BIOSORPTION OF METHYLENE BLUE AND ACID ORANGE 7 BY MODIFIED HEXADECYLTRIMETHYLAMMONIUM BROMIDE RICE HUSK

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To my beloved family:

Ahmad Jani bin Hussin

Noor Aishah binti Abdul Karim

Mohd Aswad bin Ahmad Jani

Nordiana binti Salim

Mohd Azrul Fahmi bin Ahmad Jani

and all Hussin's and Abdul Karim's family members

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ABSTRACT

In this study, rice husk (RRH) was modified with surfactant (SMRH) to remove dyes in batch mode and was compared with unmodified rice husk (RRH). SMRH was prepared by mixing the RRH with different concentrations of cationic surfactant Hexadecyltrimethylammonium Bromide (HDTMABr). All samples were then characterized with Fourier Transform-Infrared Spectroscopy (FTIR). Screening experiment was done by comparing adsorption capacity of SMRH and RRH toward several anionic and cationic dyes with concentration of dyes at 50 mg/L. From the experiment, RRH and SMRH show affinity towards cationic and anionic dyes, respectively. The adsorptive potential of the adsorbents was further investigated towards methylene blue (MB) and acid orange 7 (AO7) with different concentration of dyes solution (5.0 - 1000.0) mg/L and different concentration of HDTMABr modified rice husk (1.0, 2.5 and 4.0) mM. Langmuir and Freundlich isotherms were used to describe adsorption isotherms. The results shows that the removal of AO7 was higher for SMRH compared to RRH meanwhile MB removal was higher for RRH compared to SMRH. Modification of rice husk by surfactant was proven to decrease the adsorption site for MB. On the other hand, the presence of surfactant on the SMRH increases the adsorption site and allows more adsorption to occur for AO7. The equilibrium data were better described by Langmuir isotherm with maximum adsorption capacity of AO7 was 200.0 mg/g and 100.0 mg/g for MB. In conclusion, the modification of rice husk by HDTMABr decreased the adsorption towards cationic dyes but increased the adsorption towards anionic dyes.

ABSTRAK

Dalam kajian ini, sekam padi (RRH) telah diubahsuai dengan surfaktan (SMRH) untuk menyingkirkan pewarna dalam mod kelompok dan dibandingkan dengan sekam padi yang tidak diubahsuai (RRH). SMRH telah disediakan dengan mencampurkan RRH dengan kepekatan surfaktan kationik Heksadesiltrimetilammonium Bromida (HDTMABr) yang berbeza. Semua sampel kemudiannya dicirikan dengan kaedah spektroskopi inframerah (FTIR). Eksperimen saringan telah dilakukan dengan membandingkan kapasiti penjerapan SMRH dan RRH keatas beberapa pewarna anionik dan kationik dengan kepekatan pewarna pada 50 mg/L. Daripada ujikaji tersebut, RRH menunjukkan kapasiti penjerapan keatas pewarna kationik dan SMRH keatas pewarna anion. Potensi serapan penjerap terus dikaji terhadap metilina biru (MB) dan asid oren 7 (AO7) dengan kepekatan larutan pewarna yang berbeza (5.0-1000.0) mg/L dan kepekatan HDTMABr (1.0, 2.5 dan 4.0) mM yang berbeza. Isoterma Langmuir dan Freundlich telah digunakan untuk menggambarkan jenis isoterma penjerapan. Keputusan menunjukkan bahawa penyingkiran AO7 adalah lebih tinggi untuk SMRH berbanding RRH sementara penyingkiran MB adalah lebih tinggi untuk RRH berbanding SMRH. Pengubahsuaian sekam padi oleh surfaktan telah terbukti mengurangkan kawasan penjerapan MB dalam larutan. Sebaliknya, kehadiran surfaktan pada SMRH meningkatkan kawasan penjerapan dan membolehkan lebih penjerapan AO7 berlaku. Data keseimbangan telah digambarkan dengan lebih baik oleh isoterma Langmuir dengan kapasiti penjerapan maksimum AO7 adalah 200.0 mg/g dan 100.0 mg/g untuk MB. Kesimpulannya, pengubahsuaian sekam padi oleh HDTMABr mengurangkan penjerapan terhadap pewarna kationik tetapi meningkatkan penjerapan terhadap pewarna anionik.

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LIST OF SYMBOLS

°C	-	Degree Celsius
C_i	-	Initial concentration
C_e	-	Equilibrium concentration
cm	-	Centimeter
g	-	Gram
kg	-	Kilogram
kV	-	Kilo Volt
L	-	Liter
m	-	Meter
M	-	Molar
mg	-	Milligram
min	-	Minute
mL	-	Milliliter
mm	-	Millimeter
mmol	-	Millimole
nm	-	Nanometer
ppm	-	Parts per million
λ	-	Lambda

LIST OF ABBREVIATIONS

HDTMABr	-	Hexadecyltrimethylammonium Bromide
FTIR	-	Fourier Transform Infrared
IR	-	Infrared
[MB]	-	Concentration of Methylene blue
[AO7]	-	Concentration of Methyl orange
RRH	-	Raw rice husk
SMRH	-	Surfactant modified rice husk
1 SMRH	-	Rice husk treated with 1.0 mM concentration of (HDTMABr)
2.5 SMRH	-	Rice husk treated with 2.5 mM concentration of (HDTMABr)
4 SMRH	-	Rice husk treated with 4.0 mM concentration of (HDTMABr)
CMC	-	Critical Micelle Concentration
UV - Vis	-	Ultra Violet-Visible

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CHAPTER 1

INTRODUCTION

1.1 Research Background

The rise of the textile industry in recent centuries has a significant effect on the economic resources of the world. Nevertheless, the increase of textile industry also raised environmental concerns against pollution resulting from waste disposal of this industry as it is among the largest users of chemicals and water.During the textile production, dyes are widely used for coloring purpose such as in staining and printing process. However, not all dyestuff binds to the textile during the process. In fact, it is estimated 10 to 25 % of the dyes are lost throughout the process while 2 to 20% are directly discharged as effluent which may results in serious water pollution (Carmen and Daniela,2012).

