculant, the test was also performed using solely Polyacrylamide (PAM) and cellulose extract using the obtained optimum conditions from RSM.

1.6 Significance of Study

There are several reasons for the execution of this research. Firstly, the selection for Pandan leaves (*Pandanus amaryllifolius* Roxb.) is due to its availability (especially in Malaysia), low cost of materials and simplicity in handling. In Malaysia, the interests in Pandan leaves are only focused to food additives and food colorant. The potential of Pandan leaves as a flocculant has never been explored by any researcher. Besides that, the study of cellulose extracted from Pandan leaves also has not been conducted yet.

In recent years, considerable attention has been paid on the synthesis of grafted copolymers that combines the advantages of both natural and synthetic polymers. Thus, a great number of graft copolymers has been synthesized by grafting synthetic polymers, mainly, flexible chain of polyacrylamide (PAM) on some natural polymers backbone, such as gum guar (Wang *et al*, 2007), starch (Chang *et al*, 2008), konjac glucomannan (Tian and Xie, 2008), chitosan (Zhang *et al*., 2010), carboxymethylstarch (Sen, *et al*, 2009) and tamarind kernel (Ghosh *et al*, 2010).

However, there is no work been reported on the grafting of synthetic polymers (i.e. polyacrylamide) onto cellulose extract from Pandan leaves (*Pandanus amaryllifolius* Roxb.) to date. Moreover, cellulose extract from Pandan leaves grafted with synthetic polymers has never been used as a flocculant to treat any type of wastewater. In addition, a new alternative of grafted copolymers flocculant to treat wastewater was developed through this study.

1.7 Thesis Outline

There are 5 chapters in this thesis and each chapter describes the sequence of this research.

Chapter 1 presents brief overview of wastewater from textile industry and common method used to treat wastewater from textile industry. This chapter also presents the problem statement, hypothesis, research objectives, scopes of the study and the significance of the study.

Chapter 2 covers the deep view of related knowledge about textile industry wastewater, dyes and the available treatment methods to treat dyes in textile wastewater. After that, this chapter covers the previous studies of grafted copolymers as flocculant with the available grafting methods. Finally, the chapter was end up with the literature of cellulose characteristics and method uses to extract cellulose from natural sources.

Chapter 3 refers to the materials and methods used in the study. The chapter described the experimental procedure that being used in this research for the extraction of cellulose from Pandan leaves, preparation of the grafted copolymers flocculant (PAM-g-cellulose) and the flocculation preparation and process via RSM to treat Reactive Black 5 (RB5) dye.

Chapter 4 presents all of the results obtained in the study which cover the extraction study of cellulose from Pandan leaves, physical study on the synthesized grafted copolymers flocculant (PAM-g-cellulose) and also the performance of the developed flocculant to treat Reactive Black 5 (RB5) dye using RSM.

Chapter 5 refers to overall conclusions that are based on the findings obtained in the results and discussion which explained in Chapter 4. Besides that, the recommendations for future research were also given in this chapter to improve the structure of the study and also the findings.

REFERENCES

Abu Hassan, M. A., Lee, T. P. and Zainon Noor, Z. (2008). Coagulation and Flocculation Treatment of Wastewater in Textile Industry Using Chitosan. *Journal of Chemical and Natural Resources Engineering.* 4(1), 43-53.

Adachi, Y. (1995). Dynamic Aspects of Coagulation and Flocculation. *Advances in Colloid and Interface Science*. 56, 1-31.

Agarwal, M., Rajani, S., Rai, J. S. P. and Mishra, A. (2003). Utilization of Biodegradable Okra Gum for the Treatment of Tannery Effluent. *International Journal of Polymeric Materials*. 52(11-12), 1049-1057.

Ahmad, A. L., Harris, W. A., Syafiie and Seng, O. B. (2002). Removal of Dye from Wastewater of Textile Industry using Membrane Technology. *Jurnal Teknologi.* 36, 31-44.

Ahmad, A. L., Sumathi, S. and Hameed, B. H. (2006). Coagulation of Residue Oil and Suspended Solid in Palm Oil Mill Effluent by Chitosan, Alum and PAC. *Chemical Engineering Journal.* 118. 99-105.

Ahmad, A. L., Puasa, S. W. (2007). Reactive Dyes Decolourization from an Aqueous Solution by Combined Coagulation/Micellar-Enhanced Ultrafiltration Process. *Chemical Engineering Journal*. 132(1-3), 257-265.

Akbari, A., Remigy, J. C., Aptel, P. (2002). Treatment of Textile Dye Effluent using a Polyamide-Based Nanofiltration Membrane. *Chemical Engineering and Processing*. 41, 601-609.

Alaton, I. A., Balcioglu, I. A. and Bahnemann, D. W. (2002). Advanced Oxidation of a Reactive Dye Bath Effluent: Comparison of O_3, H_2O_2/UV-C and TiO_2/UV-a Processes. *Water Research*. 36, 1143-1154.

Anjaneyulu, Y., Chary, N. S., Raj, D. S. S. (2005). Decolourization of Industrial Effluents Available Methods and Emerging Technologies-A Review. *Reviews in Environmental Science and Biotechnology*. 4, 245-273.

Ariffin, A., Shatat, R. S. A., Nik Norulaini, A. R. and Mohd Omar, A. K. (2005). Synthetic Polyelectrolytes of Varying Charge Densities but Similar Molar Mass Based on Acrylamide and Their Applications on Palm Oil Mill Effluent Treatment. *Desalination*. 173, 201-208.

