

DAFTAR PUSTAKA

- Afzal, M.Z., Sun, X.-F., Liu, J., Song, C., Wang, S.G., dan Javed, A., 2018, Enhancement of ciprofloxacin sorption on chitosan/biochar hydrogel beads, *Sci. Total Environ.*, 639, 560–569.
- Ahammad, N.A., Zulkifli, M.A., Ahmad, M.A., Hameed, B.H., dan Din, A.T.M., 2021, Desorption of chloramphenicol from ordered mesoporous carbon-alginate beads: Effects of operating parameters, and isotherm, kinetics, and regeneration studies, *J. Environ. Chem. Eng.*, 9(1), 105015.
- Ahangaran, F., Hassanzadeh, A., dan Nouri, S., 2013, Surface modification of Fe₃O₄@SiO₂ microsphere by silane coupling agent, *Int. Nano Lett.*, 23, 1–5.
- Ahmed, M.B., Zhou, J.L., Ngo, H.H., Guo, W., Johir, M.A.H., Sornalingam, K., dan Rahman, M.S., 2017, Chloramphenicol interaction with functionalized biochar in water: sorptive mechanism, molecular imprinting effect and repeatable application, *Sci. Total Environ.*, 609, 885–895.
- Ajiz, H.A., Ardiansyah, R.P., Dwiatmaka, M.S.K.R., Setyawan, H., Nurtono, T., dan Widiyastuti, W., 2024, Silica surface modification using cellulose as a renewable organosilane derived from coconut coir fiber for carbon capture, *Results Eng.*, 24, 103060.
- Al, T.J., Amir, M., Mahvi, H., Dokht, A., dan Davoud, K., 2021, Effective adsorption of ciprofloxacin antibiotic using powdered activated carbon magnetized by iron(III) oxide magnetic nanoparticles, *J. Porous Mater.*, 28(3), 835–852.
- Al-Shik, L.A., Alshirifi, A.N., dan Alkaim, A.F., 2024, Enhanced removal of Chloramphenicol drug by low cost superabsorbent hydrogel nanocomposite: Optimization, isotherm, and thermodynamic modelling non-linear, *CJES*. 22 (3), 591–599.
- Alawa, B., Singh, S., Chakma, S., Kishor, R., Stålsby Lundborg, C., dan Diwan, V., 2025, Development of novel biochar adsorbent using agricultural waste biomass for enhanced removal of ciprofloxacin from water: Insights into the isotherm, kinetics, and thermodynamic analysis, *Chemosphere*, 375, 144252.
- Alizadeh Eslami, P., Kamboh, M.A., Rashidi Nodeh, H., dan Wan Ibrahim, W.A., 2018, Equilibrium and kinetic study of novel methyltrimethoxysilane magnetic titanium dioxide nanocomposite for methylene blue adsorption from aqueous media, *Appl. Organomet. Chem.*, 32(6).
- Al-jabari, M.H., Sulaiman, S., Ali, S., dan Barakat, R., 2019, Adsorption study of levofloxacin on reusable magnetic nanoparticles: Kinetics and antibacterial activity, *J. Mol. Liq.*, 291, 111249.
- Alyoshina, N.A., dan Parfenyuk, E.V., 2013, Functionalized mesoporous silica materials for molsidomine adsorption: Thermodynamic study, *J. Solid State Chem.*, 205, 211–216.
- Alzahrani, E., 2017, Photodegradation of binary azo dyes using core-shell Fe₃O₄@SiO₂/TiO₂ nanospheres, *Am. J. Anal. Chem.*, 8(1), 95–115.

- Amaria, A., Nuryono, N., dan Suyanta, S., 2017, Preparation of L-Arginine-modified silica-coated magnetite nanoparticles for Au(III) adsorption, *Orient. J. Chem.*, 33.
- Amirmahani, N., Mahdizadeh, H., Malakootian, M., Pardakhty, A., dan Mahmoodi, N.O., 2020, Evaluating nanoparticles decorated on Fe₃O₄@SiO₂-Schiff base (Fe₃O₄@SiO₂-APTMS-HBA) in adsorption of ciprofloxacin from aqueous environments, *J. Inorg. Organomet. Polym. Mater.*, 30(9), 3540–3551.
- Araki, S., Gondo, D., Imasaka, S., dan Yamamoto, H., 2016, Permeation properties of organic compounds from aqueous solutions through hydrophobic silica membranes with different functional groups by pervaporation, *J. Membr. Sci.*, 514, 458–466.
- Ardiyanti, H., Puspitarum, D., Maryana, O.F., dan Pujakesuma, W.A., 2019, Synthesis and bonding analysis of magnetite (Fe₃O₄)/silica (SiO₂) composite based on sugarcane bagasse, *J. Sci. Technol. Appl.*, 2(1), 197–200.
- Ariyani, M., Jansen, L.J.M., Balzer-Rutgers, P., Hofstra, N., van Oel, P., dan van de Schans, M.G.M., 2024, Antibiotic residues in the cirata reservoir, Indonesia and their effect on ecology and the selection for antibiotic-resistant bacteria, *Environ Res*, 262, 119992.
- Asgari, E., Sheikhmohammadi, A., Nourmoradi, H., Nazari, S., dan Aghanaghad, M., 2021, Degradation of ciprofloxacin by photocatalytic ozonation process under irradiation with UVA: Comparative study, performance and mechanism, *Process Saf. Environ. Prot.*, 147, 356–366.
- Ashiq, A., Adassooriya, N.M., Sarkar, B., Rajapaksha, A.U., Ok, Y.S., dan Vithanage, M., 2019, Municipal solid waste biochar–bentonite composite for the removal of antibiotic ciprofloxacin from aqueous media, *J. Environ. Manage.*, 236, 428–435.
- Avci, A., Inci, I., dan Baylan, N., 2020, Adsorption of ciprofloxacin hydrochloride on multiwall carbon nanotube, *IOP Conf. Ser. Mater. Sci. Eng.*, 1206, 012007.
- Ayawei, N., Ebelegi, A.N., dan Wankasi, D., 2017, Modelling and interpretation of adsorption isotherms, *J. Chem.*, 2017, 3039817.
- Aydin, S., Aydin, M.E., Beduk, F., dan Ulvi, A., 2019, Removal of antibiotics from aqueous solution by using magnetic Fe₃O₄/red mud-nanoparticles, *Sci. Total Environ.*, 670, 539–546.
- Badan Standardisasi Nasional., 2000, SNI 01-6366-2000: Batas maksimum cemaran mikroba dan batas maksimum residu dalam bahan makanan asal hewan, Jakarta: BSN.
- Bangi, U.K.H., Rao, A.V., dan Rao, A.P., 2008, A new route for preparation of sodium-silicate-based hydrophobic silica aerogels via ambient-pressure drying, *Sci. Technol. Adv. Mater.*, 9(3).
- Bao, W., Guo, F., Zou, H., Gan, S., Xu, X., dan Zheng, K., 2013, Synthesis of hydrophobic alumina aerogel with surface modification from oil shale ash, *Powder Technol.*, 249, 220–224.
- Bayramoglu, G., Doz, T., Ozalp, V.C., dan Arica, M.Y., 2017, Improvement stability and performance of invertase via immobilization onto silanized and

- polymer brush grafted magnetic nanoparticles, *Food Chem.*, 221, 1442–1450.
- Belay, W.Y., Getachew, M., Tegegne, B.A., Teffera, Z.H., Dagne, A., Zeleke, T.K., Abebe, R.B., Gedif, A.A., Fenta, A., Yirdaw, G., Tilahun, A., dan Aschale, Y., 2024, Mechanism of antibacterial resistance, strategies and next-generation antimicrobials to contain antimicrobial resistance: a review, *Front. Pharmacol.*, 15.
- Benkacher, N., Iggui, K., Mekhania, Z.A., Benhamida, A., Djermoune, A., Ait Merzeg, F., Satha, H., dan Layachi, A., 2025, Influence of surface modification of Algerian palygorskite with triethoxyoctylsilane as a hydrophobic agent for enhanced performance, *J. Coat. Technol. Res.*, 22.
- Bezoen, A., dan Hanekamp, J.C., 2014, Emergence of a debate: AGPs and public health, *World Mycotoxin J.*, 7(4), 293–302.
- Bih, N.L., Rwiza, M.J., Ripanda, A.S., Mahamat, A.A., Machunda, R.L., dan Choi, J.W., 2025, Adsorption of phenol and methylene blue contaminants onto high-performance catalytic activated carbon from biomass residues, *Heliyon*, 11(1), e41150.
- Bilalodin, Sunardi, dan Efeendy, M., 2013, Analisis kandungan senyawa kimia dan uji sifat magnetik pasir besi Pantai Ambal, *J. Fis. Indones.*, XVII(50), 29–31.
- Boshir, M., Zhou, J.L., Hao, H., Guo, W., dan Hasan, A., 2017, Competitive sorption affinity of sulfonamides and chloramphenicol antibiotics toward functionalized biochar for water and wastewater treatment, *Bioresour. Technol.*, 238, 306–312.
- Cabello, F.C., 2006, Heavy use of prophylactic antibiotics in aquaculture: A growing problem for human and animal health and for the environment, *Environ. Microbiol.*, 8(7), 1137–1144.
- Campbell, K.B., 2022, Antimicrobial agents and torsades de pointes, *Elsevier Drug Saf. Sci. Ser.*, 231–266.
- Candra, Sari, P.S., Putri, R.P., Wulandari, dan Fabiani, V.A., 2023, Ekstraksi dan karakterisasi silika dari sekam padi asal Bangka, *J. Kim. Valensi*, 9(2), 145–152.
- Chang, Y.-P., Ren, C.-L., Yang, Q., Zhang, Z.-Y., Dong, L.-J., Chen, X.-G., dan Xue, D.-S., 2011, Preparation and characterization of hexadecyl functionalized magnetic silica nanoparticles and its application in Rhodamine 6G removal, *Appl. Surf. Sci.*, 257(20), 8610–8616.
- Chen, Q., Liu, J., Tang, L., Zeng, Z., dan Zhu, B., 2024, A novel ex-situ method to fabricate pH-responsive material based on core-shell Fe₃O₄@SiO₂ nanoparticles for multi-functional oil-water separation and efficient recycling, *J. Environ. Chem. Eng.*, 12(2), 112422.
- Chen, J., Zhang, J., Li, X., Zhao, C., Zhao, W., dan Xu, P., 2023, Rapid antibiotic adsorption from water using MCM-41-based material, *Water*, 15(22), 4027.
- Cheng, F., Zhou, P., Liu, Y., Huo, X., Zhang, J., Yuan, Y., Zhang, H., Lai, B., dan Zhang, Y., 2021, Graphene oxide mediated Fe(III) reduction for enhancing Fe(III)/H₂O₂ Fenton and photo-Fenton oxidation toward chloramphenicol degradation, *Sci. Total Environ.*, 797, 149097.