In this study, methylene blue (MB) and acid orange 7 (AO7) were selected to be studied as model dyes mainly because these dyes are widely used in several industries such as paper and textile industries. In addition, their presence in effluent was harmful to environment as their breakdown products are toxic and carcinogenic due to the aromatic compound such as naphthalene and benzidine (Carmen and Daniela, 2012).Moreover, waste water containing dyes is reported to be among the most difficult waste water to be treated because of the complex molecular structure and high water solubility properties of dyes (Forgacs *et al*., 2004; Crini, 2006; Gupta, 2009)

In relation to the problems, many techniques have been implemented to remove dyes in waste water such as by flocculation, sedimentation and filtration (Tarley and Aruda, 2003; Yun-nen *et al*., 2010). Unfortunately , according to Srinivasan and Viraraghavan (2010) these methods are expensive , have low removal efficiency and effective for only certain type of dyes hence, adsorption method is more preferable as researchers believed this process is more efficient and lower-price compared to other methods (Ngah *et al*., 2011; Zhang *et al*., 2012).

Adsorption is a surface phenomenon in which it allows the adsorbent to passively concentrate and bind the adsorbate on its cellular surface due to the binding force of atom, molecules and ions of adsorbate toward adsorbent surface (Park *et al*., 2010). In the adsorption process activated carbon is one of the best candidate due to its large surface area properties, high reactivity on the surface and also high sorption capacity (Yun-nen *et al*., 2010). However, commercialized activated carbons are expensive and their manufacturing process possesses many problems (Ola Abdelwahab *et al*., 2005). Therefore, researchers tried to find better substitutes which offer lower cost yet efficient to replace activated carbon which has led to the use of agricultural waste since they are low cost, high availability and more importantly the lignocellulosic surface of the adsorbent that is favorable for adsorption process (Gupta, 2009; Tsai and Chen, 2010). Furthermore, the decision of using agricultural wastes as adsorbent will alleviate pollution problems because instead of thrown away the waste, there can be re-used for something beneficial. Example of agricultural wastes for dye removal were wheat straw (Zhang *et al*., 2012), papaya stem (Krishni *et al*., 2013), maize husk (Jalil *et al*., 2012) and citrus bagasse (Bhatti *et al*., 2012).

Another advantage of using biological origin such as agricultural waste is they able to remove dyes either in natural form or undergo physical or chemical modification. Thus, to improve their adsorption capacity and stability, several modifications were done. It was supported by the studies done by previous researchers who claimed that modified agricultural waste shows more adsorption capacity compared to the unmodified one (Su *et al*., 2013; Senthil Kumar *et al*., 2013; Ong *et al*., 2013; Sureshkumar and Namasivayam, 2008). The modifications can be done by using base, acid, organic or other solutions.

The choice of rice husk for this study was due to its properties that meet the criteria as a good adsorbent. There are a lot of studies done using rice husk for dye removal (Ola Abdelwahab *et al*., 2005; Chakraborty *et al*., 2011) but only a few focusing on using cationic surfactant on rice husk (Safa and Bhatti, 2011). Cationic surfactant is believed to increase the adsorption capacity on rice husk surface (Sadon*et al*., 2012). The cationic surfactant used in this study was Hexadecyltrimethylammonium Bromide (HDTMABr). It is composed of "permanent charged pentavalent nitrogen and a long straight alkyl (C16) chain" (Namasivayam and Sureshkumar, 2006). Sorption of HDTMABr on rice husk can change the chemistry of the external surface of rice husk where bilayer-like structure of HDTMABr molecules is formed and thus the charge on the surface of rice husk change from negative to positive charge. It will lead to production of electrostatic attraction with a negative charge dye molecules (Baskaralingam *et al*., 2006).

To date, there is no study reported on removal of methylene blue (MB) and acid orange 7(AO7) by surfactant modified rice husk. Thus, it is very interesting to investigate the adsorption behavior of surfactant modified rice husk toward anionic (AO7) and cationic (MB) dyes in aqueous solution as it might lead the adsorption knowledge into a new level as well as for environment preservation.

1.2 Research Problems

According to Zhang *et al*. (2012) it is estimated that almost 70,000 tonnes of dyes are released into the water every year. Unlike organic pollutant, dyes are not easily removed from the waste water due to its high solubility towards the water (Crini, 2006). Other than that, dyes are also harmful (Mohamed, 2004) and can be fatal. This situation causes various ecological problems worldwide and if occur in fresh water, the water might be toxic and unsuitable to be used as potable water sources anymore. Thus, it is very crucial for researchers to find an efficient method to tackle these pollution problems.

Many researchers find that adsorption method are able to remove dyes in waste water efficiently (Tarley and Aruda, 2003; Yun-nen *et al*., 2010; Bhatnagar and Silanpaa, 2010). This is due to its simple design and requires low initial installment as well as small space. Also, this process produces a sludge free environment (Sadon *et al*., 2012). The most common used adsorbent is activated carbon however, it is costly. Thus, this research aims to tackle this problem by using low cost adsorbent from agricultural waste which offers similar functions in term of adsorption activity.

In this study, rice husk was selected as adsorbent due to the presence of lignocellulose structure. Most plant waste have negative charged surface in water which cause them unable to adsorb anionic (negative charged) dyes efficiently (Chen *et al*., 2011). In addition, direct use of rice husk might not be efficient enough for adsorption due to low sorption capacity because of low specific surface area for solute – surface interaction (Laszlo and Dintzis, 1994). According to Wan Ngah and Hanafiah (2008), direct use of agricultural adsorbent might caused secondary pollution results from the release of some soluble compounds of the materials. Therefore, several modifications were made to the adsorbent surface to enhance their effectiveness on adsorbing anionic dyes. The modifications included mechanical modifications whereby the rice husk was ground into smaller size to increase solute-surface interaction, physical modification where the rice husk was sun dried and oven dried to remove moisture as well as chemical modification with cationic surfactant to allow more specific area for dye adsorption.

1.3 Research Objectives

a) To prepare and characterize rice husk in powder form.
b) To prepare surfactant modified rice husk (SMRH) with different surfactant loading.
c) To screen the adsorption capacity of unmodified and modified rice husk (SMRH) with several anionic and cationic dyes at fixed dyes concentration.

d) To study the biosorption behavior of methylene blue (MB) and acid orange 7 (AO7) by unmodified and modified rice husk (SMRH).