Ashmore, M. and Hearn, J. (2000). Flocculation of Model Latex Particles by Chitosans of Varying Degrees of Acetylation. *Langmuir*. 16(11), 4906-4911.

Atmani, F., Bensmaili, A. and Mezenner, N. Y. (2009). Synthetic Textile Effluent Removal by Skin Almonds Waste. *Journal of Environmental Science and Technology*. 2, 53-169.

Azbar, N., Yonar, T. and Kestioglu, K. (2004). Comparison of Various Advanced Oxidation Processes and Chemical Treatment Methods for COD and Colour Removal from a Polyester and Acetate Fiber Dying Effluent. *Chemosphere*. 55, 35-43.

Banat, I. M, Nigam, P., Singh, D. and Marchant, R. (1996). Microbial Decolorization of Textile-Dye containing Effluents: A Review. *Bioresource Technology*. 58: 217-27.

Barari, M., Abdollahi, M. and Hemmati, M. (2011). Synthesis and Characterization of High Molecular Weight Polyacrylamide Nanoparticles by Inverse Emulsion Polymerization. *Iranian Polymer Journal*. 20(1), 65-76.

Baskan, M. B. and Pala, A. (2010). A statistical Experiment Design Approach for Arsenic Removal by Coagulation Process using Aluminum Sulfate. *Desalination*. 254, 42-48.

Bezerra, M. A., Santelli, R. E., Oliveira, E. P., Villar, L. S. and Escaleira, L. A. (2008). Response Surface Methodology (RSM) as a Tool for Optimization in Analytical Chemistry. *Talanta*. 76, 965-977.

Bharti, S., Mishra, S. and Sen, G. (2013). Ceric Ion Initiated Synthesis of Polyacrylamide Grafted Oatmeal: Its Application as Flocculant for Wastewater Treatment. *Carbohydrate Polymers*. 93, 528-536.

Bhatnagar A. and Sain M. (2005.) Processing of Cellulose Nanofiber Reinforced Composites. *Journal of Reinforce Plastic Composite*. 24(12), 1259-1269.

Bhattacharya, A. and Misra, B. N. (2004). Grafting: A Versatile Means to Modify Polymers Techniques, Factors and Applications. *Progress in Polymer Science*. 29, 767-814.

Biggs, S., Habgood, M., Jameson, G. J., Yan, Y. D. (2000). Aggregate Structures Formed via a Bridging flocculation Mechanism. *Chemical Engineering Journal*. 80, 13-22.

Blackwell, J. and Kolpak, F. J. (1976). Packing Analysis of Carbohydrates and Polysaccharides. Molecular and Crystal Structure of Regenerated Cellulose II. *Macromolecules*. 9, 851-857.

Bolto, B. and Gregory, J. (2007). Organic Polyelectrolytes in Water Treatment. *Water Research*. 41(11), 2301-2324.

Bouyer, F., Robben, A., Yu, W. L. and Borkovec, M. (2001). Aggregation of Colloidal Particles in the Presence of Oppositely Charged Polyelectrolytes: Effect of Surface Charge Heterogeneities. *Langmuir*. 17(17), 5225-5231.

Bradu, C., Frunza, L., Mihalche, N., Avramescu, S. Neata, M. and Udrea, I. (2010). Removal of Reactive Black 5 Azo Dye from Aqueous Solutions by Catalytic Oxidation using CuO/Al_2O_3 and NiO/Al_2O_3. *Applied Catalysis B*: *Environmental*. 96, 548-556.

Brostow, W., Lobland, H. E. H., Pal, S. and Singh, R. P. (2009). Polymeric Flocculants for Wastewater and Industrial Effluent Treatment. *Journal of Materials Education*. 31(3-4), 157-166.

Chaiwong, N. and Nuntiya, A. (2008). Influence of pH, Electrolytes and Polymers on Flocculation of Kaolin Particle. *Chiang Mai Journal of Science*. 35(1), 11-16.

Chan, C. H., Chia, C. H., Zakaria, S., Ahmad, I. and Dufresne, A. (2013). Production and Characterization of Cellulose and Nanorystalline Cellulose from Kenaf Core Wood. *Bioresources*. 8(1), 785-794.

Chang, Q., Hao, X. and Duan, L. (2008). Synthesis of Crosslinked Starch-Graft-Polyacrylamideco-Sodium Xanthate and Its Performances in Wastewater Treatment. *Journal of Hazardous Materials*. 159, 548-553.

Chanzy, H., Nishiyama, Y & Langan, P. (1999). A Revised Structure and Hydrogen-Bonding System in Cellulose II from a Neutron Fiber Diffraction Analysis. *Journal of American Chemistry Society*. 121(43), 9940-9946.

Charoenlarp, K. and Choyphan, W. (2009).Reuse of Dye Wastewater through Colour Removal with Electrocoagulation Process. *Asian Journal on Energy and Environment*. 10(4), 250-260.

Chen, L., Chen, D. and Wu, C. (2003). A New Approach for the Flocculation Mechanism of Chitosan. *Journal of Polymers and the Environment.* 11(3), 87-92.

Chen, X., Shen, Z., Zhu, X., Fan, Y. and Wang, W. (2005). Advanced Treatment of Textile Wastewater for Reuse using Electrochemical Oxidation and Membrane Filtration. *Water South Africa*. 31, 127-132.

Chen, G., Huang, M. H., Chen, L. and Chen, D. H. (2011).A batch Decolorization and Kinetic Study of Reactive Black 5 by a Bacterial Strain *Enterobacter* sp. GY-1. *International Biodeterioration & Biodegradation*. 65, 790-796.

