

BAB V

KESIMPULAN DAN SARAN

V.1. Kesimpulan

1. Proses reduksi dari GO menjadi RGO berhasil dilakukan dengan menggunakan ekstrak kulit jeruk purut sebagai bioreduktornya.
2. Rasio optimal untuk mereduksi GO adalah 1:2 (v/v) (GO:ekstrak kulit jeruk purut) dengan waktu 8 jam.
3. Kapasitas adsorpsi maksimum (q_{\max}) MB dengan menggunakan RGO sebesar 288 mg/g.
4. Profil kinetika adsorpsi MB oleh RGO lebih sesuai dengan model persamaan *pseudo second order*, dan cenderung dikontrol oleh mekanisme *chemisorption*.
5. Profil isoterm adsorpsi MB oleh RGO lebih sesuai dengan model isoterm Langmuir.

V.2. Saran

1. RGO memiliki potensi yang baik dalam mengadsorpsi MB. Oleh karena itu, perlu dikaji lebih lanjut menggunakan limbah industri tekstil.
2. Pengaruh waktu reduksi GO terhadap struktur RGO perlu dipelajari lebih lanjut.

DAFTAR PUSTAKA

1. Chequer, F.M.D., et al., *Textile Dyes: Dyeing Process and Environmental Impact*, in *Eco-Friendly Textile Dyeing and Finishing*, M. Günay, Editor. 2013, InTech: Rijeka. p. Ch. 06.
2. Kuo, W.G., *Decolorizing dye wastewater with Fenton's reagent*. *Water Research*, 1992. **26**(7): p. 881-886.
3. Chan, S.H.S., et al., *Recent developments of metal oxide semiconductors as photocatalysts in advanced oxidation processes (AOPs) for treatment of dye waste-water*. *Journal of Chemical Technology & Biotechnology*, 2011. **86**(9): p. 1130-1158.
4. Ratna, B., *Pollution due to synthetic dyes toxicity & carcinogenicity studies and remediation*. Vol. 3. 2012. 940-955.
5. Vinodhini, P.A. and P.N. Sudha, *Removal of heavy metal chromium from tannery effluent using ultrafiltration membrane*. *Textiles and Clothing Sustainability*, 2016. **2**(1): p. 5.
6. Yurteri, C. and M.D. Gurol, *Removal of dissolved organic contaminants by ozonation*. *Environmental Progress*, 1987. **6**(4): p. 240-245.
7. Padmavathi, R., M. Minnoli, and D. Sangeetha, *Removal of heavy metal ions from waste water using anion exchange polymer membranes*. *International Journal of Plastics Technology*, 2014. **18**(1): p. 88-99.
8. Wang, C.-C., et al., *Photocatalytic organic pollutants degradation in metal-organic frameworks*. *Energy & Environmental Science*, 2014. **7**(9): p. 2831-2867.
9. Lee, J.-Y., et al., *Adsorption of Pb(II) and Cu(II) metal ions on functionalized large-pore mesoporous silica*. *International Journal of Environmental Science and Technology*, 2016. **13**(1): p. 65-76.
10. Singh, K.P., et al., *Color Removal from Wastewater Using Low-Cost Activated Carbon Derived from Agricultural Waste Material*. *Industrial & Engineering Chemistry Research*, 2003. **42**(9): p. 1965-1976.

11. Meshko, V., et al., *Adsorption of basic dyes on granular activated carbon and natural zeolite*. Water Research, 2001. **35**(14): p. 3357-3366.
12. Afkhami, A., M. Saber-Tehrani, and H. Bagheri, *Modified maghemite nanoparticles as an efficient adsorbent for removing some cationic dyes from aqueous solution*. Desalination, 2010. **263**(1): p. 240-248.
13. Qadri, S., A. Ganoe, and Y. Haik, *Removal and recovery of acridine orange from solutions by use of magnetic nanoparticles*. Journal of Hazardous Materials, 2009. **169**(1): p. 318-323.
14. Wang, L., et al., *Adsorption capability for Congo red on nanocrystalline MFe_2O_4 ($M=Mn, Fe, Co, Ni$) spinel ferrites*. Chemical Engineering Journal, 2012. **181-182**(Supplement C): p. 72-79.
15. Konicki, W., M. Aleksandrak, and E. Mijowska, *Equilibrium, kinetic and thermodynamic studies on adsorption of cationic dyes from aqueous solutions using graphene oxide*. Chemical Engineering Research and Design, 2017. **123**: p. 35-49.
16. Zhao, J., et al., *Adsorption of Phenanthrene on Multilayer Graphene as Affected by Surfactant and Exfoliation*. Environmental Science & Technology, 2014. **48**(1): p. 331-339.
17. Yalçın, N. and V. Sevinç, *Studies of the surface area and porosity of activated carbons prepared from rice husks*. Carbon, 2000. **38**(14): p. 1943-1945.
18. Tkachev, S.V., et al., *Reduced graphene oxide*. Inorganic Materials, 2012. **48**(8): p. 796-802.
19. Zollinger, H., *Color chemistry : syntheses, properties, and applications of organic dyes and pigments*. 1987, New York, USA: VCH Publications.
20. Naimah, S., et al., *Degradasi Zat Warna Pada Limbah Cair Industri Tekstil Dengan Metode Fotokatalitik Menggunakan Nanokomposit TiO_2 – Zeolit*. 2014, 2014: p. 12.
21. Nemerow, N.L., *Industrial water pollution : origins, characteristics, and treatment*. 1987, Malabar, FL: Robert E. Krieger Pub. Co.

