

## BAB V

### KESIMPULAN DAN SARAN

#### 5.1 Kesimpulan

Berdasarkan hasil penelitian mengenai pembuatan dan karakterisasi membran fotokatalitik komposit kitosan-selulosa diasetat-TiO<sub>2</sub> untuk pengolahan limbah zat warna tekstil *Congo red* dapat disimpulkan bahwa:

1. Kinerja dan sifat mekanik membran fotokatalitik komposit kitosan-selulosa diasetat-TiO<sub>2</sub> yang optimum memiliki komposisi kitosan 3%, selulosa diasetat 4% dan TiO<sub>2</sub> 0,3% dengan fluks 1061,540 L/m<sup>2</sup> hari, rejeksi 99,60%, *stress* 0,02250 kN/mm<sup>2</sup>, *strain* 0,05767, dan *modulus young* 0,39015 kN/mm<sup>2</sup>.
2. Efektifitas membran fotokatalitik komposit kitosan-selulosa diasetat-TiO<sub>2</sub> untuk mengolah limbah zat warna tekstil *congo red* dilihat dari nilai fluks sebesar 715,529 L/m<sup>2</sup> hari dan rejeksi 92,19%. Membran kitosan-selulosa diasetat-TiO<sub>2</sub> mampu mengolah limbah zat warna tekstil *congo red* karena adanya TiO<sub>2</sub> dalam membran yang mempunyai aktivitas fotokatalitik dan kemampuan membran sendiri yang dapat memfiltrasi limbah zat warna tekstil *congo red*.
3. Waktu kontak optimum antara membran fotokatalitik komposit kitosan-selulosa diasetat-TiO<sub>2</sub> dengan lampu UV untuk mendegradasi limbah zat warna tekstil *congo red* adalah 180 menit. Hal ini disebabkan oleh semakin lamanya waktu kontak antara TiO<sub>2</sub> dalam membran dengan sinar

UV dalam reaktor sehingga kemampuan  $\text{TiO}_2$  semakin aktif dalam mendegradasi limbah zat warna tekstil *congo red*.

## 5.2 Saran

Berdasarkan penelitian yang telah dilakukan dapat disarankan beberapa hal, antara lain:

1. Perlu dilakukan penelitian lanjutan mengenai komponen membran yang berasal dari polimer alam lainnya yang selama ini hanya menjadi limbah di masyarakat
2. Perlu dilakukan penelitian lanjutan mengenai aplikasi membran dalam mengolah limbah logam berat

**DAFTAR PUSTAKA**

- Alkan, M., Celikcapa, S., Demirbas, O., and Dogan, M., 2005, Removal of reactive blue 221 and acid blue 62 anionic dyes from aqueous solutions by sepiolite, *Dyes Pigments*, **65**, 251–259
- Almeida, E.V.R., Frollini, E., Castellan, A., and Coma, V., 2010, Chitosan, sisal cellulose, and biocomposite chitosan/sisal cellulose films prepared from thiourea/NaOH aqueous solution, *Carbohydrate Polymers*, **80**, 655–664
- Alvarenga, Elson Santiago, Oliveira, Christiane Pereira, Bellato, and Carlos Roberto, 2010, An approach to understanding the deacetylation degree of chitosan, *Carbohydrate Polymers*, **80**, 1155-1160
- Amin, El., A.A., Rashed, M.N., 2007, Photocatalytic Degradation of Methyl Orange in Aqueous Under Different Solar Irradiation Sources, *Journal of Physical Science*, Vol. **2** (3), p. 073-081
- Azzami, El., 2008, Carbon Dioxide Separation from Hydrogen and Nitrogen by Fixed Facilitated Transport in Swollen Chitosan Membranes, Departement of Chemical and Materials Engineering, University of Kentucky, USA
- Bae, Tae-Hyun and Tae-moon Tak, 2005, Effect of TiO<sub>2</sub> Nanoparticles on Fouling Mitigation of Ultrafiltration Membranes for Activated Sludge Filtration, *Journal of Membrane Science*, Seoul National University, South Korea
- Baker, R. W., 2004, *Membrane Technology and Application 2nd ed*, John Wiley & Sons Ltd, Chichester
- Banerjee<sup>1</sup>, S., Judy, Gopal P, Muraleedharan, A. K. Tyagi<sup>1</sup>, and Baldev Rajl, 2006, Physics and chemistry of photocatalytic titanium dioxide: Visualization of bactericidal activity using atomic force microscopy, *Current Science*, **90** : 10
- Brahmana, A., 2008, *Katalog Produk: Water Treatment Plant*, Artikel, Wahana Keserasian Indonesia, Jakarta
- Callister, W.D., David, G. R., 2010, *Material Science and Engineering an Introduction*, Eight Edition, John Wiley & Sonc Inc., USA
- Cassaignon S., Koelsch, M., Jolivet J., 2007, Selective synthesis of brookite, anatase and rutile nanoparticles: thermolysis of TiCl<sub>4</sub> in aqueous nitric acid, *Journal of Materials Science*, **42**:6689-6695

