

NEW SEMI-IPN HYDROGELS FOR REMOVAL OF HIGH CONCENTRATED CONGO RED DYE FROM AQUEOUS SOLUTIONS

NOOR D. JAFFER, SAFA M. HAMEED, AND ATHIR M. HADDAD

References:

1. Singh, N., Poonia, T., Siwal, S. S., Srivastav, A. L., Sharma, H. K., & Mittal, S. K. (2022). Challenges of water contamination in urban areas. In *Current directions in water scarcity research* (Vol. 6, pp. 173-202). Elsevier.
2. Mohammad, R. E. A., Birniwa, A. H., Abdullahi, S. S. A., & Jagaba, A. H. (2023). Decolourization of textile dyes using CNT-based hybrid materials. In *Nanohybrid Materials for Treatment of Textiles Dyes* (pp. 119-156). Singapore: Springer Nature Singapore.
3. Toledo, P. V., Bernardinelli, O. D., Sabadini, E., & Petri, D. F. (2020). The states of water in tryptophan grafted hydroxypropyl methylcellulose hydrogels and their effect on the adsorption of methylene blue and rhodamine B. *Carbohydrate Polymers*, 248, 116765.
4. Esmaeili, A. (2023). Textile Dyes Removal Using Silica-Dendrimer Hybrid Materials. In *Nanohybrid Materials for Treatment of Textiles Dyes* (pp. 303-342). Singapore: Springer Nature Singapore.
5. Islam, T., Repon, M. R., Islam, T., Sarwar, Z., & Rahman, M. M. (2023). Impact of textile dyes on health and ecosystem: A review of the structure, causes, and potential solutions. *Environmental Science and Pollution Research*, 30(4), 9207-9242.
6. Benkhaya, S., M'rabet, S., & El Harfi, A. (2020). A review of classifications, recent synthesis and applications of textile dyes. *Inorganic Chemistry Communications*, 115, 107891.
7. Kavitha, G., Vinoth Kumar, J., Arulmozhi, R., Kamath, S. M., Priya, A. K., Rao, K. S., & Abirami, N. (2022). 2D graphene supported nickel oxide nano-composite for fiber optic ethanol gas sensing, removal of azo dye, and biological activity. *Journal of Materials Science: Materials in Electronics*, 1-14.
8. Radoor, S., Karayil, J., Jayakumar, A., Kandel, D. R., Kim, J. T., Siengchin, S., & Lee, J. (2023). Recent advances in cellulose-and alginate-based hydrogels for water and wastewater treatment: A review. *Carbohydrate Polymers*, 121339.
9. Bustos-Terrones, Y. A., Hermosillo-Nevárez, J. J., Ramírez-Pereda, B., Vaca, M., Rangel-Peraza, J. G., Bustos-Terrones, V., & Rojas-Valencia, M. N. (2021). Removal of BB9 textile dye by biological, physical, chemical, and electrochemical treatments. *Journal of the Taiwan Institute of Chemical Engineers*, 121, 29-37.
10. Siddiqui, S. I., Allehyani, E. S., Al-Harbi, S. A., Hasan, Z., Abomuti, M. A., Rajor, H. K., & Oh, S. (2023). Investigation of Congo Red Toxicity towards Different Living Organisms: A Review. *Processes*, 11(3), 807.
11. Arab, C., El Kurdi, R., & Patra, D. (2022). Effect of pH on the removal of anionic and cationic dyes using zinc curcumin oxide nanoparticles as adsorbent. *Materials Chemistry and Physics*, 277, 125504.
12. Zhu, H., Chen, S., Duan, H., He, J., & Luo, Y. (2023). Removal of anionic and cationic dyes using porous chitosan/carboxymethyl cellulose-PEG hydrogels: Optimization, adsorption kinetics, isotherm and thermodynamics studies. *International Journal of Biological Macromolecules*, 231, 123213.
13. Villabona-Ortiz, Á., Figueroa-Lopez, K. J., & Ortega-Toro, R. (2022). Kinetics and adsorption equilibrium in the removal of azo-anionic dyes by modified cellulose. *Sustainability*, 14(6), 3640.
14. Nguyen, H. T., Ngwabebhoh, F. A., Saha, N., Saha, T., & Saha, P. (2022). Gellan gum/bacterial cellulose hydrogel crosslinked with citric acid as an eco-friendly green adsorbent for safranin and crystal violet dye removal. *International Journal of Biological Macromolecules*, 222, 77-89.