22. Tiwari, J.N., et al., *Reduced graphene oxide-based hydrogels for the efficient capture of dye pollutants from aqueous solutions*. Carbon, 2013. **56**(Supplement C): p. 173-182.
23. Shahwan, T., et al., *Green synthesis of iron nanoparticles and their application as a Fenton-like catalyst for the degradation of aqueous cationic and anionic dyes*. Chemical Engineering Journal, 2011. **172**(1): p. 258-266.
24. El Qada, E.N., S.J. Allen, and G.M. Walker, *Adsorption of Methylene Blue onto activated carbon produced from steam activated bituminous coal: A study of equilibrium adsorption isotherm*. Chemical Engineering Journal, 2006. **124**(1): p. 103-110.
25. Ghosh, D. and K.G. Bhattacharyya, *Adsorption of methylene blue on kaolinite*. Applied Clay Science, 2002. **20**(6): p. 295-300.
26. Gupta, V.K., et al., *Removal of Basic Dyes (Rhodamine B and Methylene Blue) from Aqueous Solutions Using Bagasse Fly Ash*. Separation Science and Technology, 2000. **35**(13): p. 2097-2113.
27. Sun, D., et al., *Adsorption of anionic dyes from aqueous solution on fly ash*. Journal of hazardous materials, 2010. **181**(1-3): p. 335-342.
28. Raza, H., *Graphene Nanoelectronics*. 2012, Berlin: Springer.
29. Yu, S., et al., *Experimental and theoretical studies on competitive adsorption of aromatic compounds on reduced graphene oxides*. Journal of Materials Chemistry A, 2016. **4**(15): p. 5654-5662.
30. Hummers, W.S. and R.E. Offeman, *Preparation of Graphitic Oxide*. Journal of the American Chemical Society, 1958. **80**(6): p. 1339-1339.
31. Sun, H., L. Cao, and L. Lu, *Magnetite/reduced graphene oxide nanocomposites: One step solvothermal synthesis and use as a novel platform for removal of dye pollutants*. Nano Research, 2011. **4**(6): p. 550-562.
32. Liu, M., et al., *Synthesis of Magnetite/Graphene Oxide Composite and Application for Cobalt(II) Removal*. The

- Journal of Physical Chemistry C, 2011. **115**(51): p. 25234-25240.
33. Aunkor, M.T.H., et al., *The green reduction of graphene oxide*. RSC Advances, 2016. **6**(33): p. 27807-27828.
 34. Thakur, S. and N. Karak, *Green reduction of graphene oxide by aqueous phytoextracts*. Carbon, 2012. **50**(14): p. 5331-5339.
 35. Wang, Y., Z. Shi, and J. Yin, *Facile Synthesis of Soluble Graphene via a Green Reduction of Graphene Oxide in Tea Solution and Its Biocomposites*. ACS Applied Materials & Interfaces, 2011. **3**(4): p. 1127-1133.
 36. Haghghi, B. and M.A. Tabrizi, *Green-synthesis of reduced graphene oxide nanosheets using rose water and a survey on their characteristics and applications*. RSC Advances, 2013. **3**(32): p. 13365-13371.
 37. Muthoosamy, K., et al., *Exceedingly biocompatible and thin-layered reduced graphene oxide nanosheets using an eco-friendly mushroom extract strategy*. International Journal of Nanomedicine, 2015. **10**: p. 1505-1519.
 38. Perrozzi, F., S. Prezioso, and L. Ottaviano, *Graphene oxide: From fundamentals to applications*. Vol. 27. 2014. 013002.
 39. *Chapter 1 - Deposition Technologies: An Overview*, in *Handbook of Deposition Technologies for Films and Coatings (Third Edition)*, P.M. Martin, Editor. 2010, William Andrew Publishing: Boston. p. 1-31.
 40. Gao, E., et al., *Mechanical exfoliation of two-dimensional materials*. Journal of the Mechanics and Physics of Solids, 2018. **115**: p. 248-262.
 41. Wan, Q., et al., *Efficient liquid-phase exfoliation of few-layer graphene in aqueous 1, 1, 3, 3-tetramethylurea solution*. Journal of Colloid and Interface Science, 2018. **526**: p. 167-173.
 42. Chen, J., et al., *An improved Hummers method for eco-friendly synthesis of graphene oxide*. Carbon, 2013. **64**: p. 225-229.
 43. Dimiev, A.M., *Mechanism of Formation and Chemical Structure of Graphene Oxide*. 2017.