Chen, D. (2012). *Biocomposites Reinforced with Cellulose Nanocrystals Derived from Potato Peel Waste*. Master, McMaster University.

Cheng, W. P., Chi, F. H., Li, C. C. and Yu, R. F. (2008). A Study on the Removal of Organic Substances from Low-Turbidity and Low-Alkalinity Water with Metalpolysilicate Coagulants. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*. 312, 238-244.

Chu, W. (2001). Dye Removal from Textile Dye Wastewater using Recycled Alum Sludge. *Water Research*. 35(13), 3147-3152.

Chung, K.T., Stevens Jr., S. E. and Cerniglia, C. E. (1992). The Reduction of Azo Dyes by the Intestinal Microflora. *Critical Reviews in Biotechnology*. 18, 175-190.

Correia, V. M., Stephenson, T. and Judd, S. J. (1994). Characteristic of Textile Wastewaters-A Review. *Environmental Technology*. 15, 917-929.

Crini, G. (2005). Recent Development in Polysaccharide-Based Materials used as Adsorbents in Wastewater Treatment. *Progress in Polymer Science*. 30, 38-70.

Das, K. K. and Somasundaran, P. (2004). A Kinetic Investigation of the Flocculation of Alumina with Polyacrylic Acid. *Journal of Colloid and Interface Science*. 271, 102-109.

da Silva, D. A., de Paula, R. C. M. and Feitosa, J. P. A. (2007). Graft Copolymerization of Acrylamide onto Cashew Gum. *European Polymer Journal*. 43, 2620-2629.

Deraman, M., Zakaria. S., Murshidi, J. A. (2001). Estimation of Crystallinity and Cryistallite Size of Cellulose in Benzylated Fibres of Oil Palm Empty Fruit Bunches by X-ray Diffraction. *Japanse Journal of Applied Physics*. 40, 311-315.

de Souza, S. M. d. A. G. U., Bonilla, K. A. S. and de Souza, A. A. U. (2010). Removal of COD and Color from Hydrolyzed Textile Azo Dye Combined Ozonation and Biological Treatment. *Journal of Hazardous Materials*. 179, 35-42.

Duan, J., Lu, Q., Chen, R., Duan, Y., Wang, L., Gao, L. and Pan, S. (2010). Synthesis of a Novel Flocculant on the Basis of Crosslinked Konjac Glucomannan-Graft- Polyacrylamide-Co-Sodium Xanthate and Its Application in Removal of Cu^{2+} Ion. *Carbohydrate Polymers*. 80, 436-441.

Dutta, S. (2013). Optimization of Reactive Black 5 Removal by Adsorption Process using Box–Behnken Design. *Desalination and Water Treatment*. 1-8.

El-Dein, A. M., Libra, J. A. and Wiesmann, U. (2003). Mechanism and Kinetic Model for the Decolorization of the Azo Dye Reactive Black 5 By Hydrogen Peroxide and UV Radiation. *Chemosphere*. 52, 1069-1077.

Enzari, M. H., Sharif al-Hoseini, Z. and Ashraf, N. (2008). Fast and Efficient Removal of Reactive Black 5 from Aqueous Solution by a Combined Method of Ultrasound and Sorption Process. *Ultrasonics Sonochemistry*. 15, 433-437.

Forgacs, E., Cserhati, T. and Oros, G. (2004). Removal of Synthetic Dyes from Wastewaters: A Review. *Environment International*. 30, 953-971.

Fu, Y. and Viraraghavan, T. (2001). Fungal Decolorization of Dye Wastewaters: A Review. *Bioresource Technology*. 79, 251-262.

Fu, Y. and Viraraghavan, T. (2002). Removal of Congo Red from Aqueous Solution by Fungus Aspergillusniger. *Advances in Environmental Research*.7, 239-247.

Ganesh, R., Boardman, G. D., and Michelsen, D. (1994). Fate of Azo Dyes in Sludges. *Water Research*. 28(6), 1367-1376.

Gardner, D. J., Oporto, G. S., Mills, R. and Samir, M. A. S. A. (2008). Adhesion and Surface Issues in Cellulose and Nanocellulose. *Journal of Adhesion Science and Technology*. 22, 545-567.

Geresh, S., Gdalevsky, G. Y., Gilboa, I., Voorspoels, J., Remon, J. P. and Kost, J.

(2004). Bioadhesive Grafted Starch Copolymers as Platforms for Peroral Drug Delivery: A Study of Theophylline Release. *Journal of Controlled Release*. 94, 391-398.

Ghosh, S., Sen, G., Jha, U. and Pal, S. (2010). Novel Biodegradable Polymeric Flocculant Based on Polyacrylamide Grafted Tamarind Kernel Polysaccharide. *Bioresource Technology*. 101, 9638-9644.

Golob, V., Vinder, A. and Simonic, M. (2005). Efficiency of Coagulation/Flocculation Method for Treatment of Dye Bath Effluents. *Dyes and Pigments*. 67, 93-97.

Gosh, D. and Hallenbeck, P.C. (2010). Response Surface Methodology for Process Parameter Optimization of Hydrogen Yield by the Metabolically Engineered Strain Escherichia coli DJT135. *Bioresource Technology*. 101, 1820-1825.

Gregory, J. and Barany, S. (2011). Adsorption and Flocculation by Polymers and Polymer Mixtures. *Advance in Colloid and Interface Science*. 169, 1-12.