15. Qu, J., Meng, Q., Peng, W., Shi, J., Dong, Z., Li, Z., ... & Zhang, Y. (2023). Application of functionalized biochar for adsorption of organic pollutants from environmental media: Synthesis strategies, removal mechanisms and outlook. *Journal of Cleaner Production*, 138690.
16. Luo, R., Wang, X., Huang, T., & Tu, C. (2023). Investigation on the methods of measuring aggregate surface energy based on spreading pressure. *Construction and Building Materials*, 378, 131135.
17. Liu, X., Tournassat, C., Grangeon, S., Kalinichev, A. G., Takahashi, Y., & Marques Fernandes, M. (2022). Molecular-level understanding of metal ion retention in clay-rich materials. *Nature Reviews Earth & Environment*, 3(7), 461-476.
18. Aragaw, T. A., & Alene, A. N. (2022). A comparative study of acidic, basic, and reactive dyes adsorption from aqueous solution onto kaolin adsorbent: Effect of operating parameters, isotherms, kinetics, and thermodynamics. *Emerging Contaminants*, 8, 59-74.
19. Umeh, A. C., Hassan, M., Egbuatu, M., Zeng, Z., Al Amin, M., Samarasinghe, C., & Naidu, R. (2023). Multicomponent PFAS sorption and desorption in common commercial adsorbents: Kinetics, isotherm, adsorbent dose, pH, and index ion and ionic strength effects. *Science of The Total Environment*, 904, 166568.

20. Hu, Y. Y., Pan, C., Liu, S., Wang, X., Zheng, X., Hu, F., ... & Peng, X. (2022). Ultra-fast adsorption of radioactive-U (VI) and Cs (I) with high adsorption capacity towards CAA@ MgAlFe spongy-like aerogel: mechanism and application feasibility study. *Journal of Nuclear Materials*, 559, 153463.
21. Pan, L., Wang, C., Wu, W., Li, X., Ma, S., Li, C., ... & Ou, J. (2022). Bioinspired honeycomb-like 3D architectures self-assembled from chitosan as dual-functional membrane for effective adsorption and detection of copper ion. *Microporous and Mesoporous Materials*, 335, 111859.
22. Ahmadian, M., & Jaymand, M. (2023). Interpenetrating polymer network hydrogels for removal of synthetic dyes: A comprehensive review. *Coordination Chemistry Reviews*, 486, 215152.
23. Yang, Y., Zhu, Q., Peng, X., Sun, J., Li, C., Zhang, X., ... & Zhang, Y. (2022). Hydrogels for the removal of the methylene blue dye from wastewater: A review. *Environmental Chemistry Letters*, 20(4), 2665-2685.
24. Safarzadeh, H., Peighambaroust, S. J., Mousavi, S. H., Foroutan, R., Mohammadi, R., & Peighambaroust, S. H. (2022). Adsorption ability evaluation of the poly (methacrylic acid-co-acrylamide)/cloisite 30B nanocomposite hydrogel as a new adsorbent for cationic dye removal. *Environmental Research*, 212, 113349.
25. Blažič, R., Marušić, K., & Vidović, E. (2023). Swelling and Viscoelastic Properties of Cellulose-Based Hydrogels Prepared by Free Radical Polymerization of Dimethylaminoethyl Methacrylate in Cellulose Solution. *Gels*, 9(2), 94.
26. Sood, A., Dev, A., Das, S. S., Kim, H. J., Kumar, A., Thakur, V. K., & Han, S. S. (2023). Curcumin-loaded alginate hydrogels for cancer therapy and wound healing applications: A review. *International Journal of Biological Macromolecules*, 123283.
27. Frent, O. D., Vicas, L. G., Duteanu, N., Morgovan, C. M., Jurca, T., Pallag, A., ... & Marian, E. (2022). Sodium alginate—Natural microencapsulation material of polymeric microparticles. *International Journal of Molecular Sciences*, 23(20), 12108.
28. Wan, P., Wu, S., Liu, Q., Zou, Y., Zhao, Z., & Chen, S. (2022). Recent advances in calcium alginate hydrogels encapsulating rejuvenator for asphalt self-healing. *Journal of Road Engineering*.