- Chirita, M., dan Grozescu, I., 2015, Fe₂O₃ nanoparticles: Physical properties and their photochemical and photoelectrochemical applications, *Bull. Sci. Univ. Politehnica Timisoara*, 54(68), 1–9.
- Chung, J., Chun, J., Lee, J., Hyup, S., Jae, Y., dan Won, S., 2012, Sorption of Pb(II) and Cu(II) onto multi-amine grafted mesoporous silica embedded with nano-magnetite: Effects of steric factors, *J. Hazard. Mater.*, 239–240, 183–191.
- Çok, S.S., dan Gizli, N., 2021, Lightweight and highly hydrophobic silica aerogels dried in ambient pressure for an efficient oil/organic solvent adsorption, *J. Hazard. Mater.*, 408, 124858.
- Crucho, C.I.C., 2024, Silica coatings: From nanostructures to biological entities, *Appl. Mater. Today*, 38, 102179.
- Dai, J., He, J., Xie, A., Gao, L., Pan, J., Chen, X., Zhou, Z., Wei, X., dan Yan, Y., 2016, Novel pitaya-inspired well-defined core-shell nanospheres with ultrathin surface imprinted nanofilm from magnetic mesoporous nanosilica for highly efficient chloramphenicol removal, *Chem. Eng. J.*, 284, 812–822.
- Dai, J., Qin, L., Zhang, R., Xie, A., Chang, Z., dan Tian, S., 2018, Sustainable bovine bone-derived hierarchically porous carbons with excellent adsorption of antibiotics: Equilibrium, kinetic and thermodynamic investigation, *Powder Technol.*, 331, 162–170.
- Danalioglu, S.T., Bayazit, Ş.S., Kerkez, Ö., Alhogbi, B.G., dan Abdel Salam, M., 2017, Removal of ciprofloxacin from aqueous solution using humic acid- and levulinic acid-coated Fe₃O₄ nanoparticles, *Chem. Eng. Res. Des.*, 123, 259–267.
- Danalioglu, S.T., Kerkez Kuyumcu, Ö., Abdel Salam, M., dan Bayazit, Ş.S., 2018, Chitosan grafted SiO₂-Fe₃O₄ nanoparticles for removal of antibiotics from water, *Environ. Sci. Pollut. Res.*, 25(36), 36661–36670.
- Darmawan, A., Utari, R., Saputra, R.E., dan Astuti, Y., 2018, Synthesis and characterization of hydrophobic silica thin layer derived from methyltrimethoxysilane (MTMS), *J. Phys. Conf. Ser.*, 1025, 012012.
- Darmawan, A., Utari, R., Saputra, R.E., Suhartana, dan Astuti, Y., 2018, Synthesis and characterization of hydrophobic silica thin layer derived from methyltrimethoxysilane (MTMS), *IOP Conf. Ser. Mater. Sci. Eng.*, 367, 012032.
- Das, S., Barui, A., dan Adak, A., 2020, Montmorillonite impregnated electrospun cellulose acetate nanofiber sorptive membrane for ciprofloxacin removal from wastewater, *J. Water Process Eng.*, 37, 101497.
- Dewa, E., dan Pasaribu, R., 2020, Analisis kandungan silikon dioksida (SiO₂) pasir Pantai Koka Kabupaten Sikka dengan metode ekstraksi, *Pros. Semin. Nas. Fisika PPs UNM*, 76–79.
- Dhiman, N., dan Sharma, N., 2019, Batch adsorption studies on the removal of ciprofloxacin hydrochloride from aqueous solution using ZnO nanoparticles and groundnut (*Arachis hypogaea*) shell powder: A comparison, *Indian Chem. Eng.*, 61(1), 67–76.
- Din, A.T.M., Ahmad, M.A., dan Hameed, B.H., 2015, Ordered mesoporous carbons originated from non-edible polyethylene glycol 400 (PEG-400) for

- chloramphenicol antibiotic recovery from liquid phase, *Chem. Eng. J.*, 260, 730–739.
- Dizge, N., Keskinler, B., dan Barlas, H., 2009, Sorption of Ni(II) ions from aqueous solution by Lewatit cation-exchange resin, *J. Hazard. Mater.*, 167, 915–926.
- Ebtasari, M. dan Aini, A.N., 2025, Studi Kandungan Residu Antibiotik Kloramfenikol pada Produk Pangan Olahan Madu, Udang, dan Ikan di Sulawesi dan Maluku, *Eruditio: Indonesia Journal of Food and Drug Safety*, 5 (1), 1–9.
- Egbosiuba, T.C., Abdulkareem, A.S., Kovo, A.S., Afolabi, E.A., Tijani, J.O., Auta, M., dan Roos, W.D., 2020, Ultrasonic enhanced adsorption of methylene blue onto the optimized surface area of activated carbon: Adsorption isotherm, kinetics and thermodynamics, *Chem. Eng. Res. Des.*, 153, 315–336.
- El-Alfy, N.Z.I., Emam, A.A.K., Mahmoud, M.F., Morgan, O.N.M., dan El-Ashry, S.R.G.E., 2024, Potential protection by vitamin D against DNA fragmentation and bone marrow cytotoxicity induced by chloramphenicol, *Toxicol. Rep.*, 13, 101828.
- Elena, Á., Gonz, B., Lozano, D., Doadrio, A.L., dan Izquierdo-Barba, I., 2021, Nanoantibiotics based in mesoporous silica nanoparticles: New formulations for bacterial infection treatment, *Pharmaceutics*, 13(8), 1203.
- Ennouri, R., Lavecchia, R., Zuurro, A., Elaoud, S.C., dan Petrucci, E., 2021, Degradation of chloramphenicol in water by oxidation on a boron-doped diamond electrode under UV irradiation, *J. Water Process Eng.*, 41, 101995.
- Fahmiati, N., Nuryono, N., dan Suyanta, S., 2017, Characteristics of iron sand magnetic material from Bugel Beach, Kulon Progo, Yogyakarta, *IOP Conf. Ser. Mater. Sci. Eng.*, 172, 012012.
- Fairus, S., Haryono, Sugita, M.H., dan Sudrajat, A., 2009, Proses pembuatan waterglass dari pasir silika dengan pelebur natrium hidroksida, *J. Tek. Kim. Indones.*, 8(2), 56–62.
- Fajaroh, F., Setyawan, H., Winardi, S., Enggawati, R., Wardhani, I.G., dan Utomo, R.Y., 2010, Stabilisasi nanopartikel magnetite hasil sintesis dengan metode elektrokimia melalui pelapisan silika secara in-situ, *Seminar Rekayasa Kimia dan Proses*, 1–6.
- Falyouna, O., Faizul, M., Maamoun, I., Bensaida, K., Ashik, U.P.M., Sugihara, Y., dan Eljamal, O., 2022, Promotion of ciprofloxacin adsorption from contaminated solutions by oxalate modified nanoscale zerovalent iron particles, *J. Mol. Liq.*, 359, 119323.
- Fan, J., Wang, X., Teng, W., Yang, J., Ran, X., Gou, X., Bai, N., Lv, M., Xu, H., Li, G., Zhang, W., dan Zhao, D., 2017, Phenyl-functionalized mesoporous silica materials for the rapid and efficient removal of phthalate esters, *J. Colloid Interface Sci.*, 487, 354–359.
- Fan, S., Jiang, S., Wang, Z., Liang, P., Fan, W., Zhuo, K., dan Xu, G., 2022, Fabrication of durable superhydrophobic surface for versatile oil/water