Gupta, P., Samant, K. and Sahu, A. (2012). Isolation of Cellulose-Degrading Bacteria and Determination of Their Cellulolytic Potential. *International Journal of Microbiology*. 2012, 1-5.

Habibi, Y., Lucia, L. A., and Rojas, O. J. (2010). Cellulose Nanocrystals: Chemistry, Self-Assembly and Applications. *Chemical Reviews*. 110(6), 3479-3500.

Hai, F. I., Yamamoto, K. and Fukushi, K. (2007). Hybrid Treatment Systems for Dye Wastewater. *Critical Reviews in Environmental Science and Technology*. 37, 315-377.

He, Y., Pang, Y., Liu, Y., Li, X. and Wang, K. (2008). Physicochemical Characterization of Rice Straw Pretreated with Sodium Hydroxide in the Solid State for Enhancing Biogas Production. *Energy & Fuel*. 22(4), 2775-2781.

Hebeish, I., Abd El-Thalouth, I., El-Kashouti, M. A. and Abdel-Fattah, S. H. (2003). Graft Copolymerization of Acrylonitrileonto Starch using Potassium Permanganate as Initiator. *Angwandte Makromolekulare Chemie*. 78, 101-108.

Iscen, C. F., Kiran, I. and Ilhan, S. (2007). Biosorption of Reactive Black 5 Dye by Penicillium restrictum: The Kinetic Study. *Journal of Hazardous Materials*. 143, 335-340.

Jiang, Y., Ju, B., Zhang, S. and Yang, J. (2010). Preparation and Application of a New Cationic Starch Ether-Starch-Methylene Dimethylamine Hydrochloride. *Carbohydrate Polymer*. 80, 467–473.

Johar, N., Ahmad I. and Dufresne, A. (2012). Extraction, Preparation and Characterization of Cellulose Fibres and Nanocrystals from Rice Husk. *Industrial Crops and Products*. 37, 93-99.

John, J. J. and Thomas, S. (2008). Biofibres and Biocomposites. *Carbohydrate Polymers*. 71, 343-364.

Jonoobi, M., Harun, J., Tahir, P. M., Zaini, L. H., Azry, S. S. and Makinejad, M. D. (2010). Characteristics of Nanofibers extracted from Kenaf Core. *Bioresources*. 5(4), 2556-2566.

Jonoobi, M., Khazaeian, A., Tahir, P. M., Azry, S. S. and Oksman, K. (2011). Characteristics of Cellulose Nanofibers Isolated from Rubberwood and Empty Fruit Bunches of Oil Palm using Chemo-Mechanical Process. *Cellulose*. 18, 1085-1095.

Joo, D. J., Shin, W. S., Choi, J. H., Choi, S. J., Kim, M. C., Han, M. H., Ha, T. W. and Kim, Y. H. (2007). Decolorization of Reactive Dyes using Inorganic Coagulants and Synthetic Polymer. *Dyes Pigments*. 73(1), 59–64.

Kammoun, R., Naili, B. and Bejar, S. (2008). Application of a Statistical Design to the Optimization of Parameters and Culture Medium for a-amylase Production by Aspergillus oryzae CBS 819.72 Grown on Gruel (Wheat Grinding By-Product). *Bioresource Technology*. 99 5602-5609.

Kang, H. M., Cai, Y. L. and Liu, P. S. (2006). Synthesis, Characterization and Thermal Sensitivity of Chitosan-Based Graft Copolymers. *Carbohydrate Research*. 11, 2851-2855.

Klemm, D., Heublein, B., Fink, H. P. and Bohn, A. (2005). Cellulose: Fascinating Biopolymer and Sustainable Raw Material. *Polymer Science*. 44, 3358-3393.

Koyuncu, I. (2003). Influence of Dyes Salts and Auxiliary Chemicals on the Nanofiltration of Reactive Dye Baths: Experimental Observations and Model Verification. *Desalination*. 154(1), 79-88.

Krishnamachari, P., Hashaikeh, R. and Tiner, M. (2011). Modified Cellulose Morphologies and Its Composites; SEM and TEM Analysis. *Micron*. 42, 751-761.

Kumar, A., Choudhary, P. and Verma, P. (2011). A Comparative Study on the Treatment Methods of Textile Dye Effluents. *Global Journal of Environmental Research*. 5(1), 46-52.

Kumar, R., Setia, A. and Mahadevan, N. (2012). Grafting Modification of the Polysaccharide by the Use of Microwave Irradiation-A Review. *International Journal of Recent Advances in Pharmaceutical Research*. 2(2), 45-53.

Kunamneni, A., Ghazi, I., Camarero, S., Ballesteros, A., Plou , F. J. and Alcalde, M. (2008). Decolorization of Synthetic Dyes by Laccase Immobilized on Epoxy-Activated Carriers. *Process Biochemistry*. 43, 169-178.

Lan, W., Liu, C. F., Sun, R. C. (2011). Fractionation of Bagasse into Cellulose, Hemicelluloses, and Lignin with Ionic Liquid Treatment Followed by Alkaline Extraction. *Journal of Agricultural and Food Chemistry*. 59, 8691-8701.

Larsson, A., Walldal, C., Wall, S. (1999). Flocculation of Cationic Polymers and Nanosized Particles. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*. 159(1), 65-76.

Licsko, I. (1997). Realistic Coagulation Mechanism in the Use of Aluminium and Iron (III) Salts. *Water Science Technology*. 36(4), 103-110.