29. Halbus, A. F., Salman, J. M., Lafta, A. J., Athab, Z. H., Hasan, F. M., Kamil, A. M., & Hussein, F. H. (2017). Equilibrium, isotherms and thermodynamic studies of congo red adsorption onto *Ceratophyllum Demersum*.
30. Abd-Alwahab, D. R., Abbas, S. H., & Haddad, A. M. (2022). Removal of Congo red by copoly (DMAE-MA-AMPS) hydrogels for water treatment. *Journal of Kufa for Chemical Sciences*, 2(9), 409-435.
31. Alwattar, A. A., Haddad, A., Moore, J., Alshareef, M., Bartlam, C., Woodward, A. W., ... & Quayle, P. (2021). Heavy metal sensors and sequestering agents based on polyaromatic copolymers and hydrogels. *Polymer International*, 70(1), 59-72.
32. Zhang, Y., He, Q., Kobayashi, K., Kusumi, R., & Wada, M. (2023). Hydrogels from dextran/carboxymethyl cellulose exhibited high post-drying swelling ratios and recovery. *Cellulose*, 30(1), 263-276.
33. Alharbi, R. A., Alminderej, F. M., Al-Harby, N. F., Elmehbad, N. Y., & Mohamed, N. A. (2023). Preparation and characterization of a new bis-uracil chitosan-based hydrogel as efficient adsorbent for removal of anionic Congo red dye. *Polymers*, 15(6), 1529.
34. Webber, J. J., Etzold, M. A., & Worster, M. G. (2023). A linear-elastic–nonlinear-swelling theory for hydrogels. Part 2. Displacement formulation. *Journal of Fluid Mechanics*, 960, A38.
35. Vairavel, P., Rampal, N., & Jeppu, G. (2023). Adsorption of toxic Congo red dye from aqueous solution using untreated coffee husks: Kinetics, equilibrium, thermodynamics and desorption study. *International Journal of Environmental Analytical Chemistry*, 103(12), 2789-2808.
36. Ghosh, N., Sen, S., Biswas, G., Saxena, A., & Haldar, P. K. (2023). Adsorption and desorption study of reusable magnetic iron oxide nanoparticles modified with *Justicia adhatoda* leaf extract for the removal of textile dye and antibiotic. *Water, Air, & Soil Pollution*, 234(3), 202.
37. Su, Z. B.; Hu, S. R.; Weng, W.; Li, S. X.; Guo, H. X.; Wu, W. B., NH₂-rich polymer/graphene oxide use as a novel adsorbent for removal of Cu (II) from aqueous solution. *Chemical Engineering Journal*, 263, 280-289 (2015).
38. Mizhir, A., Abdulwahid, A., & Al-Lami, H. (2020). Chemical functionalization graphene oxide for the adsorption behavior of bismarck brown dye from aqueous solutions. *Egyptian Journal of Chemistry*, 63(5), 1679-1696.
39. Ahmad, N., Bano, D., Jabeen, S., Ahmad, N., Iqbal, A., Anwer, A. H., & Jeong, C. (2023). Insight into the adsorption thermodynamics, kinetics, and photocatalytic studies of polyaniline/SnS₂ nanocomposite for dye removal. *Journal of Hazardous Materials Advances*, 10, 100321.
40. Takahashi, I., & Allonas, X. (2023). Novel Peroxide-Free redox initiator based on Saccharin/Electron Donor/Copper salt for radical polymerization. *European Polymer Journal*, 188, 111900.
41. Shahrzaman, M., Islam, M. M., Islam, M. S., Sakib, M. N., Mallik, A. K., Haque, P., & Rahman, M. M. (2020). Semi-IPN Systems for Drug Delivery. *Interpenetrating Polymer Network: Biomedical Applications*, 205-236.
42. Berradi, A., Aziz, F., Achaby, M. E., Ouazzani, N., & Mandi, L. (2023). A Comprehensive Review of Polysaccharide-Based Hydrogels as Promising Biomaterials. *Polymers*, 15(13), 2908.
43. Zhan, Z., Chen, L., Wang, C., Shuai, Y., Duan, H., & Wang, Z. (2023). Super Water-Storage Self-Adhesive Gel for Solar Vapor Generation and Collection. *ACS Applied Materials & Interfaces*, 15(6), 8181-8189.