1.4 Research Scope

The scope of this study was to analyse the potential of surfactant modified rice husk (SMRH) as low cost natural adsorbent to remove cationic (MB) and anionic (AO7) dyes from solution. It was done by observation on several adsorption parameters such as concentration of dyes and concentration of surfactant onto rice husk during modification. In addition, characterization of modified and unmodified rice husk by FTIR spectroscopy was done to observe if modification changes the chemical linkages of the samples.

The maximum adsorption of dyes by studied samples was calculated by adsorption isotherm and all the data in this study were obtained from batch experiments in laboratory scale.

1.5 Research Significance

In this experiment, methylene blue (MB) and acid orange 7(AO7)acted as the adsorbate which removal of these dyes become the major aim of this study. The release of these dyes into the effluent may cause severe water pollution as had happened in the Citarum River located in West Java where the people there suffered serious skin disease due to the pollution of the main source of water (Brigden *et al*., 2013).Therefore this adsorption study might help in tackling the dye pollution problems so that number of water pollution cases will be reduced.

Activated carbon was proven to be a good adsorbent as it has high adsorption capacity and high contact surface area due to its micro porous structure however, its

production cost is expensive. Therefore, modified rice husk is a potential low-cost replacement of adsorbent since it was selective towards dye adsorption. In addition, being an agricultural waste make it easily to be found at almost no cost especially in Malaysia which is among the largest rice-producing countries (Akinbile *et al*., 2011).

As this project manage to remove dyes in water, it should benefit the society by improving the wastewater management especially in dye polluted area and consequently providing a cleaner environment. Thus this project is relevant to human health as well as environment.

REFERENCES

Ahmaruzzaman, M., &Gupta, V. K. (2011).Rice husk and its ash as low-cost adsorbents in water and wastewater treatment.*Industrial and Engineering Chemistry Research*, *50*(24), 13589-13613.

Ahmaruzzaman, M.,& Sharma, D. K. (2005).Adsorption of phenols from wastewater.*Journal of Colloid and Interface Science*,287(1), 14-24.

Akar, T.,Celik, S., &Akar, S. T. (2010).Biosorption performance of surface modified biomass obtained from*Pyracanthacoccinea*for the decolorizationof dye contaminated solutions.*Chemical Engineering Journal*,160(2), 466-472.

Akinbile, C. O., El-Latif, K. M., Abdullah, R., &Yusoff, M. S. (2011). Rice production and water use efficiency for self-sufficiency in Malaysia: a review.*Trends in Applied Sciences Research*,6(10).

Annadurai, G., Juang, R. S., & Lee, D. J. (2002).Use of cellulose-based wastes for adsorption of dyes from aqueous solutions. *Journal of Hazardous Materials*, *92*(3), 263-274.

Ansari, R., &Seyghali, B. (2013).Application of wood sawdust modified with cationic surfactants for efficient removal of acidic dyes from aqueous solutions: kinetic and thermodynamic studies. *European Chemical Bulletin*, *2*(7), 499-506.

Ansari, R., Seyghali, B., Mohammad-Khah, A., &Zanjanchi, M. A. (2012).Highly efficient adsorption of anionic dyes from aqueous solutions using sawdust modified by cationic surfactant of cetyltrimethylammoniumbromide.*Journal of Surfactants and Detergents*,15(5), 557-565.

Ashoka, H. S., &Inamdar, S. S. (2010). Adsorption removal of methyl red from aqueous solutions with treated sugarcane bagasse and activated carbon-a comparative study.*Global Journal of Environmental Research*, 4(3), 175-182.

Attia, A. A., Rashwan, W. E., &Khedr, S. A. (2006). Capacity of activated carbon in the removal of acid dyes subsequent to its thermal treatment.*Dyes and Pigments*,69(3), 128-136.

Azhar, S. S., Liew, A. G., Suhardy, D., Hafiz, K. F., &Hatim, M. I. (2005).Dye removal from aqueous solution by using adsorption on treated sugarcane bagasse.*American Journal of Applied Sciences*,*2*(11), 1499.

Babel, S.,&Kurniawan, T.A., (2003).Low-cost adsorbents for heavy metals uptake from contaminated water: a review. *Journal Hazardous Material* B97, 219–243.

Bae, J. S., & Freeman, H. S. (2007).Aquatic toxicity evaluation of new direct dyes to the daphnia magna .*Dyes and Pigments*, *73*(1), 81-85.

Bagane, M.,&Guiza, S., (2000).Removal of a dye from textile effluents by adsorption.*Annual Chemistryand Science Matter.* 25, 615–626

Ben Ali, H., Hentati, S. B., Al-Deyab, S. S., &Rzaigui, M. (2012). The influence of the chemical structures of chitosan and acid dye on the adsorption process. *Journal of Chemistry*,9(4), 2415-2423.

Bhatnagar A. & Jain A.K.,(2005)A comparative adsorption study with different industrial wastes as adsorbents for the removal of cationic dyes from water, *Journal Colloid Interface Science*., 281, 49-55

Bhatnagar, A., &Sillanpaa, M. (2010).Utilization of agro-industrial and municipal waste materials as potential adsorbents for water treatment—a review. *Chemical Engineering Journal*,*157*(2), 277-296.

Bhattacharyya, K. G., &Sarma, A. (2003).Adsorption characteristics of the dye, brilliant green on Neem leaf powder.*Dyes and Pigments*,57(3), 211-222.

Bhatti, H. N., Akhtar, N., &Saleem, N. (2012).Adsorptive removal of methylene blue by low-cost citrus sinensis bagasse: equilibrium, kinetic and thermodynamic characterization.*Arabian Journal for Science and Engineering*,*37*(1), 9-18.

Bingol, A., Ucun, H., Bayhan, Y. K., Karagunduz, A., Cakici, A., &Keskinler, B. (2004). Removal of chromate anions from aqueous stream by a cationic surfactant-modified yeast.*BioresourceTechnology*,94(3), 245-249

Bishnoi, N. R., Bajaj, M., Sharma, N., & Gupta, A. (2004). Adsorption of Cr (VI) on activated rice husk carbon and activated alumina.*Bioresource Technology*,91(3), 305-307.

Brigden, K., Labunska, I., Santillo, D., Wang, M., & Johnston, P. (2013) Organic chemical and heavy metal contaminants in waste waters discharged from two textile manufacturing facilities in Indonesia.