Lin, S. H. and Peng, F. C. (1996). Continuous Treatment of Textile Wastewater by Combined Coagulation, Electrochemical Oxidation and Activated Sludge. *Water Research*. 30, 587-592.

Ledakowicz, S., Solecka, M. and Zylla, R. (2001). Biodegradation, Decolourisation and Detoxification of Textile Wastewater Enhanced by Advanced Oxidation Processes. *Journal of Biotechnology*. 89, 175-184.

Lee, S. H., Shin, M .C., Choi, S. J. and Park, I. S. (1998). Improvement of Flocculation Efficiency of Water Treatment by using Polymer Flocculants. *Environmental Technology*. 19, 431-437.

Lee, K. E., Morad, N., Teng, T. T. and Poh, B. T. (2012). Development, Characterization and the Application of Hybrid Materials in Coagulation/Flocculation of Wastewater: A Review. *Chemical Engineering Journal*. 203, 370-386.

Lu, P. and Hsieh, Y. L. (2010). Preparation and Properties of Cellulose Nanocrystals: Rods, Spheres, and Network. *Carbohydrate Polymers*. 82, 329-336.

Lucas, M. S. and Peres, J. A. (2006).Decolorization of the Azo Dye Reactive Black 5 by Fenton and Photo-Fenton Oxidation. *Dyes and Pigments*. 71, 236-244.

Ma, K. and Pierre, A. C. (1997).Effect of Interaction between Clay Particles and Fe^{3+} Ions on Colloidal Properties of Kaolinite Suspensions. *Clays Clay Minerals*. 45(5), 733-744.

Maiti, S., Ranjit, S. and S, B. (2010). Polysaccharide-Based Graft Copolymers in Controlled Drug Delivery. *International Journal of Pharmaceutical Technology and Research*. 2, 1350-1358.

Man, Z., Muhammad, N., Sarwono, A., Bustam, M. A., Kumar, M. V. and Rafiq, S. (2011). Preparation of Cellulose Nanocrystals Using an Ionic Liquid. *Journal of Polymers and the Environment*. 19, 726-731.

Merzouk, B., Madani, K. and Sekki, A. (2010). Using Electrocoagulation-Electroflotation Technology to Treat Synthetic Solution and Textile Wastewater, Two Case Studies. *Desalination*. 250, 573–577.

Mishra, A., Srinivasan, R. and Dubey, R. (2002). Flocculation of Textile Wastewater by *Plantago psyllium* Mucilage. *Macromolecular Materials and Engineering*. 287, 592-596.

Mishra, A., Agarwal, M. and Yadav, A. (2003). Fenugreek Mucilage as a Flocculating Agent for Sewage Treatment. *Colloid Polymer Science*. 281, 164-167.

Mishra, A. and Bajpai, M. (2005). Flocculation Behaviour of Model Textile Wastewater Treated with a Food Grade Polysaccharide. *Journal of Hazardous Materials*. 118(1-3), 213-217.

Mishra, A. and Bajpai, M. (2006). The Flocculation Performance of Tamarindus mucilage in Relation to Removal of Vat and Direct Dyes. *Bioresource Technology*. 97, 1055-1059.

Mishra, S., Mukul, A., Sen, G. and Jha, U. (2011a). Microwave Assisted Synthesis of Polyacrylamide Grafted Starch (St-g-PAM) and Its Applicability as Flocculant for Water Treatment. *International Journal of Biological Macromolecules*. 48, 106-111.

Mishra, S., Sen, G., Rani, G. U. and Sinha, S. (2011b). Microwave Assisted Synthesis of Polyacrylamide Grafted Agar (Ag-g-PAM) and Its Application as Flocculant for Wastewater Treatment. *International Journal of Biological Macromolecules*. 49, 591-598.

Moran, J., Alvarez, V., Cyras, V. and Vazquez, A. (2008). Extraction of Cellulose and Preparation of Nanocellulose from Sisal Fibers. *Cellulose*. 15(1), 149-159.

Muyibi, S. A., Ambali, A. R. and Eissa, G. S. (2008). The Impact of Economic Development on Water Pollution: Trends and Policy Actions in Malaysia. *Water Resource Management*. 22(4), 485-508.

Nadanathangam, V. and Satyamurthy, P. (2011). Preparation of Spherical Nanocellulose by Anaerobic Microbial Consortium. *2nd International Conference on Biotechnology and Food Science IPCBEE*. Singapore. 7, 181-183.

Oke, I. A., Okuofu, C. A. and Otun, J. A. (2006). A Statistical Classification of Textile Wastewaters in Northern Nigeria. *Journal of Applied Sciences Research*. 2(4), 209-216.

Okuda, T., Baes, A. U., Nishijima, W. and Okada, M. (1999). Improvement of Extraction Method of Coagulation Active Components from Moringa Oleifera Seed. *Water Research*. 33(15), 3373-3378.

Pal, S., Nasim, T., Patra, A., Ghosh, S. and Panda, A. B. (2010). Microwave Assisted Synthesis of Polyacrylamide Grafted Dextrin (Dxt-g-PAM): Development and Application of a Novel Polymeric Flocculant. *International Journal of Biological Macromolecules*. 47, 623-631.

Pal, S., Ghorai, S., Dash, M. K., Ghosh, S., Udayabhanu, G. (2011). Flocculation Properties of Polyacrylamide Grafted Carboxymethyl Guar Gum (CMG-g-PAM) Synthesised by Conventional and Microwave Assisted Method. *Journal of Hazardous Materials*. 192, 1580-1588.