- Chen K.C., Wu, J.Y., Huang C.C., Liang, S.S., Hwang, S.C.J., 2003, Decolorization of azo dye using PVA-immobilized microorganisms, *J. Biotechnol*, **101**, 241–252
- Christina, M., 2007, Studi Pendahuluan Mengenai Degradasi Zat Warna Azo (Metil Orange) dalam Pelarut Air Menggunakan Mesin Berkas Elektron 350 keV/10 mA, BATAN, Yogyakarta
- Choi, W., 2006, *Catalysis Surveys*, Asia, 10, 16
- Drioli, Enrico and Giorno, Lidietta, 2009, *Membrane Operations Innovative Separations and Transformations*, WILEY-VCH, Republik of Germany
- Ernasuryaningtyas, Ike, 2011, **Pembuatan dan Karakterisasi Membran Fotokatalitik Kitosan-TiO<sub>2</sub> dengan Penambahan Polietilen Glikol (PEG) untuk Pengolahan Air Sumur**, *Skripsi*, Universitas Airlangga, Surabaya
- Emsley, J., 2002, *Nature's building blocks, An A-Z Guide to the Elements*, Oxford University Press
- Fatimah, 2005, Titanium-oxide on natural zeolite (TiO<sub>2</sub>-Zeolite) and its application for congo red photodegradation, *Indo J Chem*, **6**: 38-42
- Fengel, D., Wegener, G., 1995, *Kayu Kimia Ultrastruktur Reaksi-Reaksi* (diterjemahkan oleh Hardjono Sastro Hamidjojo), Edisi 1, UGM Press, Yogyakarta
- Filho, J. A. R., Bach, E.E., Barrak, E.R., 2000. Novel Material for Nickel Recuperation, *Materials Research*, Vol **4**:2, 53-57
- Gao, Y., Lee, K.H., Oshima, M., Motomizu, S., 2000, Adsorption Behavior of Metal Ions on Cross-linked Chitosan and the Determination of Oxoanions after Pretreatment with a Chitosan Column, *Analytical Sciences*, Vol:**16**, 1303-1308
- Garcia, J., Ruiz, N., Munoz, I., Domenech, X., Garcia-Hortal, J.A., Torrades, F., Peral, J. 2006, Environmental assessment of different photo-Fenton approaches for commercial reactive dye removal., *J. Hazard. Mater. A*, **138**, 218– 225
- Garland, Carl W., Nibler, Joseph W., Shoemaker, David P., 2003, *Experiments In Physical Chemistry*, Mc Graw-Hill Companies, Inc., New York

- Gong, R., Ding, Y., Li, M., Yang, C., Liu, H., Sun, Y., 2005, Utilization of powdered peanut hull as biosorbent for removal of anionic dyes from aqueous solution, *Dyes Pigments*, **64**, 187–192
- Gunlazuardi, J., 2001, Fotokatalisis Pada Permukaan TiO<sub>2</sub>: Aspek Fundamental dan Aplikasinya, Seminar Nasional Kimia Fisika II, Jakarta, 14-15 Juni
- 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 Technol*, 99, 2938–2946
- Hasan, M.A., and Puteh, Hafiz Mohd, 2007, **Pre-Treatment of Palm Oil Mill Effluent (POME) : Comparison Study Using Chitosan and Alum** **Departement of Chemical Engineering, Facultas of Chemical and Natural Resources Engineering**, *Thesis*, Universiti Teknologi Malaysia, 81310, UTM, Skudai Johor Malaysia
- Janesh, K.A., Alonso, M.J, 2003, Depolymerized chitosan nanoparticles for protein delivery : Preparation and characterization, *Journal of applications of Polimer Science*. **88**, 2769-2776
- Johnson, D.D., and Hilal, N., 2010, *Compreherensive Membrane Science and Engineering Elseiver*, B.V, Italy
- Judd, Simon and Jefferson, Bruce, 2003, *Membranes for industrial wastewater recovery and re-use*, Elsevier Advanced Technology, The Boulevard, Langford Lane, Kidlington Oxford , page 148
- Kalia, Susheel., Kaith, B.S., Kaur, Inderject., 2011, *Comprehensive Membrane Science and Engineering Elseiver*, B.V, Italy
- Kasaai, M. R., 2007, A review of Several Reported Procedures to determine the degree of N-acetylation for Chitin and Chitosan using infrared Spectroscopy, *Carbohydrate Polymers*, **71**, 497-508
- Kavita, K., Rubina, C. and Rameshwar, L.S., 2004, *Industrial & Engineering Chemistry Research*, 43, 7683
- Khan, T.A, 2002, Reporting degree of deacetylation values of chitosan: The influence of analytical methods, *Journal of Pharmacy and Pharmaceutical Science*, 5 (3), 205-212
- Khor, E., 2002, *Chitin: a biomaterial in waiting*, *Curr Opin Solid State Mater*, Vol 6, 3137