44. Dreyer, D.R., et al., *The chemistry of graphene oxide*. Chem Soc Rev, 2010. **39**(1): p. 228-40.
45. De Silva, K.K.H., H.-H. Huang, and M. Yoshimura, *Progress of reduction of graphene oxide by ascorbic acid*. Applied Surface Science, 2018. **447**: p. 338-346.
46. Jamilah, B., et al., *Phenolics in Citrus hystrix leaves obtained using supercritical carbon dioxide extraction*. International Food Research Journal, 2011. **18**(3): p. 941-948.
47. Chan, S., et al., *Optimisation of extraction conditions for phenolic compounds from limau purut (Citrus hystrix) peels*. International Food Research Journal, 2009. **16**(2): p. 203-213.
48. Tripoli, E., et al., *Citrus flavonoids: Molecular structure, biological activity and nutritional properties: A review*. Food Chemistry, 2007. **104**(2): p. 466-479.
49. Devy, N.F., Y. Yulianti, and A. Andriani, *Kandungan Flavonoid dan Limonoid pada Berbagai Fase Pertumbuhan Tanaman Jeruk Kalamondin (Citrus mitis Blanco) dan Purut (Citrus hystrix Dc.)*. 2010, 2010. **20**(1).
50. González-Manzano, S., J.C. Rivas-Gonzalo, and C. Santos-Buelga, *Extraction of flavan-3-ols from grape seed and skin into wine using simulated maceration*. Analytica Chimica Acta, 2004. **513**(1): p. 283-289.
51. Singleton, V.L. and J.A. Rossi, *Colorimetry of Total Phenolics with Phosphomolybdic-Phosphotungstic Acid Reagents*. American Journal of Enology and Viticulture, 1965. **16**(3): p. 144-158.
52. Singleton, V.L., R. Orthofer, and R.M. Lamuela-Raventós, *[14] Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent*, in *Methods in Enzymology*. 1999, Academic Press. p. 152-178.
53. A. Gürses, Ç.D., M. Yalçın, M. Açıkyıldız, R. Bayrak, S. Karaca, *The adsorption kinetics of the cationic dye, methylene blue, onto clay*. Journal of Hazardous Materials, 2006. **Volume 131, Issues 1–3**: p. Pages 217-228.
54. Adam Hughmanick Berger, A.S.B., *Comparing physisorption and chemisorption solid sorbents for use*

separating CO₂ from flue gas using temperature swing adsorption,

- Energy Procedia*. 2011. **Volume 4**: p. Pages 562-567.
55. A Dąbrowski, *Adsorption — from theory to practice*. 2001. **Volume 93**: p. Pages 135-224.
 56. Vipasiri Vimonses, S.L., Bo Jin, Chris W.K. Chow, Chris Saint, *Kinetic study and equilibrium isotherm analysis of Congo Red adsorption by clay materials*. 2009. **Volume 148**: p. Pages 354-364.
 57. Luo, Z., et al., *High Yield Preparation of Macroscopic Graphene Oxide Membranes*. Journal of the American Chemical Society, 2009. **131**(3): p. 898-899.
 58. Jana, M., et al., *Bio-reduction of graphene oxide using drained water from soaked mung beans (*Phaseolus aureus* L.) and its application as energy storage electrode material*. Vol. 186. 2014. 33–40.
 59. Abdolhosseinzadeh, S., H. Asgharzadeh, and H. Seop Kim, *Fast and fully-scalable synthesis of reduced graphene oxide*. Scientific Reports, 2015. **5**: p. 10160.
 60. Conference on Application of, X.r.A. and J.C.-I.C.f.D. Data. *Advances in X-ray analysis : proceedings of the ... annual Conference on Application of X-ray Analysis*. Newtown Square, PA: International Centre for Diffraction Data.
 61. Li, Y., et al., *Comparative study of methylene blue dye adsorption onto activated carbon, graphene oxide, and carbon nanotubes*. Chemical Engineering Research and Design, 2013. **91**(2): p. 361-368.
 62. Draper, N.R. and H. Smith, *Applied Regression Analysis*. 3rd Edition ed. 1998: John Wiley.
 63. Ho, Y.S. and G. McKay, *Pseudo-second order model for sorption processes*. Process Biochemistry, 1999. **34**(5): p. 451-465.
 64. C R, M., et al., *Adsorption behaviour of reduced graphene oxide towards cationic and anionic dyes: Co-action of electrostatic and $\pi - \pi$ interactions*. Vol. 194. 2017.
 65. Sun, C.-J., L.-Z. Sun, and X.-X. Sun, *Graphical Evaluation of the Favorability of Adsorption Processes by Using*

Conditional Langmuir Constant. Industrial & Engineering Chemistry Research, 2013. **52**(39): p. 14251-14260.