Bromophenol blue (CHEBI: 5924) retrieved on May 17, 2014 at http://www.ebi.ac.uk/chebi/searchId.do?chebiId=59424

Brown, D. (1987). Effects of colorants in the aquatic environment.*Ecotoxicology and Environmental Safety*,13(2), 139-147.

Carmen, Z., & Daniela, S. eds.Textile organic dyes–characteristics, polluting effects and separation/elimination procedures from industrial effluents–a critical overview.Romania :ISBN, 978-953.2012.

Carpenter, J., Sharma, S., Sharma, A. K., &Verma, S. (2013). Adsorption of dye by using the solid waste from leather industry as an adsorbent. *International Journal of Engineering Science Invention* ,2(1).

Chakraborty, S., Chowdhury, S., & Das Saha, P. (2011). Adsorption of crystal violet from aqueous solution ontoNaOH-Modified rice husk. *Carbohydrate Polymers*,86(4), 1533-1541.

Chandrasekhar, S., Pramada, P. N., & Praveen, L. (2005).Effect of organic acid treatment on the properties of rice husk silica.*Journal of Materials Science*,*40*(24), 6535-6544.

Chatterjee, S., Lee, D. S., Lee, M. W., & Woo, S. H. (2009). Congo red adsorption from aqueous solutions by using chitosan hydrogel beads impregnated with nonionic or anionic surfactant.*BioresourceTechnology*, 100(17), 3862-3868.

Chen, B., Hui, C. W., & McKay, G. (2001). Pore-surface diffusion modeling for dyes from effluent on pith.*Langmuir*,*17*(3), 740-748.

Chen, H., Zhao, J., Wu, J., & Dai, G. (2011).Isotherm, thermodynamic, kinetics and adsorption mechanism studies of methyl orange by surfactant modified silkworm exuviae.*Journal of Hazardous Materials*,192(1), 246-254.

Chuah, T. G., Jumasiah, A., Azni, I., Katayon, S., &Choong, S. Y. T. eds.(2005) Rice husk as a potentially low – cost biosorbent for heavy metal and dye removal: an overview, *Desalination,* vol. 175, pp. 305 – 316.Malaysia:ISSN

Constantin, M., Asmarandei, I., Harabagiu, V., Ghimici, L., Ascenzi, P., & Fundueanu, G. (2013). Removal of anionic dyes from aqueous solutions by

an ion-exchanger based on pullulan microspheres.*Carbohydrate Polymers*, 91(1), 74-84.

Crini, G. (2006). Non-conventional low-cost adsorbents for dye removal: a review. *BioresourceTechnology*,97(9), 1061-1085.

Dąbrowski, A. (2001). Adsorption — from theory to practice,*Advances in Colloid and Interface Science*. 93(1-3), 135-224.

Daffalla, S. B., Mukhtar, H., &Shaharun, M. S. (2010). Characterization of adsorbent developed from rice husk: effect of surface functional group on phenol adsorption. *Journal of Applied Sciences*, 10(12).

Demirbas, A. (2009). Agricultural based activated carbons for the removal of dyes from aqueous solutions: a review. *Journal of Hazardous Materials*,*167*(1), 1-9.

Deng, H., Lu, J., Li, G., Zhang, G., & Wang, X. (2011). Adsorption of methylene blue on adsorbent materials produced from cotton stalk.*Chemical Engineering Journal*,172(1), 326-334.

Deniz, F. (2013). Adsorption properties of low-cost biomaterial derived from *PrunusAmygdalul.* for dye removal from water.*The Scientific World Journal*.

Dudugul, U. L. K. U. Y. E., &Donmez, G. (2012). Comparison the dye removal activity of systems contained surfactants and fungus.*Journal of the Chilean Chemical Society*, *57*(2), 1170-1173.

Elham, A., Hossein, T., &Mahnoosh, H. (2010).Removal of Zn (Ii) and Pb (Ii) ions using rice husk in food industrial wastewater.*Journal of Applied Sciences and Environmental Management*,14(4).

Elias, S. M., Marzuki, A. M., Mokhtar, H., George, C., Zakaria, N. A., &Aris, A. Z. eds.(2014)Heavy metals (As, Cd, Cr and Pb) concentration in selected sources to solution(pp. 573-578).Singapore:Springer..

Elsner P, Hatch, K., &Wigger-Alberti, W. eds.(2003): Textiles and the Skin Current Problems in Dermatology, Basel: Karger,pp 114-122

Eren, E. (2009). Investigation of a basic dye removal from aqueous solution onto chemically modified unyebentonite. *Journal of Hazardous Materials*,166(1), 88-93.

Eskizeybek, V., Sarı, F., Gülce, H., Gülce, A., &Avcı, A. (2012). Preparation of the newPolyaniline/Znon Nano composite and its photocatalytic activity for

degradation of methylene blue and malachite green dyes under UV and natural sun lights irradiations.*Applied CatalysisEnvironmental*,119, 197-206.

Feng, Q., Lin, Q., Gong, F., Sugita, S., &Shoya, M. (2004). Adsorption of lead and mercury by rice husk ash. *Journal of Colloid and Interface Science*,*278*(1), 1-8.

Feng, Y., Yang, F., Wang, Y., Ma, L., Wu, Y., Kerr, P. G., & Yang, L. (2011). Basic dye adsorption onto an agro-based waste material–sesame hull (*SesamumindicumL.*).*Bioresource Technology*,102(22), 10280-10285.

Foo, K. Y., & Hameed, B. H. (2009). Utilization of rice husk ash as novel adsorbent: a judicious recycling of the colloidal agricultural waste.*Advances In Colloid and Interface Science*,152(1), 39-47.

Foo.K., Y.,& Hameed, B. H. (2010).Insights into the modeling of adsorption isotherm systems.*Chemical Engineering Journal*,*156*(1), 2-10.

Forgacs, E., Cserhati, T., &Oros, G. (2004). Removal of synthetic dyes from waste waters: a review. *Environment international*,*30*(7), 953-971.

Franca, A. S., Oliveira, L. S., & Ferreira, M. E. (2009). Kinetics and equilibrium studies of methylene blue adsorption by spent coffee grounds. *Desalination*, *249*(1), 267-272.