Pal, S., Sen, G., Ghosh, S. and Singh, R. P. (2012). High Performance Polymeric Flocculants Based on Modified Polysaccharides-Microwave Assisted Synthesis. *Carbohydrate Polymers*. 87, 336-342.

Pang, Y. L. and Abdullah, A. Z. (2013). Current Status of Textile Industry Wastewater Management and Research Progress in Malaysia: A Review. *Clean-Soil, Air, Water*. 1-14.

Phalakornkule, C., Polgumhang, S., Tongdaung, W., Karakat, B. and Nuyut, T. (2010). Electrocoagulation of Blue Reactive, Red Disperse and Mixed Dyes, and Application in Treating Textile Effluent. *Journal of Environmental Management.* 91, 918-926.

Pillai, J. (1997). Flocculants and Coagulants: *The Keys to Water and Waste Management in Aggregate Production*. Doctor Philosophy, Nalco Company.

Pinheiro, H. M., Touraud, E. and Thomas, O. (2004). Aromatic Amines from Azo Dye Reduction: Status Review with Emphasis on Direct UV Spectrophotometric Detection in Textile Industry Wastewater. *Dyes Pigments*. 61, 121-139.

Rai, H., M. Bhattacharya, J. Singh, T. K. Bansal, P. Vats, and U. C. Banerjee. (2005). Removal of Dyes from the Effluent of Textile and Dyestuff Manufacturing Industry: A Review of Emerging Techniques with Reference to Biological Treatment. *Critical Review Environmental Science Technology*. 35(3), 219-238.

Rabiee, A. (2010). Acrylamide-Based Anionic Polyelectrolytes and Their Applications: A Survey. *Journal of Vinyl and Additive Technology*. 16(2), 111-119.

Ragonese, R., Macka, M., Hughes, J., and Petocz, P. (2002). The Use of the Box-Behnken Experimental Design in the Optimisation and Robustness Testing of a Capillary Electrophoresis Method for the Analysis of Ethambutol Hydrochloride in a Pharmaceutical Formulation. *Journal of Pharmaceutical and Biomedical Analysis*. 27(6), 995-1007.

Rani, P., Sen, G., Mishra, S. and Jha, U. (2012). Microwave Assisted Synthesis of Polyacrylamide Grafted Gum Ghatti and Its Application as Flocculant. *Carbohydrate Polymers*. 89, 275-281.

Rath, S. K. and Singh, R. P. (1998). Grafted Amylopectin: Applications in Flocculation. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*. 139, 129-135.

Reddy, N. and Yang, Y. (2008). Characterizing Natural Cellulose Fibers from Velvet Leaf (Abutilon theophrasti) Stems. *Bioresource Technology*. 99, 2449-2454.

Reife, A. and Freeman, H. S. *Environmental Chemistry of Dyes and Pigments*. New York: John Wiley and Sons, Inc. (1996).

Renault, F., Sancey, B., Badot, P. M. and Crini, G. (2009). Chitosan for Coagulation/Flocculation Processes-An Eco-Friendly Approach. *European Polymer Journal*. 45, 1337-1348.

Riera-Torres, M. Gutierrez-Bouzan, C. and Crespi, M. (2010). Combination of Coagulation-Flocculation and Nanofiltration Techniques for Dye Removal and Water Reuse in Textile Effluents. *Desalination*. 252, 53-59.

Robinson, T., Mcmullan, G., Marchant, R., Nigham, P. (2001). Remediation of Dyes in Textile Effluent: A Critical Review on Current Treatment Technologies with Proposed Alternatives. *Bioresource Technology*. 77, 247-255.

Roussy, J., Vooren, M. V., Dempsey, B. A. and Guibal, E. (2005). Influence of Chitosan Characteristics of the Coagulation and the Flocculation of Bentonite Suspensions. *Water Research*. 39, 3247-3258.

Sandhya, S. and Swaminathan, K. (2006). Kinetic Analysis of Treatment of Textile Wastewater in Hybrid Column Upflow Anaerobic Fixed Bed Reactor. *Chemical Engineering Journal*. 122, 87-92.

Saeed, A., Sharif, M. and Iqbal, M. (2010). Application Potential of Grapefruit Peel as Dye Sorbent: Kinetics, Equilibrium and Mechanism of Crystal Violet Adsorption. *Journal of Hazardous Materials*. 179, 564-572.

Saratale, R. G., Saratale, G. D., Chang, J. S. and Govindwar, S. P. (2011). Bacterial Decolorizationand Degradation of Azo Dyes: A Review. *Journal of the Taiwan Institute of Chemical Engineers*. 42, 138-157.

Schintu, M., Meloni, P., Contu, A. (2000). Aluminum Fractions in Drinking Water from Reservoirs. *Ecotoxicology and Environmental Safety*. 46, 29-33.

Segal, L., Creely, J. J., Martin, A. E. and Conrad, C. M. (1959). An Empirical Method for Estimating the Degree of Crystallinity of Native Cellulose using the X-ray Diffractometer. *Textile Research Journal*. 29(10), 786-794.

Sen, G., Kumar, R., Ghosh, S. and Pal, S. (2009). A Novel Polymeric Flocculant Based on Polyacrylamide Grafted Carboxymethylstarch. *Carbohydrate Polymers*. 77, 822-831.

Sen, G., Mishra, S., Jha, U. and Pal, S. (2010a). Microwave Initiated Synthesis of Polyacrylamide Grafted Guar Gum (GG-g-PAM)-Characterizations and Application as Matrix for Controlled Release of 5-Amino Salicylic Acid. *International Journal of Biological Macromolecules*. 47, 164-170.