44. Martinez-Garcia, F. D., Fischer, T., Hayn, A., Mierke, C. T., Burgess, J. K., & Harmsen, M. C. (2022). A beginner's guide to the characterization of hydrogel microarchitecture for cellular applications. *Gels*, 8(9), 535.

45. Wu, Z., Zhang, P., Zhang, H., Li, X., He, Y., Qin, P. & Yang, C., "Tough porous nanocomposite hydrogel for water treatment", *J. Hazard. Mater.*, 421(1), 126-754 (2022).
46. Lei, C., Bian, Y., Zhi, F., Hou, X., Lv, C., & Hu, Q. (2022). Enhanced adsorption capacity of cellulose hydrogel based on corn stalk for pollutants removal and mechanism exploration. *Journal of Cleaner Production*, 375, 134130.
47. Irwansyah, F. S.; Amal, A. I.; Diyanthi, E. W.; Hadisantoso, E. P.; Noviyanti, A. R.; Eddy, D. R.; Risdiana, R. How to read and determine the specific surface area of inorganic materials using the Brunauer-Emmett-Teller (BET) method. *AJSE*. 2024, 4, 1, 61-70; DOI: <https://doi.org/10.17509/ajse.v4i1.60748>.
48. Miao, Y.; Zhai, S.; Pan, M.; Sun, E.; Xia, C.; Lyu, J.; Imai, T. New insight into cell wall pore structure in brown-rotted wood and its utilization as a new low-cost, sustainable adsorbent. *Ind. Crops Prod.* 2024, 208, 117843; DOI:10.1016/j.indcrop.2023.117843.
49. Lee, S. J.; Yu, Y.; Jung, H. J.; Naik, S. S.; Yeon, S.; Choi, M. Y. Efficient recovery of palladium nanoparticles from industrial wastewater and their catalytic activity toward reduction of 4-nitrophenol. *Chemosphere*. 2021, 262, 128358; DOI: 10.1016/j.chemosphere.2020.128358.
50. Qiu, B., Shao, Q., Shi, J., Yang, C., & Chu, H. (2022). Application of biochar for the adsorption of organic pollutants from wastewater: Modification strategies, mechanisms and challenges. *Separation and Purification Technology*, 121925.
51. Zahid, M. et al., "Hybrid nanomaterials for water purification", *Multifunct. Hybrid Nanomater. Sustain. Agri-Food Ecosyst*, 155– 188 (2020).
52. Shahinpour, A., Tanhaei, B., Ayati, A., Beiki, H., & Sillanpää, M. (2022). Binary dyes adsorption onto novel designed magnetic clay-biopolymer hydrogel involves characterization and adsorption performance: Kinetic, equilibrium, thermodynamic, and adsorption mechanism. *Journal of Molecular Liquids*, 366, 120303.
53. Khader, E. H., Khudhur, R. H., Abbood, N. S., & Albayati, T. M. (2023). Decolourisation of anionic azo dye in industrial wastewater using adsorption process: Investigating operating parameters. *Environmental Processes*, 10(2), 34.
54. Aniagor, C. O., Igwegbe, C. A., Ighalo, J. O., & Oba, S. N. (2021). Adsorption of doxycycline from aqueous media: a review. *Journal of Molecular Liquids*, 334, 116124.
55. Bakr, A. A., Sayed, N. A., Salama, T. M., Ali, I. O., Gayed, R. A., & Negm, N. A. (2018). Kinetics and thermodynamics of Mn (II) removal from aqueous solutions onto Mg-Zn-Al LDH/montmorillonite nanocomposite. *Egyptian journal of petroleum*, 27(4), 1215-1220.
56. Alghamdi, A. A., Al-Odayni, A. B., Abduh, N. A., Alramadhan, S. A., Aljboar, M. T., & Saeed, W. S. (2021). Adsorptive performance of polypyrrole-based KOH-activated carbon for the cationic dye crystal violet: kinetic and equilibrium studies. *Adsorption Science & Technology*, 2021, 1-11.
57. Soldatkina, L. & Zavrichko, M., "Equilibrium, kinetic, and thermodynamic studies of anionic dyes adsorption on corn stalks modified by cetylpyridinium bromide", *Colloids and Interfaces*, 3(1), 1-16 (2019).