- separation based on HDTMS modified PPy/ZnO, *Nanomaterials*, 12(14), 2546.
- Fan, Y., Wang, B., Yuan, S., Wu, X., Chen, J., dan Wang, L., 2010, Adsorptive removal of chloramphenicol from wastewater by NaOH modified bamboo charcoal, *Bioresour. Technol.*, 101(19), 7661–7664.
- Farzinmanesh, O., Hosseini Sabzevari, M., dan Asghariganjeh, M.R., 2024, Efficient removal of ciprofloxacin and ofloxacin from aqueous solutions using a novel nano-scale adsorbent: Modeling, optimization, and characterization, *Chemosphere*, 354, 141640.
- Fukuhara, Y., Ohzuno, Y., Takei, T., dan Yoshida, M., 2021, Effect of alkyl chain length on adsorption and release of hydrophobic drug to/from hydrophobically-modified gelatin hydrogel, *MATEC Web Conf.*, 333, 11008.
- Fei, Y., Li, Y., Han, S., dan Ma, J., 2016, Adsorptive removal of ciprofloxacin by sodium alginate/graphene oxide composite beads from aqueous solution, *J. Colloid Interface Sci.*, 484, 196–204.
- Gao, L., Tang, Y., Wang, C., Yao, L., Zhang, J., Gao, R., Tang, X., Chong, T., dan Zhang, H., 2019, Highly-efficient amphiphilic magnetic nanocomposites based on a simple sol-gel modification for adsorption of phthalate esters, *J. Colloid Interface Sci.*, 552, 142–152.
- Gao, N., Ke, W., Fan, Y., dan Xu, N., 2013, Evaluation of the oleophilicity of different alkoxysilane modified ceramic membranes through wetting dynamic measurements, *Appl. Surf. Sci.*, 283, 863–870.
- Gao, B., Li, P., Yang, R., Li, A., dan Yang, H., 2019, Investigation of multiple adsorption mechanisms for efficient removal of ofloxacin from water using lignin-based adsorbents, *Sci. Rep.*, 9(1), 637.
- Gemeay, A.H., Keshta, B.E., El-Sharkawy, R.G., dan Zaki, A.B., 2020, Chemical insight into the adsorption of reactive wool dyes onto amine-functionalized magnetite/silica core-shell from industrial wastewaters, *Environ. Sci. Pollut. Res.*, 27(26), 32341–32358.
- Giri, A.S., dan Golder, A.K., 2018, Mechanism and identification of reaction byproducts for the degradation of chloramphenicol drug in heterogeneous photocatalytic process, *Groundw. Sustain. Dev.*, 7, 343–347.
- Gomes, C.P., Almeida, M.F., dan Loureiro, M., 2001, Gold recovery with ion exchange used resins, *Sep. Purif. Technol.*, 24, 35–57.
- Goncalves, G., Marques, P.A.A.P., Pinto, R.J.B., Trindade, T., dan Neto, C.P., 2009, Surface modification of cellulosic fibres for multi-purpose TiO₂ based nanocomposites, *Compos. Sci. Technol.*, 69(7–8), 1051–1056.
- Gong, Y., Liu, G., Wang, Q., Zhu, A., dan Liu, P., 2021, Synthesis of a novel mesoporous Fe₃O₄@SiO₂/CTAB-SiO₂ composite material and its application in the efficient removal of bisphenol A from water, *J. Hazard. Mater.*, 406, 124703.
- Gosiamemang, T., dan Heng, J.Y.Y., 2023, Sodium hydroxide catalysed silica sol-gel synthesis: Physicochemical properties of silica nanoparticles and their post-grafting using C8 and C18 alkyl-organosilanes, *Powder Technol.*, 417, 118237.

- Hadi, S., Munasir, M., dan Triwikantoro, T., 2011, Sintesis silika berbasis pasir alam Bancar menggunakan metode kopresipitasi, *J. Fisika dan Aplikasinya*, 7(2), 1–4.
- Hachem, D. and Nguyen, Q.P., 2025, Effect of Organosilane Structures on Mineral Surface Energy and Wettability, *ACS Omega*, 10 (15), 15540–15552.
- Hasan, A., dan Pandey, L.M., 2016, Kinetic studies of attachment and re-orientation of octyltriethoxysilane for formation of self-assembled monolayer on a silica substrate, *Mater. Sci. Eng. C*, 68, 423–429.
- Hasan, D.B., dan Sinulingga, K., 2017, Sintesis dan karakterisasi nanopartikel silika dari abu ampas tebu sebagai filler aluminium, *J. Einstein*, 5(2), 25–31.
- Hayati, R., dan Astuti., 2015, Sintesis nanopartikel silika dari pasir Pantai Purus Padang Sumatera Barat dengan metode kopresipitasi, *J. Fisika Unand*, 4(3), 282–287.
- Hu, J., Chen, G., dan Lo, I.M.C., 2005, Removal and recovery of Cr(VI) from wastewater by maghemite nanoparticles, *Water Res.*, 39, 4528–4536.
- Hu, Y., Zhu, Y., Zhang, Y., Lin, T., Zeng, G., Zhang, S., Wang, Y., He, W., Zhang, M., dan Long, H., 2019, An efficient adsorbent: Simultaneous activated and magnetic ZnO doped biochar derived from camphor leaves for ciprofloxacin adsorption, *Bioresour. Technol.*, 288, 121511.
- Iacoviță, C., Fizeșan, I., Nitica, S., Florea, A., Barbu-Tudoran, L., Dudric, R., Pop, A., Vedeanu, N., Crisan, O., Tetean, R., Loghin, F., dan Lucaciu, C.M., 2021, Silica coating of ferromagnetic iron oxide magnetic nanoparticles significantly enhances their hyperthermia performances for efficiently inducing cancer cells death in vitro, *Pharmaceutics*, 13(12), 2026.
- Idris, Z.M., Hameed, B.H., Ye, L., dan Mattiasson, B., 2020, Amino-functionalised silica-grafted molecularly imprinted polymers for chloramphenicol adsorption, *J. Environ. Chem. Eng.*, 8(5), 103981.
- Iida, H., Takayanagi, K., Nakanishi, T., dan Osaka, T., 2007, Synthesis of Fe₃O₄ nanoparticles with various sizes and magnetic properties by controlled hydrolysis, *J. Colloid Interface Sci.*, 314, 274–280.
- Jia, X., Xie, L., Li, Z., Li, Y., Ming, R., Zhang, Q., Mi, X., dan Zhan, S., 2021, Photo-electro-Fenton-like process for rapid ciprofloxacin removal: The indispensable role of polyvalent manganese in Fe-free system, *Sci. Total Environ.*, 768, 144368.
- Jonville-Béra, A.-P., Largeau, B., di Meglio, F., dan Pariente, A., 2025, The safety profile of fluoroquinolones, *Infect. Dis. Now*, 55(4), 105064.
- Kamgar, A., dan Hassanajili, S., 2020, Super-hydrophobic Fe₃O₄@SiO₂@MPS nanoparticles for oil remediation: The influence of pH and concentration on clustering phenomenon and oil sorption, *Chem. Eng. J.*, 315, 123.
- Kementerian Kesehatan RI. 1999. Peraturan Menteri Kesehatan Nomor 1168/Menkes/PER/X/1999 tentang bahan tambahan pangan, Jakarta: Kemenkes RI.
- Kaya, G.G., Aznar, E., dan Deveci, H., 2021, Low-cost silica xerogels as potential adsorbents for ciprofloxacin removal, *J. Non-Cryst. Solids*, 563, 120783.