- Khor, Eugene, 2001, *Chitin: Fulfilling a Biomaterial Promise*, (ed) Chitin Handbook, Singapore
- Kim, S. F., 2008, **Physicochemical and Functional Properties of Crawfish Chitosan as Affected by Different Processing Protocols**. *Tesis*. Departement of Food Science Louisiana State University
- Kim, D.H., Chui, D.K., Kim, S.J., Lee, K.S, 2008, *Catal. Commun.* **9**, 654
- Kolodziejewska, I., Wojtazs-Pajak, A., Ogonowska G., and Sikorski Z.E., 2000, Deacetylation of chitin in two-stage chemical and enzymatic process, *Bull Sea Fish Inst*, **150**:15-24
- Krisdaningrum, N., 2003, **Pemanfaatan Suspensi TiO<sub>2</sub> Untuk Proses Degradasi Fotokatalisis Senyawa Penta Klorofenol**, *Skripsi*, Jurusan Kimia, Universitas Airlangga, Surabaya
- Kumar, M.N.V.R, 2000, **A Review of Chitin and Chitosan Application**, *Thesis*, Department of Chemistry, University of Roorkee, India
- Lachheb, H., Puzenat, E., Houas, A., Ksibi, M., Elaloui, E., Guillard, C., Hermann, J.M., 2002, Appl. *Catal. B: Environ.* **39**, 75
- Lee, G.D. and Falconer, J.L., 2000. Transient Measurements of Lattice Oxygen in Photocatalytic Decomposition of Formic Acid on TiO<sub>2</sub>, *Catal. Letters*, **70**, 145-148
- Li, Z., Zhuang, X., Liu, X., Guan, Y., & Yao, K., 2002, Study on antibacterial Ocarboxymethylated chitosan/cellulose blend film from LiCl/N,N-dimethylacetamide solution, *Polymer*, **43**, 1541–1547
- Libanori, Rafael, 2008, Effect of TiO<sub>2</sub> surface modification in Rhodamine B Photodegradation, *Springer Science+Business Media*, **95**
- Liu, C., Bai, R., 2005, Preparation of chitosan/cellulose acetate blend hollow fibers for adsorptive performance. *Journal of Membrane Science*, **267**, 68–77
- Liu, X., Li, Y. and Wang, X., 2006, *Materials Letters*, **60**, 1943
- Lodha, *et al.*, 2008, Photocatalytic Degradation of Sunset Yellow FCF in Presence of some Transition Metal Complexes and Hydrogen Peroxide, *J. Chem. Indian*, Vol. **47A**, pp 397-400