Fungaro, D. A., & Magdalena, C. P. (2014). Counterioneffects on the adsorption of acid orange 8 from aqueous solution onto HDTMA-Modified nanozeolite from fly ash.*Environment and Ecology Research* 2(2):97-106,

Gadd, G. M. (2009). Biosorption: critical review of scientific rationale, environmental importance and significance for pollution treatment.*Journal of Chemical Technology and Biotechnology*,84(1), 13-28.

Garg, V. K., Amita, M., Kumar, R., & Gupta, R. (2004). Basic dye (methylene blue) removal from simulated wastewater by adsorption using indian rosewood sawdust: a timber industry waste.*Dyes and Pigments*,*63*(3), 243-250.

Ghobadi, J., Arami, M., Bahrami, H., &Mahmoodi, N. M. (2013).Modification of carbon nanotubes with cationic surfactant and its application for removal of direct dyes.*Desalination and Water Treatment*, 1-13.

Ghoreishi, S. M., &Haghighi, R. (2003).Chemical catalytic reaction and biological oxidation for treatment of non-biodegradable textile effluent.*Chemical Engineering Journal*,*95*(1), 163-169.

Ghoreishi, S. M., Behpour, M., &Golestaneh, M. (2011). Simultaneous voltammetric determination of brilliant blue and tartrazine in real samples at the surface of a multi-walled carbon nanotube paste electrode.*Analytical Methods*,*3*(12), 2842-2847.

Ghoreishi, S. M., Behpour, M., &Shabani-Nooshabadi, M. (2009). Interaction of anionic azo dye and TTAB: cationic surfactant. *Journal of the Brazilian Chemical Society*, *20*(3), 460-465.

Gimbert, F., Morin-Crini, N., Renault, F., Badot, P.M., &Crini, G. (2008). Adsorption isotherm model for dye removal by cationized starch-based material in single component system: error analysis, *Journal of Hazardous Materials*, 157, 34-46.

Guo, Y.; Zhang, H.; Tao, N.; Liu, Y.; Qi, J.; Wang, Z.; &Xu, H. (2003). Adsorption of malachite green and iodine on rice husk-based porous carbon.*Material. Chemistry Physics,* 82, 107

Gupta, V. K. (2009). Application of low-cost adsorbents for dye removal–a review. *Journal of Environmental Management*,90(8), 2313-2342.

Gupta, V. K., Mittal, A., Gajbe, V., & Mittal, J. (2006).Removal and recovery of the hazardous azo dye acid orange 7 through adsorption over waste materials: bottom ash and de-oiled soya. *Industrial andEngineering Chemistry Research*,*45*(4), 144.

Gupta, V. K., Mittal, A., Jain, R., Mathur, M., &Sikarwar, S. (2006). Adsorption of safranin-T from wastewater using waste materials—activated carbon and activated rice husks.*Journal of Colloid and Interface Science*,*303*(1), 80-86.

Hamzeh, Y., Izadyar, S., Azadeh, E., Abyaz, A., &Asadollahi, Y. (2011). Application of canola stalks waste as adsorbent of acid orange 7 from aqueous solution. *Iranian Journal of Health and Environment*, *4*(1), 49-56.

Han, R., Han, P., Cai, Z., Zhao, Z., & Tang, M. (2008). Kinetics and isotherms of neutral red adsorption on peanut husk.*Journal of Environmental Sciences*, *20*(9), 1035-1041.

Han, R.; Ding, D.; Xu, Y.; Zou, W.; Wang, Y.; Li, Y.; Zou, L. (2008) Use of rice husk for adsorption of Congo red from aqueous solution in column mode *Bioresource Technology*,99, 2938

Hassanein, T. F., &Koumanova, B. (2010).Evaluation ofadsorption potential of the agricultural waste wheat straw forBasic Yellow 21.*Journal of the University of Chemical Technology and Metallurgy*,*45*(4), 407-414

Haven, M. O., &Jorgensen, H. (2013).Adsorption of B-Glucosidases in two commercial preparations onto pretreated biomass and lignin. *Biotechnology for Biofuels*, *6*(1), 165.

Hoseinzadeh, E., Samarghandi, M. R., McKay, G., Rahimi, N., &Jafari, J. (2013). Removalof acid dyes from aqueous solution using potato peel waste biomass: a kinetic and equilibrium study. *Desalination and Water Treatment*, 1-8.

Ibrahim, S., Fatimah, I., Ang, H. M., & Wang, S. (2010). Adsorption of anionic dyes in aqueous solution using chemically modified barley straw. *Water Science and Technology*, *62*(5).

Iqbal, M. J., &Ashiq, M. N. (2007).Adsorption of dyes from aqueous solutions on activated charcoal. *Journal of Hazardous Materials*, *139*(1), 57-66.

Ismail, Z. Z., Tezel, U., &Pavlostathis, S. G. (2010).Sorption of quaternary ammonium compounds to municipal sludge. *Water Research*, 44(7), 2303-2313.

Itodo, A. U., Abdulrahman, A., Usman, A., &Ugboaja, V. C. (2011). Pseudo constants for methyl red sorption: a rate study of received and derived activated carbon. *Journal of Encapsulation and Adsorption Sciences*, *1*, 57.

Jalil, A. A., Triwahyono, S., Yaakob, M. R., Azmi, Z. Z. A., Sapawe, N., Kamarudin, N. H. N.&Hameed, B. H. (2012). Utilizationof bivalve shell-treated zeamays (maize) husk leaf as a low-cost biosorbentfor enhanced adsorption of malachite green. *BioresourceTechnology*.

Jha, P. (2010). Potential of Rice-husk as an adsorbent for phenol removal from aqueous solutions. *Journal of Environmental Research andDevelopment,* 5(2).

Karadag, D., Koc, Y., Turan, M., &Ozturk, M. (2007).A comparative study of linear and non-linear regression analysis for ammonium exchange of clinoptilolite zeolite,*Journal of Hazardous Materials*, 144, 432-437.

Khalid, N., Ahmad, S., Toheed, A., & Ahmed, J. (2000). Potential of rice husks for antimony removal. *Applied Radiation and Isotopes*, *52*(1), 31-38.

Khambhaty, Y., Mody, K., &Basha, S. (2012). Efficient removal of brilliant blue g (bbg) from aqueous solutions by marine*Aspergilluswenti* kinetics, equilibrium and process design. *Ecological Engineering*, *41*, 74-83.