- Khan, A.H., Abdul Aziz, H., Palaniandy, P., Naushad, M., dan Zouli, N., 2024, Ciprofloxacin adsorption onto CNT loaded pumice: Adsorption modelling, kinetics, equilibriums and reusability studies, *J. Mol. Liq.*, 399, 124388.
- Khazaei, M.A., Bastani, D., Mohammadi, A., dan Kordzadeh, A., 2022, Adsorption dynamics of surface-modified silica nanoparticles at solid–liquid interfaces, *Langmuir*, 38(41), 12421–12431.
- Khelifa, M., Mellouk, S., Lecomte-Nana, G.L., Batonneau-Gener, I., Marouf-Khelifa, K., dan Khelifa, A., 2023, Methodological approach to the chloramphenicol adsorption by acid-leached halloysites: Preparation, characterization, performance and mechanism, *Microporous Mesoporous Mater.*, 348, 112412.
- Khosroshahi, M.E., dan Ghazanfari, L., 2012, Synthesis and functionalization of SiO₂ coated Fe₃O₄ nanoparticles with amine groups based on self-assembly, *Mater. Sci. Eng. C*, 32(5), 1043–1049.
- Kikivi, J., Mutua, G., Gembo, R.O., dan Orata, F., 2025, Kinetic, isothermal and thermodynamic study on the adsorptive removal of chloramphenicol from water by iron-impregnated Kenyan clinoptilolite zeolite, *React. Kinet. Mech. Catal.*, 136, 411–426.
- Kord, F., Davoud, M., dan Baniasadi, M., 2019, Removal of ciprofloxacin from pharmaceutical wastewater by adsorption on SiO₂ nanoparticle, *J. Water Environ. Nanotechnol.*, 25(6), 1–9.
- Kornak, R., Niznansky, D., Haimann, K., dan Tylus, W., 2005, Synthesis of magnetic nanoparticles via the sol-gel technique, *Mater. Sci.-Poland*, 23(1), 87–92.
- Kosmulski, M., 2020, The pH dependent surface charging and points of zero charge. VIII. Update, *Adv. Colloid Interface Sci.*, 275, 102064.
- Kujawa, J., dan Kujawski, W., 2016, Functionalization of ceramic metal oxide powders and ceramic membranes by perfluoroalkylsilanes and alkylsilanes possessing different reactive groups: Physicochemical and tribological properties, *ACS Appl. Mater. Interfaces*, 8(11), 7509–7521.
- Lach, J., 2022, Adsorption of chloramphenicol on commercial and modified activated carbons, *Adsorpt. Sci. Technol.*, 40(5–6), 237–254.
- Lambert, S., Thill, A., Ginestet, P., Audic, J.M., and Bottero, J.Y., 2000, Structural Interpretations of Static Light Scattering Patterns of Fractal Aggregates, *J Colloid Interface Sci*, 228 (2), 379–385.
- Lee, J., Jo, S.H., dan Lim, J., 2019, Effect of surface modification of CaCO₃ nanoparticles by a silane coupling agent methyltrimethoxysilane on the stability of foam and emulsion, *J. Ind. Eng. Chem.*, 74, 63–70.
- Lee, K., Nah, H., Choi, H., Parale, V.G., dan Park, H., 2018, Methyltrimethoxysilane silica aerogel composite with carboxyl-functionalised multi-wall carbon nanotubes, *Mater. Res. Express*, 15, 587–597.
- Li, H., Jin, H., Li, R., Hua, J., Zhang, Z., dan Li, R., 2024, Magnetic Fe₃O₄@SiO₂ study on adsorption of methyl orange on nanoparticles, *Sci. Rep.*, 14(1), 1217.

- Li, H., Zhang, D., Han, X., dan Xing, B., 2014, Adsorption of antibiotic ciprofloxacin on carbon nanotubes: pH dependence and thermodynamics, *Chemosphere*, 95, 150–155.
- Li, L., Wang, X., Zhang, D., Guo, R., dan Du, X., 2015, Excellent adsorption of ultraviolet filters using silylated MCM-41 mesoporous materials as adsorbent, *Appl. Surf. Sci.*, 328, 26–33.
- Li, P., Chen, Y., Hu, X., dan Lian, H., 2015, Magnetic solid phase extraction for the determination of trace antimony species in water by inductively coupled plasma mass spectrometry, *Talanta*, 134, 292–297.
- Li, T., Sun, F., Zhao, Y., dan Chen, M., 2023, The corrosion resistance of SiO₂-hexadecyltrimethoxysilane hydrophobic coating on AZ91 alloy pretreated by plasma electrolytic oxidation, *Prog. Org. Coat.*, 174, 107232.
- Li, X., Zhang, C., Zhao, R., Lu, X., Xu, X., Jia, X., Wang, C., dan Li, L., 2013, Efficient adsorption of gold ions from aqueous systems with thioamide-group chelating nanofiber membranes, *Chem. Eng. J.*, 229, 420–428.
- Li, Y., Xiao, G., Chen, C., Chen, C., Li, F., dan Lin, L., 2021, Foam stability properties of eco-friendly three-phase foam system reinforced by polydopamine@KH560/(octyl)-trimethoxysilane modified basalt, *Colloids Surf. A Physicochem. Eng. Asp.*, 627, 127147.
- Li, Y., Zhang, J., dan Liu, H., 2018, Removal of chloramphenicol from aqueous solution using low-cost activated carbon prepared from *Typha orientalis*, *Water (Switzerland)*, 10(4), 467.
- Liao, P., Zhan, Z., Dai, J., Wu, X., Zhang, W., Wang, K., dan Yuan, S., 2013, Adsorption of tetracycline and chloramphenicol in aqueous solutions by bamboo charcoal: A batch and fixed-bed column study, *Chem. Eng. J.*, 228, 496–505.
- Lin, C., dan Lee, C., 2020, Adsorption of ciprofloxacin in water using Fe₃O₄ nanoparticles formed at low temperature and high reactant concentrations in a rotating packed bed with co-precipitation, *Mater. Chem. Phys.*, 240, 122049.
- Lin, C.C., dan Lee, C.Y., 2020, Adsorption of ciprofloxacin in water using Fe₃O₄ nanoparticles formed at low temperature and high reactant concentrations in a rotating packed bed with co-precipitation, *Mater. Chem. Phys.*, 240, 122049.
- Lin, Y.-F., Ko, C.-C., Chen, C.-H., Tung, K.-L., dan Chang, K.-S., 2014, Reusable methyltrimethoxysilane-based mesoporous water-repellent silica aerogel membranes for CO₂ capture, *RSC Adv.*, 4(3), 1456–1459.
- Liu, B., Zhang, W., Yang, F., Feng, H., dan Yang, X., 2011, Facile method for synthesis of Fe₃O₄@polymer microspheres and their application as magnetic support for loading metal nanoparticles, *J. Mater. Chem.*, 21(32), 12423–12430.
- Liu, H., Yu, H., Jin, P., Jiang, M., Zhu, G., Duan, Y., Yang, Z., dan Qiu, H., 2020, Preparation of mesoporous silica materials functionalized with various amino-ligands and investigation of adsorption performances on aromatic acids, *Chem. Eng. J.*, 379, 122405.

- Liu, L., Kong, G., Zhu, Y., Lai, D., Zhang, S., dan Che, C., 2022, Ultralight, compressive and superhydrophobic methyltriethoxysilane-modified graphene aerogels for recyclable and selective organic pollutants adsorption from water, *Appl. Surf. Sci.*, 598, 153694.
- Liu, P., Dong, Y., Li, X., Zhang, Y., Liu, Z., Lu, Y., Peng, X., Zhai, R., dan Chen, Y., 2024, Multilayered $\text{Fe}_3\text{O}_4@(\text{ZIF-8})^3$ combined with a computer-vision-enhanced immunosensor for chloramphenicol enrichment and detection, *J. Hazard. Mater.*, 470, 134150.
- Ma, W., Dai, J., Dai, X., dan Yan, Y., 2014, Preparation and characterization of chitosan/kaolin/ Fe_3O_4 magnetic microspheres and their application for the removal of ciprofloxacin, *J. Appl. Polym. Sci.*, 131(20), 40824.
- Ma, Y., Dai, J., Wang, L., Yan, Y., dan Gao, M., 2020, Fabrication of porous molecularly imprinted polymer using halloysite nanotube as template for selective recognition and separation of chloramphenicol, *J. Iran. Chem. Soc.*, 17(3), 555–565.
- Mahmoud, M.E., Saad, S.R., El-Ghanam, A.M., dan Mohamed, R.H.A., 2021, Developed magnetic $\text{Fe}_3\text{O}_4\text{-MoO}_3\text{-AC}$ nanocomposite for effective removal of ciprofloxacin from water, *Mater. Chem. Phys.*, 257, 123454.
- Manoj, G.M., Shalini, M., Thenmozhi, K., Ponnusamy, V.K., dan Hari, S., 2024, Recent advancements in the surface modification and functionalization of magnetic nanomaterials, *Appl. Surf. Sci. Adv.*, 21, 100608.
- Manyi-Loh, C., Mamphweli, S., Meyer, E., dan Okoh, A., 2018, Antibiotic use in agriculture and its consequential resistance in environmental sources: Potential public health implications, *Int. J. Environ. Res. Public Health*, 15(3), 616.
- Mashayekh-Salehi, A., dan Moussavi, G., 2015, Removal of acetaminophen from the contaminated water using adsorption onto carbon activated with NH_4Cl , *Desalin. Water Treat.*, 56(9), 2481–2492.
- Meftah, N., Hani, A., dan Merdas, A., 2023, Extraction and physicochemical characterization of highly-pure amorphous silica nanoparticles from locally available dunes sand, *Chem. Afr.*, 6(6), 3039–3048.
- Meng, X., Liu, Z., Wang, S., dan Kong, F., 2021, Synergistic degradation of chloramphenicol by an ultrasound-enhanced Fenton-like sponge iron system, *Water (Switzerland)*, 13(24), 3584.
- Milijasevic, M., Veskovic-Moracanin, S., Babic Milijasevic, J., Petrovic, J., dan Nastasijevic, I., 2024, Antimicrobial resistance in aquaculture: Risk mitigation within the One Health context, *Foods*, 13(15), 2448.
- Millanao, A.R., Mora, A.Y., Villagra, A., Bucarey, S.A., dan Hidalgo, A.A., 2021, Biological effects of quinolones: A family of broad-spectrum antimicrobial agents, *Biomed. Res. Int.*, 2021, 6648559.
- Mirizadeh, A., dan Hejazi, P., 2025, MPS polymer functionalized silica-coated magnetic nanoparticles for selective adsorption of BSA: An insight into adsorption mechanisms, *Colloids Surf. A Physicochem. Eng. Asp.*, 705, 135647.