- Mall, I.D., Srivastava, V.C., Agarwal, N.K., Mishra, I.M., 2005, Removal of congo red from aqueous solution by bagasse fly ash and activated carbon: kinetic study and equilibrium isotherm analyses, *Chemosphere*, **61**, 492–501
- Mak, Arthur F.T., Sun, Shan, 2008, *Intelligent Material*, editor: Shahinpoor and Schnelder,, The Royal Society of Chemistry, Cambridge
- Mohapatra, Debandya., Sabyasachi, Mishra., Namrata, Sutar., 2010, Banana and Its by-Product Utilisation: an overview, *Journal of Scientific and Industrial Research*, vol **69**, pp 323-329
- Molinari, R., Borgese, M., Drioli, E., Palmisano, L., Schiavello, M., 2002, Hybrid Processes Coupling Photocatalysis and Membranes for Degradation of Organic Pollutans in Water, *Elsevier Catalysis Today* 75, Italy , Page:75-85
- Mourya, V.K., and Inamdar, Nazama N., 2008, Chitosan – Modification Applications: Opportunities Galore, *Reactive & Fungtional Polymers*, **68**: 1013-051
- Mulder, M., 1996, *Basic Principle of Membrane Technology*, Kluwer Academic publ, London
- Mulya, M. dan Suharman. 1995, Analisis Instrumental , Airlangga University Press, Surabaya , hal 31-45
- Muthukumar, M, Selvakumar, N., 2004, Studies on the effect of inorganic salts on decoloration of acid dye effluents by ozonation, *Dyes Pigments*, **62**, 221–228
- Nakamoto, K., 2009, *Infrared and Raman Spectra of Inorganic and Coordination Compound*, sixth edition, John Wiley and Sons Inc, New York
- Neppolian, B., Choi, H.C., Sackthivel, S., Arabindoo, B., Murugesan, V., 2002, *Chemosphere*, **46**, 971
- No, Kyoony., Meyers, S.P., 2000, *Preparation of Chitin and Chitosan dalam R.A.A. Muzzarelli and M.G Peter (ed) Chitin Handbook*, European Chitin Society, Italy
- Noble, Richard D., Stern , S. Alexander, 2003, *Membrane Separations Technology: Principles And Aplications*, Elsevier Science B, V., The Netherlands, page 138
- O'neil, M. J, 2001, *The Merck Index : An Enclopedia of Chemical, Drugs, and Biological*, Merck & Co. Inc, New York , Page:437

- Pabby, Anil K., Syed S.H. Rizvi., Ana Maria Sastre, 2009, *Handbook of Membran Separation: Chemical, Pharmaceutical, Food, and Biotechnological Application*, CRC Press Taylor and Francis Group, United State of America
- Patil, R S., V. Chormade and M.v Desphande, 2000, Chitinolytic enzymes an exploration, *Enz microb technol*, **26**:473-483
- Pinheiro, H.M., Touraud, E., Thomas, O., 2004, Aromatic amines from azo dye reduction: status review with emphasis on direct UV spectrophotometric detection in textile industry wastewaters, *Dyes and Pigments*, **61**, 121–139
- Pretsch, E., Buhlmann, Affolter C, 2006, Structure determination of organic compound, tables of spectral data, *Springer*, Switzerland
- Pudjaatmaka,A.Hadyana, 2002, *Kamus Kimia*, Jakarta:Balai Pustaka, Hal 860
- Puspawati, N.M, Simpen I.N, 2010, **Optimasi Deasetilasi Kitin dari Kulit Udang dan Cangkang Kepiting Limbah Restoran Seafood Menjadi Kitosan Melalui Variasi Konsentrasi NaOH**, *Skripsi*, Jurusan Kimia FMIPA Universitas Udayana, Bukit Jimbaran
- Rao, K.V.S., Srivinas, B., Prasad, A.R., and Subrahmanyam, M., 2000, *Chem.Commun*, 1553-1534
- Roberts, G. A. F., 1992, *Chitin Chemistry*, The Macmillan Press Ltd., London
- Robert, D., 2007, *Catalysis Today*, 122, 20
- Rodrigues Filho G, Monteiro DS, Silva Meireles C, Assuncao RMN, Cerqueira DA, Barud H.S, 2008, *Carbohydr Polym*, **74**:99–105.
- Sadeli, E., 2008, Tenologi Membran Pada Pemrosesan Pangan, *Artikel, Majari Magazine*, Jakarta
- Sjostrom, E, 1997, *Kimia Kayu: Dasar-Dasar dan Penggunaanya* , Edisi Kedua, Gadjah Mada University Press, Yogyakarta
- Sofiana, Nani Dian, 2011, Pembuatan Membran Fotokatalitik dari Selulosa Dasetat Serat Daun Nanas (*Ananas cemosus*) dan TiO<sub>2</sub> untuk Mendegradasi Congo Red, *Skripsi*, Universitas Airlangga, Surabaya
- Soetrisno, 2008, Membran Baru Untuk Efisiensi Desalinasi, *Artikel, Majari Magazine*, Jakarta