Khan, R., Bhawana, P., &Fulekar, M. H. (2013). Microbial decolorizationand degradation of synthetic dyes: a review. *Reviews in Environmental Science and Bio/Technology*, *12*(1), 75-97.

Khosla, E., Kaur, S., & Dave, P. N. (2013).Mechanistic study of adsorption of acid orange-7 over aluminum oxide nanoparticles. *Journal of Engineering*,

Koh, J. (2011). Dyeing with disperse dyes. *Textile Dyeing*, 195-220.

Kousha, M., Daneshvar, E., Sohrabi, M. S., Jokar, M., &Bhatnagar, A. (2012). Adsorption of acid orange ii dye by raw and chemically modified brown macroalga*StoechospermummarginatumChemical Engineering Journal*, *192*, 67-76.

Krishna, B. S., Murty, D. S. R., & Jai Prakash, B. S. (2001).Surfactant-modified clay as adsorbent for chromate. *Applied Clay Science*, *20*(1), 65-71.

Krishni, R. R., Foo, K. Y., & Hameed, B. H. (2013). Adsorption of cationic dye using a low-cost bio waste adsorbent: equilibrium, kinetic, and thermodynamic study. *Desalination and Water Treatment*, (ahead-of-print), 1-8.

Kumar, K.V., &Sinavesan, S, (2006). Isotherm parameters for basic dyes onto activated carbons: comparison of linear and nonlinear method, *Journal of Hazardous Materials*, 129, 147-150

Kumar, K. V. &Sivanesan, S. (2007) Sorption isotherm for safraninonto rice husk: comparison of linear and non-linear methods *Dyes Pigments* , 72, 130

Lakshmi, U. R., Srivastava, V. C., Mall, I. D., &Lataye, D. H. (2008) 'Rice husk ash as an effective adsorbent: evaluation of adsorptive characteristics for indigo carmine dye', *Journal of Environmental Management,* vol. 90, pp. 710 – 720.

Lapuerta, M., Hernández, J. J., and Rodríguez, J. (2004) 'Kinetics of devolatilization of forestry wastes from thermogravimetric analysis', *Biomass Bioenergy*, , pp. 385 - 391.

Laszlo, J. A., &Dintzis, F. R. (1994). Crop resides as lon-exchange materials. Treatment of soybean hull and sugar beet fiber (pulp) with epichlorohydrin to improve cation-exchange capacity and physical stability. *Journal of Applied Polymer Science*, *52*(4), 531-538.

Leyva-Ramos, R., Jacobo-Azuara, A., Diaz-Flores, P. E., Guerrero-Coronado, R. M., Mendoza-Barron, J., & Berber-Mendoza, M. S. (2008). Adsorption of Chromium (VI) from an aqueous solution on a surfactant-modified zeolite.*Colloids andSurfaces A: Physicochemical and Engineering Aspects*, *330*(1), 35-41.

Lu, K., Zhang, X. L., Zhao, Y. L., & Wu, Z. L. (2010).Removal of color from textile dyeing waste water by foam separation.*Journal of Hazardous Materials*, *182*(1), 928-932.

Ludueña, L., Fasce, D., Alvarez, V. A., & Stefani, P. M. (2011).Nanocellulosefrom rice husk following alkaline treatment to remove silica.*BioResources*, *6*(2), 1440-1453.

Mahvi, A. H.; Maleki, A., &Eslami A., (2004) Potential of rice husk and rice husk ash for phenol removal in aqueous system. *American Journal* of *Applied* Sciences*1, 321.*

Malik, P. K. (2003) Use of activated carbons prepared from sawdust and rice-husk for adsorption of acid dyes: a case study ofAcid Yellow 36. *Dyes and Pigments,* 56, 239

Man, H. C., Chin, W. H., Zadeh, M. R., &Yusof, M. R. M. (2012). Adsorption potential of unmodified rice husk for boron removal. *BioResources*, *7*(3).

Mi-Na, Z. Xue-Pin, L., & Bi, S. (2006). Adsorption of surfactants on chromium leather waste.*Journal-Society of Leather Technologists and Chemists*, *90*(1), 1.

Mittal, A., Kaur, D., Malviya, A., Mittal, J., & Gupta, V. K. (2009). Adsorption studies on the removal of coloring agent phenol red from wastewater using waste materials as adsorbents. *Journal of Colloid and Interface Science*, *337*(2), 345-354.

Mittal, A., Malviya, A., Kaur, D., Mittal, J., &Kurup, L. (2007).Studies on the adsorption kinetics and isotherms for the removal and recovery of methyl *Materials*, *148*(1), 229-240.

Mittal, A., Mittal, J., Malviya, A., Kaur, D., & Gupta, V. K. (2010).Adsorption of hazardous dye crystal violet from wastewater by waste materials. *Journal of Colloid and Interface Science*, *343*(2), 463-473.

Module 1: Dye Synthesis & Dyeing (2005) retrieved on, May 17 2014 from http://faculty.georgetown.edu/jas2/DYES.pdf

Mohamed, M. M. 2004. Acid dye removal: comparison of surfactant-modified mesoporousfsm-16 with activated carbon derived from rice husk. *Journal of Colloid and Interface Science*272: 28-34

Mohan, D., Singh, K. P., Singh, G., & Kumar, K. (2002).Removal of dyes from wastewater using flyash, a low-cost adsorbent. *Industrial &Engineering Chemistry Research*, *41*(15), 3688-3695.

Moussavi, G., &Khosravi, R. (2011).The removal of cationic dyes from aqueous solutions by adsorption onto pistachio hull waste. *Chemical Engineering Research and Design*, *89*(10), 2182-2189.

Naidoo, S., &Olaniran, A. O. (2013).Treated wastewater effluent as a source of microbial pollution of surface water resources. *International Journal Of Environmental Research And Public Health*, *11*(1), 249-270.

Nakbanpote, W., Thiravetyan, P., &Kalambaheti, C. (2002).Comparison of gold adsorption by *chlorella vulgaris,* rice husk and activated carbon.*Minerals Engineering*, *15*(7), 549-552.

Namasivayam, C. &Sureshkumar, M. V. (2006).Anionicdye adsorption characteristics of surfactant-modified coir pith, a 'waste' lignocellulosic polymer.*Journal of Applied Polymer Science*, *100*(2), 1538-1546.