- Mishra, S., Singh, A.K., Cheng, L., Hussain, A., dan Maiti, A., 2023, Occurrence of antibiotics in wastewater: Potential ecological risk and removal through anaerobic–aerobic systems, *Environ. Res.*, 226, 115678.
- Mitchell, S.M., Ullman, J.L., Teel, A.L., dan Watts, R.J., 2015, Hydrolysis of amphenicol and macrolide antibiotics: Chloramphenicol, florfenicol, spiramycin, and tylosin, *Chemosphere*, 134, 504–511.
- Mohamed Idris, Z., Hameed, B.H., Ye, L., Hajizadeh, S., Mattiasson, B., dan Mohd Din, A.T., 2020, Amino-functionalised silica-grafted molecularly imprinted polymers for chloramphenicol adsorption, *J. Environ. Chem. Eng.*, 8(5), 104002.
- Mohammed, E.A.H., Kovács, B., Kuunya, R., Mustafa, E.O.A., Abbo, A.S.H., dan Pál, K., 2025, Antibiotic resistance in aquaculture: Challenges, trends analysis, and alternative approaches, *Antibiotics*, 14(6), 598.
- Mohanan, S., Guan, X., Liang, M., Karakoti, A., dan Vinu, A., 2024, Stimuli-responsive silica silanol conjugates: Strategic nanoarchitectonics in targeted drug delivery, *Small*, 20(39), 2402321.
- Mohd Din, A.T., Ahmad, M.A., dan Hameed, B.H., 2015, Ordered mesoporous carbons originated from non-edible polyethylene glycol 400 (PEG-400) for chloramphenicol antibiotic recovery from liquid phase, *Chem. Eng. J.*, 260, 730–739.
- Mokni, S., Tlili, M., Jedidi, N., dan Hassen, A., 2022, Applicability of electrocoagulation process to the treatment of ofloxacin and chloramphenicol in aqueous media: Removal mechanism and antibacterial activity, *J. Water Process Eng.*, 49, 103080.
- Mondal, S.K., Saha, A.K., dan Sinha, A., 2018, Removal of ciprofloxacin using modified advanced oxidation processes: Kinetics, pathways and process optimization, *J. Clean. Prod.*, 171, 1203–1214.
- Mosayebi, M., Salehi, Z., Doosthosseini, H., Tishbi, P., dan Kawase, Y., 2020, Amine, thiol, and octyl functionalization of GO-Fe₃O₄ nanocomposites to enhance immobilization of lipase for transesterification, *Renew. Energy*, 154, 569–580.
- Movasaghi, Z., Yan, B., dan Niu, C., 2019, Adsorption of ciprofloxacin from water by pretreated oat hulls: Equilibrium, kinetic, and thermodynamic studies, *Ind. Crops Prod.*, 127, 237–250.
- Muflikhah, N., Rusdiarso, B., Putra, E.G.R., dan Nuryono, N., 2017, Modification of silica coated on iron sand magnetic material with chitosan for adsorption of Au(III), *Indones. J. Chem.*, 17(2), 264–273.
- Mujiyanti, D.R., Nuryono, N., dan Kunarti, E.S., 2010, Sintesis dan karakterisasi silika gel dari abu sekam padi yang diimmobilisasi dengan 3-(trimetoksisilil)-1-propantiol, *J. Sains Terapan Kim.*, 4(2), 150–167.
- Munasir, M., Triwikantoro, T., dan Zainuri, M., 2013, Analisis komposit Fe₃O₄/C-SiO₂ dari pasir Talaud dan pasir Lumajang, *J. Penelit. Fisika dan Aplikasinya (JPFA)*, 3(2), 12–17.
- Muteeb, G., Rehman, M.T., Shahwan, M., dan Aatif, M., 2023, Origin of antibiotics and antibiotic resistance, and their impacts on drug development: A narrative review, *Pharmaceuticals*, 16(11), 1615.

- Mufit, Fatni, Fadhillah, Amr, H and Bijaksana, S., 2006, Kajian Tentang Sifat Magnetik Pasir Besi dari Pantai Sunur Pariaman Sumatera Barat, *Jurnal Geofisika*.
- Naat, J.N., Lapailaka, T., Sabarudin, A., dan Tjahjanto, R.T., 2018, Synthesis and characterization of chitosan-silica hybrid adsorbent from the extraction of Timor-East Nusa Tenggara island silica and its application to adsorption of copper(II) ion, *Rasayan J. Chem.*, 11(4), 1467–1476.
- Nadargi, D.Y., Gurav, J.L., El Hawi, N., Rao, A.V., dan Koebel, M., 2010, Synthesis and characterization of transparent hydrophobic silica thin films by single step sol-gel process and dip coating, *J. Alloys Compd.*, 496(1–2), 436–441.
- Nassar, M.Y., Ahmed, I.S., dan Abo-Raya, M.A., 2019, A facile and tunable approach for synthesis of pure silica nanostructures from rice husk for the removal of ciprofloxacin drug from polluted aqueous solutions, *J. Mol. Liq.*, 277, 312–321.
- Nguyen, V.T., Pham, N.A.T., Duong, T.H.T., Nguyen, T.V., Pham, L.H., Ly, P.H., Nguyen, D.M., Thuy, N.T.N., dan Hoang, D., 2024, High-performance hydrophobic aerogel based on nanocellulose, graphene oxide, polyvinyl alcohol, and hexadecyltrimethoxysilane: Structure, properties, and applicability, *J. Environ. Chem. Eng.*, 12(4), 113215.
- Nikmah, A., Taufiq, A., dan Hidayat, A., 2019, Synthesis and characterization of Fe₃O₄@SiO₂ nanocomposites, *IOP Conf. Ser. Earth Environ. Sci.*, 276(1), 012020.
- Nizar, M., dan Supardi, I., 2016, Sintesis SiO₂ berbahan dasar abu vulkanik sebagai adsorben ion Pb(II), *J. Inov. Fis. Indones.*, 5(1), 28–32.
- Novak, S., Chaves, T.F., Martins, L., dan Santilli, C.V., 2020, Preparation of hydrophobic MFI zeolites containing hierarchical micro-mesopores using seeds functionalized with octyltriethoxysilane, *Colloids Surf. A Physicochem. Eng. Asp.*, 585, 124109.
- Nuryono, N., Miswanda, D., Candra, S., Sakti, W., Rusdiarso, B., Anggo, P., Utami, N., Otomo, R., dan Kamiya, Y., 2020, Chitosan-functionalized natural magnetic particle@silica modified with (3-chloropropyl) trimethoxysilane as a highly stable magnetic adsorbent for gold(III) ion, *Mater. Chem. Phys.*, 255, 123507.
- Nuryono, N., Rosiati, N.M., Rusdiarso, B., Candra, S., Sakti, W., dan Tanaka, S., 2014, Coating of magnetite with mercapto modified rice hull ash silica in a one-pot process, *Arab. J. Chem.*, 7(6), 1025–1032.
- Nuryono, N., Sukamto, S., Kunarti, E.S., Krisbiantoro, P.A., Wan Abdullah, W.N., dan Kamiya, Y., 2025, Magnetically separable silica-chitosan hybrids for efficient phosphate adsorption in aqueous solution, *Case Stud. Chem. Environ. Eng.*, 11, 101100.
- Öztürk, D., dan Mihçioğur, H., 2021, Production of innovative magnetic adsorbent Fe₃O₄@PEI®Tween 85 and removal of oxytetracycline from aqueous media, *Sep. Sci. Technol.*, 56(3), 481–492.