- Srijanto, B., 2005, *Kajian Pengembangan Teknologi Proses Produksi Kitin dan Kitosan Secara Kimiawi, Prosiding seminar Nasional Teknik Kimia Indonesia*, Volume I, hal F 01-1 – F01-5
- Stevens, M.P, 2001, *Kimia Polimer*, Terjemahan Iis Sopyan, Paradnya Paramita, Jakarta
- Stephenson, T., Judd, S., Jeffresin, B., and Brindle, K., 2000, *Membran Bioreactor for Wastewater Treatment*, IWA Publishing, London
- Suryani, N.I., 2011, **Sintesis dan Karakterisasi Selulosa Diasetat dari Serat Batang Pisang Raja Bulu (*Musa paradisiaca var sapientum*)**, *Skripsi*, Departemen Kimia, Fakultas Sains dan Teknologi, Universitas Airlangga, Surabaya
- Swaminathan, K., Sandhya, S., Carmalin A., Sophia, K., Pachhade, Y.V., Subrahmanyam, 2003, Decolorization and degradation of H-acid and other dyes using ferrous-hydrogen peroxide system, *Chemosphere*, **50**, 619–625
- Tarbojevich, M., and Cosani A., 1996, *Molecular Weight Determination of Chitin and Chitosan*, Ancona: European Chitin Society
- Timotius, H.K. Mangimbulude, Ch, Jubhar, Meitirniarti, 2002, Biodegradasi Pewarna Azo oleh Konsortium Bakteri, *Seminar Cakrawala Baru Pengembangan Teknologi Tepat Guna Pengolahan Limbah Cair*. 57-64
- Timoti, H., 2005, Aplikasi Teknologi Membran Pada Pembuatan Virgin Coconut Oil (VCO), *Artikel*, Nawapanca Adhi Cipta, Yogyakarta
- Ueno, H., Mori, T., and Fujinaga, T., 2002, Topical Formulations and Wound Healing Application of Chitosan, *Adv. Drug Deliv, Rev*, 59(3): 438-49
- Urreaga, J. M., Orden, M. U. 2006. Chemical interactions and yellowing in chitosan-treated cellulose, *European Polymer Journal*, **42**, 2606–2616
- Vassilyev, Oleksiy, 2006, Efficient Surface Functionalization of Zeolites Via Esterification, *Journal*, Rutgers University, USA
- Velde, K.V. and Kiekens, P., 2004, Structure Analysis and Degree of Substitution of Chitin, Chitosan and Dibuthyrylchitin by FT-IR spectroscopy and solid state <sup>13</sup>C NMR, *Carbohydr. Polym.*, **58**, 409-416
- Waite, TD., 2006, Toxic Organic Destruction by Electron Beam Irradiation An Innovative Technology for Developing Countries, *Thesis*, University of Miami, Coral Gables, Florida

- Wawan Kartika H, 2004, Pulp Kertas Seni dari Tanaman Serat Bukan Kayu Kertas, Berita Selulosa, Vol XVIII, No 1, hal. 27-32
- Wenten, I.G., 2001, *Membrane Technology for Industri and Enviromental Protection*, UNESCO, Center for Membrane Science and Technology
- Wijaya,K., Sugiharto, E., Fatimah,I., Sudiono,S., dan Kurniaysih, D., 2006, *Utilisasi TiO<sub>2</sub>-Zeolit dan Sinar UV untuk Fotodegradasi Zat Warna Congo red*, Berkala MIPA, 16(3), p. 27-35
- Wu, Y. B., Yu, S. H., Mia, L., Wu, C. W., Shyu, S. S., Peng, C. K., 2004, Preparation and characterization on mechanical and antibacterial properties of chitosan/cellulose blends, *Carbohydrate Polymers*, **57**, 435–440
- Yanming, D., Congyi,X., Jianwei, W., Mian, W., Yusong, W.and Yonghong, R., 2001, Determination of Degree of Substitution for N-Acylated Chitosan using IR Spectra, *Sci. China,Ser. B*, 44 (2), 216-224
- Yesilada, O., Asma, D., Cing, S., 2003, Decolorization of textile dyes by fungal pellets, *Process Biochem*, **33**: 933-938.
- Zee, Van der, 2002, Anaerobic azo dye reduction, *Thesis*, Wageningen University, Netherlands
- Zeida, N.Y. Abou, Walya, A.I., Kandileb, N.G., Rushdyc, A.A., El-Sheikha, M.A., Ibrahima, H.M., 2011, Preparation, characterization and antibacterial properties of cyanoethylchitosan/cellulose acetate polymer blended films, *Carbohydrate Polymers*, **84**, 223–230