Namasivayam, C., &Sureshkumar, M. V. (2008). Removal of chromium (vi) from water and wastewater using surfactant modified coconut coir pith as a biosorbent. *Bioresource Technology*, *99*(7), 2218-2225.

Navratilova, Z., Wojtowicz, P., Vaculikova, L., &Sugarkova, V. (2007).sorption of alkylammoniumcations on montmorillonite. *ActaGeodynamicaet Geomaterialia*, *4*(3), 59.

Ngah, W.S.W., Teong, L.C., Hanafiah, M., (2011). Adsorption of dyes and heavy metal ions by chitosan composites: a review.*Carbohydrate Polymer*, 83, 1446–1456.

Oei, B. C., Ibrahim, S., Wang, S., &Ang, H. M. (2009). Surfactant modified barley straw for removal of acid and reactive dyes from aqueous solution. *Bioresource Technology*, *100*(18), 4292-4295.

OlaAbdelwahab, Ahmed El Nemr, Amany El Sikaily&AzzaKhaled (2005). Use of rice husk for adsorption of direct dyes from aqueous solution: a case study of Direct F. Scarlet.*EgyptionJournal of Aquatic Research* 31(1): 1-12.

Ong, S. A., Ho, L. N., Wong, Y. S., &Zainuddin, A. (2013). Adsorption behaviour of cationic and anionic dyes onto acid treated coconut coir. .*Separation Science and Technology*.*41*(15), 3688-3695

Oros, G., Cserháti, T., &Forgács, E. (2003).Separation of the strength and selectivity of the microbiological effect of synthetic dyes by spectral mapping technique. *Chemos,343*(2), 463-473.

Otero, M., Rozada, F., Calvo, L.F., Garcia, A.I., &Moran, A., (2003a). Kinetic and equilibrium modelling of the methylene blue removal from solution by adsorbent materials produced from sewage sludge. *Biochemistry Engineering*. *Journal* 15, 59–68.

Ozcan, A.S., Erdem, B., Ozcan, A., (2004). Adsorption of Acid Blue193 from aqueous solutions ontoNa-Bentonite and DTMA-bentonite.*Journal of Colloid and Interface Science*. 280, 44–54.

Ozdemir, O., Armagan, B., Turan, M., Celik, M.S., (2004).Comparison of the adsorption characteristics of azo-reactive dyes on mezoporous minerals. *Dyes Pigments*62, 49–60.

Park, D., Yun, Y. S., & Park, J. M. (2010).The past, present, and future trends of biosorption. *Biotechnology and Bioprocess Engineering*, *15*(1), 86-102.

Pedro Silva, J., Sousa, S., Rodrigues, J., Antunes, H., Porter, J. J., Gonçalves, I., & Ferreira-Dias, S. (2004). Adsorption of Acid Orange 7 dye in aqueous solutions by spent brewery grains. *Separation and Purification Technology*, *40*(3), 309-315.

Perez, S., &Samain, D. (2010).Structure and Engineering of Celluloses.*Advances in Carbohydrate Chemistry and Biochemistry*, *64*, 25-116.

Pointing, S. B., &Vrijmoed, L. L. P. (2000).Decolorizationof azo and triphenylmethane dyes by pycnoporussanguineus producing laccase as the sole phenoloxidase. *World Journal of Microbiology and Biotechnology*, *16*(3), 317-318.

Pouretedal, H. R., Eskandari, H., Keshavarz, M. H., &Semnani, A. (2009). Photodegradationof organic dyes using nanoparticles of cadmium sulfide doped with manganese, nickel and copper as nanophotocatalyst. *ActaChimicaSlovenica*, *56*(2).

Rangabhashiyam, S., Anu, N., &Selvaraju, N. (2013).Sequestration of dye from textile industry wastewater using agricultural waste products as adsorbents. *Journal of Environmental Chemical Engineering*, *1*(4), 629-641.

Ravi Kumar, M.N.V., Sridhari, T.R., Bhavani, K.D., &Dutta, P.K., 1998. Trends in color removal from textile mill effluents. *Colorage* 40, 25–34.

Reddy, S., Sivaramakrishna, L., &Varada Reddy, A. (2012). The Use of an agricultural waste material, jujuba seeds for the removal of anionic dye (congo red) from aqueous medium. *Journal of Hazardous Materials*, *203*, 118-127.

Sadon, F.N., A. S. Ibrahem, & K.N. Ismail. (2012). Anoverview of rice husk applications and modification techniques in waste water treatment. *Journal of Purity Utility Reaction Environment*.1:308-334.

Safa, Y.,&Bhatti, H. N. (2011). Adsorptive removal of direct dyes by low cost rice husk: effect of treatments and modifications. *African Journal of Biotechnol.*, *10*, 3128.

Safa, Y.; &Bhatti, H. N. (2011) Kinetic and thermodynamic modeling for the removal of Direct Red-31 and Direct Orange-26 Dyes from aqueous solutions by rice husk. *Desalination*, 272, 313.

Safarik, I., &Safarikova, M. (2002).Detection of low concentrations of malachite green and crystal violet in water. *Water Research*, *36*(1), 196-200.

Salleh, M. A. M., Mahmoud, D. K., Karim, W. A. W. A., &Idris, A. (2011). Cationic and anionic dye adsorption by agricultural solid wastes: a comprehensive review. *Desalination*, *280*(1), 1-13.

Senthil Kumar, P., Palaniyappan, M., Priyadharshini, M., Vignesh, A. M., Thanjiappan, A., Sebastina Anne Fernando, P., &Srinath, R. (2013). Adsorption of basic dye onto raw and surface-modified agricultural waste.*Environmental Progress and Sustainable Energy*. 33: 87–98.

Shah, B. A., Shah, A. V., Patel, H. D., & Mistry, C. B. (2013). High-value zeolitic material from bagasse fly ash: utilization for dye elimination. *Water Environment Research*, *85*(6), 558-567.

Silva, L. S., Lima, L. C., Silva, F. C., Matos, J. M. E., Santos, M. R., Santos Júnior, L. S.,&da Silva Filho, E. C. (2013). Dye anionic sorption in aqueous solution onto a cellulose surface chemically modified with Aminoethanethiol.*Chemical Engineering Journal*, *218*, 89-98.