Sen, G., Singh, R. P. and Pal, S. (2010b). Microwave-Initiated Synthesis of Polyacrylamide Grafted Sodium Alginate: Synthesis and Characterization. *Journal of Applied Polymer Science*. 115, 63-71.

Sen, G., Ghosh, S., Jha, U. and Pal, S. (2011). Hydrolyzed Polyacrylamide Grafted Carboxymethylstarch (Hyd. CMS-g-PAM): An Efficient Flocculant for the Treatment of Textile Industry Wastewater. *Chemical Engineering Journal*. 171, 495-501.

Sen, G., Mishra, S., Rani, G. U., Rani, P. and Prasad, R. (2012). Microwave Initiated Synthesis of Polyacrylamide Grafted Psyllium and Its Application as a Flocculant. *International Journal of Biological Macromolecules*. 50, 369-375.

Sharma, B. R., Dhuldhoya, N. C. and Merchant, U. C. (2006). Flocculants-an Ecofriendly Approach. *Journal of Polymers and the Environment*. 14, 195-202.

Shehu, M. S., Manan, Z. A. and Alwi, S. R. W. (2012). Optimization of Thermo-Alkaline Disintegration of Sewage Sludge for Enhanced Biogas Yield. *Bioresource Technology*. 114, 69-74.

Sheltami, R. M., Abdullah, I., Ahmad, I., Dufresne, A. and Kargarzadeh, H. (2012). Extraction of Cellulose Nanocrystals from Mengkuang Leaves (Pandanus tectorius). *Carbohydrate Polymer*. 88, 772-779.

Singh, R. P., Tripathy, T., Karmakar, G. P., Rath, S. K., Karmakar, N. C., Pandey, S. R., Kannan, K., Jain, S. K. and Lan, N. T. (2000). Novel Biodegradable Flocculants Based Polysaccharides. *Current Science*. 78, 798-803.

Singh, R. P., Pal, S., Krishnamoorthy, S., Adhikary, P. and Ali, S. K. (2009). High-Technology Materials Based on Modified Polysaccharides. *Pure Applied Chemistry*. 81,525-547.

Singh, V., Kumar, P. and Sanghi, R. (2012). Use of Microwave Irradiation in the Grafting Modification of the Polysaccharides-A Review. *Progress in Polymer Science*. 37, 340-364.

Subki, N. S. and Hashim, R. A Preliminary Study on Batik Effluent in Kelantan State: A Water Quality Perspective. *International Conference on Chemical, Biological and Environment Sciences (ICCEBS'2011)*. December, 2011. Bangkok. 274-276.

Sun, J. X., Sun, X. F., Zhao, H. and Sun, R. C. (2004). Isolation and Characterization of Cellulose from Sugarcane Bagasse. *Polymer Degradation and Stability*. 84, 331-339.

Sun, Y., Lin, L., Deng, H., Li, J., He, B., Sun, R. and Ouyang, P. (2008). Structural Changes of Bamboo Cellulose in Formic Acid. *Bioresources*. 3(2), 297-315.

Swatloski, R. P., Spear, S. K., Holbrey, J. D. and Rogers, R. D. (2002). Dissolution of Cellose with Ionic Liquids. *Journal of American Chemical Society*. 124, 4974-4975.

Szygula, A., Guibal, E., Palacin, M. A., Ruiz, M. and Saatre, A. M. (2009). Removal of an Anionic Dye (Acid Blue 92) by Coagulation-Flocculation using Chitosan. *Journal of Environmental Management*. 90, 2979-2986.

Tian, D. and Xie, H. Q.(2008). Graft Copolymerization of Acrylamide onto Konjac Glucomannan via Inverse Emulsion Polymerization and Its Thickening Properties. *Journal of Applied Polymer Science*. 108, 3122-3127.

Togo, C. A., Mutambanengwe, C. C. Z. and Whiteley, C. G. (2008). Decolourisation and Degradation of Textile Dyes using a Sulphate Reducing Bacteria (SRB)-Biodigester Microflora Co-Culture. *African Journal of Biotechnology*. 7(2), 114-121.

Tripathy, T. and Singh, R. P. (2001). Characterization of Polyacrylamide-Grafted Sodium Alginate: A Novel Polymeric Flocculant. *Journal of Applied Polymer Science*. 81, 3296-3308.

Tripathy, T. and De, B. R. (2004). Flocculation: A New Way to Treat the Waste Water. *Journal of Physical Sciences.* 10, 93-127.

Tripathy, T. and De, B. R. (2006). Flocculation: A New Way to Treat the Waste Water. *Journal of Physical Sciences*. 10, 93-127.

Tufekcu, N., Sivri, N. and Toroz, I. (2007). Pollutant of Textile Industry Wastewater and Assessment of its Discharge Limits by Water Quality Standards. *Journal of Fisheries and Aquatic Sciences*. 7, 97-103.

Vahdat, A., Bahrami, H., Ansari, N. and Ziaie, F. (2007). Radiation Grafting of Styrene onto Polypropylene Fibres by a 10 Mev Electron Beam. *Radiation Physics and Chemistry*. 76, 787-793.

Van der Zee, F.P. (2002). *Anaerobic Azo Dye Reduction*. Doctor Philosophy, University. Wageningen, The Netherlands.

Vajnhandl, S. and Marechal, A. M. L. (2007). Case Study of the Sonochemical Decolouration of Textile Azo Dye Reactive Black 5. *Journal of Hazardous Materials*. 141, 329–335.