- Park, M., Shim, I.-K., Jung, E.-Y., dan Choy, J.-H., 2004, Modification of external surface of laponite by silane grafting, *J. Phys. Chem. Solids*, 65(2–3), 499–501.
- Parsa, J.B., Panah, T.M., dan Chianeh, F.N., 2016, Removal of ciprofloxacin from aqueous solution by a continuous flow electrocoagulation process, *Int. J. Environ. Sci. Technol.*, 13, 893–901.
- Peng, H., Wang, H., Wu, J., Meng, G., Wang, Y., Shi, Y., Liu, Z., dan Guo, X., 2016, Preparation of superhydrophobic magnetic cellulose sponge for removing oil from water, *Ind. Eng. Chem. Res.*, 55(3), 832–838.
- Peng, X., Hu, F., Lam, F.L.-Y., Wang, Y., Liu, Z., dan Dai, H., 2015, Adsorption behavior and mechanisms of ciprofloxacin from aqueous solution by ordered mesoporous carbon and bamboo-based carbon, *J. Colloid Interface Sci.*, 460, 349–360.
- Peng, X., Hu, F., Zhang, T., Qiu, F., dan Dai, H., 2018, Amine-functionalized magnetic bamboo-based activated carbon adsorptive removal of ciprofloxacin and norfloxacin: A batch and fixed-bed column study, *Bioresour. Technol.*, 249, 924–934.
- Peralta, M.E., Mártire, D.O., Moreno, M.S., Parolo, M.E., dan Carlos, L., 2021, Versatile nanoadsorbents based on magnetic mesostructured silica nanoparticles with tailored surface properties for organic pollutants removal, *J. Environ. Chem. Eng.*, 9(1), 104841.
- Perera, H.J., Latifi, R., dan Blum, F.D., 2019, Development of structure in hexadecyltrimethoxysilane adsorbed on silica, *J. Phys. Chem. C*, 123(31), 19005–19012.
- Pham, T.D., Vu, T.N., Nguyen, H.L., Hai, P., dan Le, P., 2020, Adsorptive removal of antibiotic ciprofloxacin from water, *Polymers (Basel)*, 12(57), 120.
- Pyo, C.E., dan Chang, J.H., 2021, Hydrophobic mesoporous silica particles modified with nonfluorinated alkyl silanes, *ACS Omega*, 6(24), 16100–16109.
- Qalyoubi, L., Al-Othman, A., dan Al-Asheh, S., 2022, Removal of ciprofloxacin antibiotic pollutants from wastewater using nano-composite adsorptive membranes, *Environ. Res.*, 215, 114182.
- Qi, J., Liu, X., Zhang, Y., Zhu, G., Tang, S., Yu, X., Su, Y., Chen, S., Liang, D., dan Chen, G., 2022, Adsorption of chloramphenicol from water using *Carex meyeriana* Kunth-derived hierarchical porous carbon with open channel arrays, *Environ. Sci. Pollut. Res.*, 30(11), 31060–31076.
- Qin, L., Zhou, Z., Dai, J., Ma, P., Zhao, H., He, J., Xie, A., Li, C., dan Yan, Y., 2016, Novel N-doped hierarchically porous carbons derived from sustainable shrimp shell for high-performance removal of sulfamethazine and chloramphenicol, *J. Taiwan Inst. Chem. Eng.*, 62, 228–238.
- Qin, S., Fan, Y., Li, X., Zhang, Y., dan Qi, S., 2018, Rapid preparation of methyltrimethoxy-modified magnetic mesoporous silica as an effective solid-phase extraction adsorbent, *J. Sep. Sci.*, 41(3), 669–677.
- Qin, S.-B., Fan, Y.-H., Mou, X.-X., Li, X.-S., dan Qi, S.-H., 2018, Preparation of phenyl-modified magnetic silica as a selective magnetic solid-phase

- extraction adsorbent for polycyclic aromatic hydrocarbons in soils, *J. Chromatogr. A*, 1568, 29–37.
- Qu, Y., Huang, R., Qi, W., Qu, Q., Su, R., dan He, Z., 2017, Structural insight into stabilization of Pickering emulsions with $\text{Fe}_3\text{O}_4@\text{SiO}_2$ nanoparticles for enzyme catalysis in organic media, *Part. Part. Syst. Charact.*, 34(7).
- Quynh, H.G., Kiet, N.A., Thanh, H.V., Tue, T.M., Truc Phuong, N.T., dan Long, N.Q., 2021, Removal of aqueous organic pollutant by photo-Fenton process using low-cost Fe_3O_4 /zeolite A, *IOP Conf. Ser. Earth Environ. Sci.*, 947(1), 012051.
- Radabutra, S., Srisombat, S., Khemthong, P., Saengsuwan, S., Youngjan, S., Butburee, T., dan Thedsakhulwong, A., 2022, Superhydrophobic and superoleophilic natural rubber latex foam coated by hexadecyltrimethoxysilane modified halloysite nanotube for oil/water separation, *Mater. Today Commun.*, 33, 104376.
- Ragadhita, R., dan Nandiyanto, A.B.D., 2021, How to calculate adsorption isotherms of particles using two-parameter monolayer adsorption models and equations, *Indones. J. Sci. Technol.*, 6(1), 205–234.
- Rahal, J.J., dan Simberkoff, M.S., 1979, Bactericidal and bacteriostatic action of chloramphenicol against meningeal pathogens, *Antimicrob. Agents Chemother.*, 16(1), 13–18.
- Raheem, A., Rahman, N., dan Khan, S., 2024, Monolayer adsorption of ciprofloxacin on magnetic inulin/Mg–Zn–Al layered double hydroxide: Advanced interpretation of the adsorption process, *Langmuir*, 40(25), 12939–12953.
- Raini, M., 2016, Fluoroquinolones antibiotics: Benefit and side effects, *Buletin Penelitian Kesehatan*, 44(3), 163–174.
- Ramezani, M., Vaezi, M.R., dan Kazemzadeh, A., 2014, Preparation of silane-functionalized silica films via two-step dip coating sol–gel and evaluation of their superhydrophobic properties, *Appl. Surf. Sci.*, 317, 147–153.
- Rao, A.V., Latthe, S.S., Mahadik, S.A., dan Kappenstein, C., 2011, Mechanically stable and corrosion resistant superhydrophobic sol–gel coatings on copper substrate, *Appl. Surf. Sci.*, 257(13), 5772–5776.
- Rasoulzadeh, H., Mohseni-Bandpei, A., Hosseini, M., dan Safari, M., 2019, Mechanistic investigation of ciprofloxacin recovery by magnetite–imprinted chitosan nanocomposite: Isotherm, kinetic, thermodynamic and reusability studies, *Int. J. Biol. Macromol.*, 140, 1047–1057.
- Riandani, U., 2014, Preparasi dan karakterisasi keramik silika dari daun bambu hasil leaching asam sitrat dan suhu pembakaran 800–1000 °C, *Pros. Sem. Nas. Fisika*, 2, 45–50.
- Ristiana, D.D., Suyanta, S., dan Nuryono, N., 2022, Sulfonic acid-functionalized silica with controlled hydrophobicity as an effective catalyst for esterification of levulinic acid, *Mater. Today Commun.*, 32, 103953.
- Romdhani, M., Attia, A., Charcosset, C., Mahouche-Chergui, S., Ates, A., Duplay, J., dan Ben Amar, R., 2023, Optimization of paracetamol and chloramphenicol removal by novel activated carbon derived from sawdust using response surface methodology, *Sustainability*, 15(3), 2516.

- Safa Kamila, N., Alfarisyi Syah, A., dan Ricky Wijaya, A., 2024, Application of silica from beach sand in the synthesis of calcium-alginate-silica as adsorbent of Na^+ and Cl^- ions, *E3S Web Conf.*, 481, 03011.
- Salazar-Camacho, C., Villalobos, M., Rivas-Sánchez, L., Arenas-Alatorre, J., Alcaraz-Cienfuegos, J., dan Gutiérrez-Ruiz, M.E., 2013, Characterization and surface reactivity of natural and synthetic magnetites, *Chem. Geol.*, 347, 233–245.
- Samadhiya, A., Jhinge, P.K., dan Kushwah, K.K., 2023, An experimental investigation on synthesized and characterized self-cleaning modified superhydrophobic nano- SiO_2 coating for solar photovoltaic application: Effects of HDTMS & TEA, *Indian J. Eng. Mater. Sci.*, 30(4), 425–432.
- Samraj, J., Gurusamy, A., Perachiselvi, M., Bagavathy, S., Samraj, J.J., Pushpalaksmi, E., dan Annadurai, G., 2020, Synthesis and characterization of Mn_3O_4 nanoparticles for biological studies, *Appl. Ecol. Environ. Sci.*, 8(5), 273–277.
- Sari, J.M. dan Hafiludin, H., 2023, Analisis Kadar Residu Antibiotik Kloramfenikol Pada Udang Vannamei (*Litopenaeus Vannamei*) Di Kabupaten Bangkalan Dengan Metode Elisa (Enzym Link Immunosorbent Assay), *Juvenil*, 4 (2), 84–89.
- Santos D.S , M.E., Lied, E.B., Costa Junior, I.L., Bittencourt, P.R.S., José Baraldi, I., Giona, R.M., Trevisan, A.P., Passig, F.H., dan de Carvalho, K.Q., 2023, Optimizing ciprofloxacin removal using ion exchange resin: Exploring operational parameters and assessing toxicity, *Chem. Eng. Sci.*, 282, 119317.
- Selvarajan, V., Obuobi, S., Lai, P., dan Ee, R., 2020, Silica nanoparticles versatile tool for the treatment of bacterial infections, *Nanomaterials*, 10(3), 559.
- Sert Çok, S., Koç, F., Len, A., Almásy, L., dan Dudás, Z., 2025, Silica aerogels modified with vinyl, epoxide, methacrylate moieties for the removal of ciprofloxacin by adsorption from water, *Sep. Purif. Technol.*, 354, 129112.
- Shao, Z., He, X., Cheng, X., dan Zhang, Y., 2017, A simple facile preparation of methyltriethoxysilane based flexible silica aerogel monoliths, *Mater. Lett.*, 204, 93–96.
- Shao, Z., Luo, F., Cheng, X., dan Zhang, Y., 2013, Superhydrophobic sodium silicate based silica aerogel prepared by ambient pressure drying, *Mater. Chem. Phys.*, 141(1), 570–575.
- Sheikhmohammadi, A., Safari, M., Alinejad, A., Esrafil, A., Nourmoradi, H., dan Asgari, E., 2019, The synthesis and application of $\text{Fe}_3\text{O}_4@\text{SiO}_2$ nanoparticles functionalized with 3-aminopropyltriethoxysilane as an efficient sorbent for the adsorption of ethylparaben from wastewater: Synthesis, kinetic, thermodynamic and equilibrium studies, *J. Environ. Chem. Eng.*, 7(5), 103315.
- Shen, Y.F., Tang, J., Nie, Z.H., Wang, Y.D., Ren, Y., dan Zuo, L., 2009, Preparation and application of magnetic Fe_3O_4 nanoparticles for wastewater purification, *Sep. Purif. Technol.*, 68, 312–319.
- Silvia, L., 2020, Analisis silika (SiO_2) hasil kopresipitasi berbasis bahan alam menggunakan uji XRF dan XRD, *J. Fisika dan Aplikasinya*, 16(2), 56–62.