Sincero, A. P., &Sincero, G. A. (2003). Physical-chemical treatment of water and wastewater.IWA Publishing.

Sivakumar, V. M., Thirumarimurugan, M., Xavier, A. M., Sivalingam, A., & Kannadasan, T. (2012) Colourremoval of direct red dye effluent by adsorption process using rice husk.*International Journal of Bioscience, Biochemistry and Bioinformatics,* 2,(6),

Song, J., Zou, W., Bian, Y., Su, F., & Han, R. (2011).Adsorption characteristics of methylene blue by peanut husk in batch and column modes. *Desalination*, *265*(1), 119-125.

Srinivasan, A., &Viraraghavan, T. (2010).Decolorizationof dye waste waters by biosorbents: a review. *Journal of Environmental Management*, *91*(10), 1915-1929.

Stolz, A. (2001). Basic and applied aspects in the microbial degradation of azo dyes. *Applied Microbiology and Biotechnology*, *56*(1-2), 69-80.

Su J, Huang HG, Jin XY, Lu XQ, Chen ZL (2011) Synthesis, characterization and kinetic of a surfactant-modified bentonite used toremove As(III) and As(V) From aqueous solution. *JournalHazard Material* ,185:63–70

Su, Y., Jiao, Y., Dou, C., & Han, R. (2013).Biosorptionof methyl orange from aqueous solutions using cationic surfactant-modified wheat straw in batch mode. *Desalination and Water Treatment*, 1-11.

Sud, D., Mahajan, G., & Kaur, M. P. (2008).Agricultural waste material as potential adsorbent for sequestering heavy metal ions from aqueous solutions–a review. *Bioresource Technology*, *99*(14), 6017-6027.

Sun, R. C., &Tomkinson, J. (2002). Characterization of hemicelluloses obtained by classical and ultrasonically assisted extractions from wheat straw. *Carbohydrate Polymers*, *50*(3), 263-271.

Sureshkumar, M. V., &Namasivayam, C. (2008).Adsorption behavior of direct red 12b and rhodamine b from water onto surfactant-modified coconut coir pith. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *317*(1), 277-283.

Suteu, D., &Malutan, T. (2013). Industrial cellolignin wastes as adsorbent for removal of methylene blue dye from aqueous solutions. *BioResources*, *8*(1).

Syafri, R., Ahmad, I., & Abdullah, I. (2011). Effect of rice husk surface modification by LENR the on mechanical properties of NR/HDPE reinforced rice husk composite. *SainsMalaysiana*, *40*(7), 749-756.

Tabak, A., Eren, E., Afsin, B., &Caglar, B. (2009). Determination of adsorptive properties of a turkishsepiolite for removal of reactive blue 15 anionic dye from aqueous solutions. *Journal of Hazardous Materials*, *161*(2), 1087-1094.

Tarley, C. R. T.,&Arruda,M. A. Z. (2003).Biosorptionof heavy metals using rice milling by-products characterization and application for removal of metals from aqueous effluents.*Chemosphere* 54: 987- 995.

Tehrani-Bagha, A. R., & Holmberg, K. (2013).Solubilization of hydrophobic dyes in surfactant solutions. *Materials*, *6*(2), 580-608.

Teixeira Tarley, C. R., Costa Ferreira, S. L., &ZezziArruda, M. A. (2004). Use of modified rice husks as a natural solid adsorbent of trace metals: characterisationand development of an on-line preconcentration system for cadmium and lead determination by FAAS. *Microchemical Journal*, *77*(2), 163-175.

Tian, D., Zhang, X., Lu, C., Yuan, G., Zhang, W., & Zhou, Z. (2014).Solvent-free synthesis of carboxylate-functionalized cellulose from waste cotton fabrics for the removal of cationic dyes from aqueous solutions. *Cellulose*, *21*(1), 473-484.

Tilaki, D., Ali, R., Balarak, D., &Ghasemi, M. (2014). Removal of Acid Orange 7 (AO7) Dye from aqueous solution by using of adsorption on to rice stem waste: Kinetic and Equilibrium Study. *Iranian Journal of Health Sciences*, *2*(1), 51-61.

Tsai, W. T., Chang, C. Y., Lin, M. C., Chien, S. F., Sun, H. F., & Hsieh, M. F. (2001). Adsorption of acid dye onto activated carbons prepared from agricultural waste bagasse by $ZnCl_2$ activation. *Chemosphere*, *45*(1), 51-58.

Umpuch, C., &Jutarat, B. (2013) Adsorption of organic dyes from aqueous solution by surfactant modified corn straw.*International Journal of Chemical Engineering and Applications*, 4 (3).

Vasanth Kumar, K., &Sivanesan, S. (2007). Sorption isotherm for safranin onto rice husk: comparison of linear and non-linear methods. *Dyes and pigments*, *72*(1), 130-133.

Wan Ngah, W. S., &Hanafiah, M. A. K. M. (2008). Removal of heavy metal ions from wastewater by chemically modified plant wastes as adsorbents: A Review. *BioresourceTechnology*, *99*(10), 3935-3948.

Wongjunda, J., &Saueprasearsit, P. (2010) 'Biosorptionof chromium (vi) using rice husk ash and modified rice husk ash', *Environmental Research Journal,* 4(3), pp. 244 -250.

Yu, Y., Murthy, B. N., Shapter, J. G., Constantopoulos, K. T., Voelcker, N. H., & Ellis, A. V. (2013). Benzene carboxylic acid derivatizedgraphene oxide nanosheets on natural zeolites as effective adsorbents for cationic dye removal.*Journal of Hazardous Materials*, *260*, 330-338.

Yun-nen, C., Jin-xia, N., & Ming, C. (2010).Adsorption behavior of methylene blue dye on rice husk. In *Bioinformatics and Biomedical engineering (iCBBE), 2010 4th International Conference on* (pp. 1-4). IEEE.

Zhang, W., Li, H., Kan, X., Dong, L., Yan, H., Jiang, Z., & Cheng, R. (2012). Adsorption of Anionic Dyes From Aqueous Solutions Using Chemically Modified Straw. *Bioresource Technology*, 117, 40 - 44

Zou, W., Li, K., Bai, H., Shi, X., & Han, R.(2011) Enhanced cationic dyes removal from aqueous solution by oxalic acid modified rice husk. *Journal of Chemical Engineering Data*, 56, 1882