Verma, A. K., Dash, R. R. and Bhunia, P. (2012). A Review on Chemical Coagulation/Flocculation Technologies for Removal of Colour from Textile Wastewaters. *Journal of Environmental Management*. 93, 154-168.

Wallace, T. H. (2001). *Biological Treatment of a Synthetic Dye Water and An Industrial Textile Wastewater Containing Azo Dye Compounds*. Master, Virginia Polytechnic Institute.

Wan Omar, W. N. N. and Saidina Amin, N. A. (2011). Optimization of Heterogeneous Biodiesel Production from Waste Cooking Palm Oil via Response Surface Methodology. *Biomass and Bioenergy*. 35, 1329-1338.

Wang, J. P., Chen, Y. Z., Ge, X. W. and Yu, H. O. (2007). Optimization of Coagulation-Flocculation Process for a Paper-Recycling Wastewater Treatment using Response Surface Methodology. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*. 302, 204-210.

Wang, Y. (2008). *Cellulose Fiber Dissolution in Sodium Hydroxide Solution at Low Temperature: Dissolution Kinetics and Solubility Improvement*. Doctor Philosophy, Georgia Institute of Technology.

Wang, J. P., Chen, Y. Z., Zhang, S. J. and Yu, H. Q. (2008). A Chitosan-based Flocculant Prepared with Gamma-Irradiation-Induced Grafting. *Bioresource Technology*. 99, 3397-3402.

Wang, H., Zheng, X. W., Su, J. Q., Tian,Y., Xiong, X. J. and Zheng, T. L. (2009). Biological Decolorization of the Reactive Dyes Reactive Black 5 by a Novel Isolated Bacterial Strain *Enterobacter* sp. EC3. *Journal of Hazardous Materials*. 171, 654-659.

Wang, Y. F., Gao, B. Y., Yue, Q. Y., Wang, Y. and Yang, Z. L. (2012). Removal of Acid and Direct Dye by Epichlorohydrin-Dimethylamine: Flocculation Performance and Floc Aggregation Properties. *Bioresource Technology*. 113, 265-271.

Watanabe, S., Ohkita, J., Hayashi, J. and Sufoka, A. (1975). The Confirmation of Existences of Cellulose IIII, IIIII, IVI, and IVII by the x-ray method. *Journal of Polymer Science: Polymer Letters Edition*. 13, 23-27.

Wojnarovits, L., Foldvary, C. M. and Takacs, E. (2010). Radiation-Induced Grafting of Cellulose for Adsorption of Hazardous Water Pollutants: A Review. *Radiation Physics and Chemistry*. 79, 848-862.

Wu, L., Yick, K. I., Ng, S. P. and Yip, J. (2012). Application of the Box-Behnken Design to the Optimization of Process Parameters in Foam Cup Molding. *Expert Systems with Applications*. 39, 8059-8065.

Xu, K., Xu, X., Ding, Z. and Zhou, M. (2006). Synthesis and Flocculability of Sodium Alginate Grafted with Acrylamide. *China Particuology*. 4(2), 60-64.

Yan, T., Xu, Y. and Yu, C. (2009). The Isolation and Characterization of Lignin of Kenaf Fiber. *Journal of Applied Polymer Science*. 114(3), 1896-1901.

Yang, Q., Yediler, A., Yang, M. and Kettrup, A. (2005). Decolorization of an Azo Dye, Reactive Black 5 and MnP Production by Yeast Isolate: Debaryomyces polymorphus. *Biochemical Engineering Journal*. 24, 249–253.

Yang, H., Yan, R., Chen, H., Lee, D. H., Zheng, C. (2007). Characteristic of Hemicellulose, Cellulose and Lignin Pyrolysis. *Fuel*. 86(12-13), 1782-1788.

Yang, Z., Yuan, B., Huang, X., Zhou, J., Cai, J., Yang, H., Li, A. and Cheng, R. (2012). Evaluation of the Flocculation Performance of Carboxymethylchitosan-Graft-Polyacrylamide, a Novel Amphoteric Chemically Bonded Composite Flocculant. *Water Research*. 46, 107-114.

Yusuff, R. O. and Sonibare, J. A. (2004).Characterization of Textile Industries' Effluents in Kaduna, Nigeria and Pollution Implications. *Global Nest: The International Journal*. 6(3), 212-221.

Zhang, P., Hahn, H. H., Hoffmann, E. and Zeng. G. (2004). Influence of Some Additives to Aluminium Species Distribution in Aluminium Coagulants. *Chemosphere*. 57, 1489-1494.

Zhang, W., Shang, Y., Yuan, B., Jiang, Y., Lu, Y., Qin, Z., Chen, A., Qian, X., Yang, H., Cheng, R. (2010). The Flocculating Properties of Chitosan-*graft*-Polyacrylamide Flocculants (II)-Test in Pilot Scale. *Journal of Applied Polymer Science*. 117, 2016-2024.

Zhang, Q., Tang, L., Zhang, J., Mao, Z., Jiang, L. (2011). Optimization of Thermal-Dilute Sulfuric Acid Pretreatment for Enhancement of Methane Production from Cassava Residues. *Bioresource Technology*. 102, 3958-3965.

Zonoozi, M. H., Moghaddam, M. R. A. and Arami, M. (2008). Removal of Acid Red 398 Dye from Aqueous Solutions by Coagulation/Flocculation Process. *Environmental Engineering and Management Journal*. 7(6), 695-699.