- Sing, K.S.W., 1985, Reporting physisorption data for gas/solid systems with special reference to the determination of surface area and porosity (Recommendations 1984), *Pure Appl. Chem.*, 57(4), 603–619.
- Sinha Ray, S., Lee, H.K., Huyen, D.T.T., Park, Y.-I., Park, H., Nam, S.-E., Kim, I.-C., dan Kwon, Y.-N., 2021, Fluorine-free anti-droplet surface modification by hexadecyltrimethoxysilane-modified silica nanoparticles-coated carbon nanofibers for self-cleaning applications, *Prog. Org. Coat.*, 153, 106165.
- Śniegocki, T., Sell, B., Giergiel, M., dan Posyniak, A., 2020, Determination of chloramphenicol by QuEChERS and HPLC-MS/MS combination in matrices of animal origin, *Food Addit. Contam. Part A Chem. Anal. Control Expo. Risk Assess.*, 37(3), 401–409.
- Su, H., Xu, W., Hu, X., Xu, Y., Wen, G., dan Cao, Y., 2021, Spatiotemporal variations and source tracking of antibiotics in an ecological aquaculture farm in Southern China, *Sci. Total Environ.*, 763, 143022.
- Su, J.F., Wu, Z.Z., Huang, T.L., Zhang, H., dan Li, J.W., 2020, A new technology for simultaneous calcium–nitrate and fluoride removal in the biofilm reactor, *J. Hazard. Mater.*, 399, 122846.
- Suardana, P., Sumadiyasa, M., dan Hendrawan, I.G., 2022, Study of magnetite crystal structure extracted from local sands of Tegal Lenga Beach, *J. Mater. Sci. Chem. Eng.*, 10(9), 1–9.
- Sufiandi, D., 2011, Konsentrasi pasir besi titan dari pengotornya dengan cara magnetik, *Majalah Metalurgi*, 26(1), 15–20.
- Sun, C., Wang, G., Liu, Y., Bei, K., Yu, G., Zheng, W., dan Liu, Y., 2024, The adsorption mechanism and optimal dosage of walnut shell biochar for chloramphenicol, *Heliyon*, 10(20), e39123.
- Sun, S., Guo, H., Ke, Q., Sun, J., Shi, S., Zhang, M., dan Zhou, Q., 2009, Degradation of antibiotic ciprofloxacin hydrochloride by photo-Fenton oxidation process, *J. Environ. Sci.*, 21(6), 753–759.
- Sun, Y., Waterhouse, G.I.N., Qiao, X., Xiao, J., dan Xu, Z., 2023, Determination of chloramphenicol in food using nanomaterial-based electrochemical and optical sensors – A review, *Food Chem.*, 410, 135434.
- Suprpto, H., Sudarno, S., 1605 Detection of Antibiotic Residue from Shrimp Ponds and Their Environment in East Java Province, Indonesia, *Aquacultura Indonesiana*, 16(1), 29-32.
- Susilawati, S., Doyan, A., dan Hadisaputra, S., 2022, Analysis of magnetic mineral content of natural iron sand in Beach Island Lombok as basic materials of microwave absorbers, *J. Penelit. Pendidikan IPA*, 8(4), 2048–2052.
- Sulastri, S., Kristianingrum, S., and Arianingrum, R., 2004, Pengaruh Perendaman Pasir Malelo dengan HNO₃ terhadap Efisiensi Penjerapan Kromium, *J. Penelitian Saintek*, 9, 51-68.
- Sweetman, S.C., 2009, The complete drug reference, *Pharm. Press*, 36th Ed.
- Ta, T.K.H., Trinh, M.-T., Long, N.V., Nguyen, T.T.M., Nguyen, T.L.T., Thuoc, T.L., Phan, B.T., Mott, D., Maenosono, S., Tran-Van, H., dan Le, V.H., 2016, Synthesis and surface functionalization of Fe₃O₄-SiO₂ core-shell nanoparticles with 3-glycidoxypropyltrimethoxysilane and 1,1'-

- carbonyldiimidazole for bio-applications, *Colloids Surf. A Physicochem. Eng. Asp.*, 504, 376–383.
- Taba, P., Jannah, M., dan Hala, Y., 2021, Synthesis of magnetic nanocomposites from natural iron sand, *Indones. J. Chem. Res.*, 8(3), 242–246.
- Tajabadi, F., Ghambarian, M., Yamini, Y., dan Yazdanfar, N., 2016, Combination of hollow fiber liquid phase microextraction followed by HPLC-DAD and multivariate curve resolution to determine antibacterial residues in foods of animal origin, *Talanta*, 160, 400–409.
- Tan, Z., Yang, X., Chen, L., Liu, Y., Xu, H.-J., Li, Y., dan Gong, B., 2022, Biodegradation mechanism of chloramphenicol by *Aeromonas media* SZW3 and genome analysis, *Bioresour. Technol.*, 344, 126280.
- Taufiq, A., Nikmah, A., Hidayat, A., Sunaryono, S., Mufti, N., Hidayat, N., dan Susanto, H., 2020, Synthesis of magnetite/silica nanocomposites from natural sand to create a drug delivery vehicle, *Heliyon*, 6(4), e03784.
- Teja, A.S., dan Koh, P., 2009, Synthesis, properties, and applications of magnetic iron oxide nanoparticles, *Prog. Cryst. Growth Charact. Mater.*, 55(1–2), 22–45.
- Tian, S., Dai, J., Jiang, Y., Chang, Z., dan Xie, A., 2017, Facile preparation of intercrossed-stacked porous carbon originated from potassium citrate and their highly effective adsorption performance for chloramphenicol, *J. Colloid Interface Sci.*, 494, 22–31.
- Timin, A., Rumyantsev, E., dan Solomonov, A., 2014, Synthesis and application of amino-modified silicas containing albumin as hemoadsorbents for bilirubin adsorption, *J. Non-Cryst. Solids*, 385, 81–88.
- Timin, A.S., Solomonov, A.V., Musabirov, I.I., Sergeev, S.N., dan Ivanov, S.P., 2014, Immobilization of bovine serum albumin onto porous poly(vinylpyrrolidone)-modified silicas, *Ind. Eng. Chem. Res.*, 53(40), 15762–15771.
- Ting, T.H., 2020, Synthesis and characterization of Fe₃O₄/polymer composites with stealth capabilities, *Results Phys.*, 16, 102975.
- Tiwow, V.A., Arsyad, M., Palloan, P., dan Rampe, M.J., 2018, Analysis of mineral content of iron sand deposit in Bontokanang Village and Tanjung Bayang Beach, South Sulawesi, Indonesia, *J. Phys. Conf. Ser.*, 997, 012010.
- Tran, Q.T., Do, T.H., Ha, X.L., Nguyen, H.P., dan Nguyen, A.T., 2022, Study of the ciprofloxacin adsorption of activated carbon prepared from mangosteen peel, *J. Environ. Chem. Eng.*, 10(2), 107193.
- Tran, T.V., Jalil, A.A., Nguyen, D.T.C., Nguyen, T.T.T., Nguyen, L.T.T., Nguyen, C.V., dan Alhassan, M., 2024, Effect of pyrolysis temperature on characteristics and chloramphenicol adsorption performance of NH₂-MIL-53(Al)-derived amine-functionalized porous carbons, *Chemosphere*, 355, 141599.
- Tran, T.V., Thi, D., Nguyen, C., Le, H.T.N., dan Bach, L.G., 2019, Tunable synthesis of mesoporous carbons from Fe₃O₄(BDC)₃ for chloramphenicol antibiotic remediation, *Nanomaterials*, 9(237), 1–18.
- Tran, V.S., Ngo, H.H., Guo, W., Ton-That, C., Li, J., Li, J., dan Liu, Y., 2017, Removal of antibiotics (sulfamethazine, tetracycline and chloramphenicol)

- from aqueous solution by raw and nitrogen plasma modified steel shavings, *Sci. Total Environ.*, 601–602, 845–856.
- Umeh, C.T., Nduka, J.K., Akpomie, K.G., Ighalo, J.O., dan Mogale, R., 2025, Adsorptive effect of corn silk-loaded nickel oxide and copper oxide nanoparticles for elimination of ciprofloxacin from wastewater, *ACS Omega*, 10 (4), 3784–3800.
- Valenti, S., Romanini, M., Franco, L., Puiggali, J., Tamarit, J.L., dan Macovez, R., 2018, Tuning the kinetic stability of the amorphous phase of the chloramphenicol antibiotic, *Mol. Pharm.*, 15(12), 5615–5624.
- Wahyudi, P., Hidayat, A.A., dan Sugiharto, S.A., 2020, Pengaruh waktu aging terhadap sifat hidrofobisitas silika xerogel termodifikasi trimetilklorosilan, *Indones. J. Pure Appl. Chem.*, 3(1), 15–21.
- Wang, F., Yang, B., Wang, H., Song, Q., Tan, F., dan Cao, Y., 2016, Removal of ciprofloxacin from aqueous solution by a magnetic chitosan grafted graphene oxide composite, *J. Mol. Liq.*, 222, 188–194.
- Wang, L., Shen, C., dan Cao, Y., 2019, PVP modified Fe₃O₄@SiO₂ nanoparticles as a new adsorbent for hydrophobic substances, *J. Phys. Chem. Solids*, 133, 28–34.
- Wang, Y., Liu, Y., Ma, M., Jing, H., Gao, R., dan Wang, S., 2026, Design of honeycomb-structured magnetic molecularly imprinted polymers for efficient adsorption and detection of chloramphenicol in environmental water, *Talanta*, 297, 128752.
- Wei, B., Sun, B., Zhang, B., Long, J., Chen, L., dan Tian, Y., 2016, Synthesis, characterization and hydrophobicity of silylated starch nanocrystal, *Carbohydr. Polym.*, 136, 1203–1208.
- Wei, S., Li, J., Liu, Y., dan Ma, J., 2016, Development of magnetic molecularly imprinted polymers with double templates for the rapid and selective determination of amphenicol antibiotics in water, blood, and egg samples, *J. Chromatogr. A*, 1473, 19–27.
- Wei, Z., Ma, X., Zhang, Y., Guo, Y., Wang, W., dan Jiang, Z.-Y., 2022, High-efficiency adsorption of phenanthrene by Fe₃O₄-SiO₂-dimethoxydiphenylsilane nanocomposite: Experimental and theoretical study, *J. Hazard. Mater.*, 422, 126948.
- WHO, 2024, Maximum residue limits (MRLs) and risk management recommendations (RMRs) for residues of veterinary drugs in foods CXM 2-2024, *FAO/WHO Codex Alimentarius*.
- Widati, A.A., Nuryono, N., dan Kartini, I., 2019, Water-repellent glass coated with SiO₂-TiO₂-methyltrimethoxysilane through sol-gel coating, *AIMS Mater. Sci.*, 6(6), 1026–1037.
- Widihati, I.A.G., 2008, Adsorpsi anion Cr(VI) oleh batu pasir teraktivasi asam dan tersalut Fe₂O₃, *J. Kimia*, 2(1), 25–30.
- Wu, T., Ke, Q., Lu, M., Pan, P., Zhou, Y., Gu, Z., Cui, G., dan Lu, H., 2022, Recent advances in carbon-silica composites: Preparation, properties, and applications, *Catalysts*, 12(5), 573.
- Wu, Y., Yue, Q., Ren, Z., dan Gao, B., 2018, Immobilization of nanoscale zero-valent iron particles (nZVI) with synthesized activated carbon for the

- adsorption and degradation of chloramphenicol (CAP), *J. Mol. Liq.*, 262, 19–28.
- Xing, W., Liu, Q., Wang, J., Xia, S., Ma, L., Lu, R., Zhang, Y., Huang, Y., dan Wu, G., 2021, High selectivity and reusability of biomass-based adsorbent for chloramphenicol removal, *Nanomaterials*, 11(11), 3037.
- Xu, B., dan Zhang, Q., 2021, Preparation and properties of hydrophobically modified nano-SiO₂ with hexadecyltrimethoxysilane, *ACS Omega*, 6(14), 9764–9770.
- Xu, Y., Yu, X., Xu, B., Peng, D., dan Guo, X., 2021, Sorption of pharmaceuticals and personal care products on soil and soil components: Influencing factors and mechanisms, *Sci. Total Environ.*, 753, 141891.
- Yanasin, S., dan Munasir, 2017, Pengaruh komposisi nanokomposit Fe₃O₄@SiO₂ core-shell untuk aplikasi adsorben logam berat, *J. Inov. Fis. Indones.*, 6(1), 14–17.
- Yang, J., Chen, J., dan Song, J., 2009, Studies of the surface wettability and hydrothermal stability of methyl-modified silica films by FT-IR and Raman spectra, *Vib. Spectrosc.*, 50(2), 178–184.
- Yang, L., Tian, J., Meng, J., Zhao, R., Li, C., Ma, J., dan Jin, T., 2018, Modification and characterization of Fe₃O₄ nanoparticles for use in adsorption of alkaloids, *Molecules*, 23(3), 562.
- Yang, Q., Cao, J., Ding, R., Zhan, K., Yang, Z., Zhao, B., Wang, Z., dan Ji, V., 2023, The synthesis and mechanism of superhydrophobic coatings with multifunctional properties on aluminum alloys surface: A review, *Prog. Org. Coat.*, 183, 107643.
- Yao, W., Fu, J., Yang, H., Yu, G., dan Wang, Y., 2019, The beneficial effect of cathodic hydrogen peroxide generation on mitigating chlorinated by-product formation during water treatment by an electro-peroxone process, *Water Res.*, 157, 209–217.
- Yilmaz, M., Al-Musawi, T.J., Saloot, M., Khatibi, A.D., Baniyasi, M., dan Balarak, D., 2024, Synthesis of activated carbon from *Lemna minor* plant and magnetized with iron(III) oxide magnetic nanoparticles and its application in removal of ciprofloxacin, *Biomass Convers. Biorefin.*, 14(1), 649–662.
- Yousefi, M., Gholami, M., Oskoei, V., Mohammadi, A.A., Baziar, M., dan Esrafil, A., 2021, Comparison of LSSVM and RSM in simulating the removal of ciprofloxacin from aqueous solutions using magnetization of functionalized multi-walled carbon nanotubes: Process optimization using GA and RSM techniques, *J. Environ. Chem. Eng.*, 9(4), 105677.
- Yuan, X., Lv, Z., Zhang, Z., Han, Y., Liu, Z., dan Zhang, H., 2023, A review of antibiotics, antibiotic resistant bacteria, and resistance genes in aquaculture: Occurrence, contamination, and transmission, *Toxics*, 11(5), 420.
- Zandipak, R. dan Sobhanardakani, S., 2018, Novel mesoporous Fe₃O₄@SiO₂/CTAB–SiO₂ as an effective adsorbent for the removal of amoxicillin and tetracycline from water, *Clean Technol. Environ. Policy*, 20, 871–885

- Zandipak, R., Ardakani, S.S., dan Shirzadi, A., 2019, Synthesis and application of nanocomposite $\text{Fe}_3\text{O}_4@\text{SiO}_2@\text{CTAB-SiO}_2$ as a novel adsorbent for removal of cyclophosphamide from water samples, *Sep Sci Technol*, 55(3), 456–470.
- Zahoor, M., Ullah, A., Alam, S., Muhammad, M., Setyobudi, R.H., Zekker, I., dan Sohail, A., 2022, Novel magnetite nanocomposites ($\text{Fe}_3\text{O}_4/\text{C}$) for efficient immobilization of ciprofloxacin from aqueous solutions through adsorption pretreatment and membrane processes, *Water (Basel)*, 14(5), 724.
- Zamel, D., Khan, A.U., Waris, A., Ebrahim, A., dan Abd El-Sattar, N.E.A., 2023, Nanomaterials advancements for enhanced contaminant removal in wastewater treatment: Nanoparticles, nanofibers, and metal-organic frameworks (MOFs), *Results Chem.*, 6, 101092.
- Zeng, Z., Tan, X., Liu, Y., Tian, S., Zeng, G., Jiang, L., Yin, Z., Liu, S., Li, J., dan Liu, S., 2018, Comprehensive adsorption studies of doxycycline and ciprofloxacin antibiotics by biochars prepared at different temperatures, *Front. Chem.*, 6, 80.
- Zhang, B., Zhang, H., Li, X., Lei, X., Li, C., Yin, D., Fan, X., dan Zhang, Q., 2013, Synthesis of BSA/ Fe_3O_4 magnetic composite microspheres for adsorption of antibiotics, *Mater. Sci. Eng. C*, 33(7), 4401–4408.
- Zhang, H., Fan, X., Liu, X., He, Q., Zhao, W., Han, L., Cui, J., Guo, F., dan Wang, W., 2023, Green and cost-efficient functionalized clay adsorbent enables one-step ultraefficient removal of Pb(II) at very low and high concentrations, *Appl. Clay Sci.*, 238, 106934.
- Zhang, J., Gan, W., Zhao, R., Yu, K., Lei, H., Li, R., Li, X., dan Li, B., 2020, Chloramphenicol biodegradation by enriched bacterial consortia and isolated strain *Sphingomonas* sp. CL5.1: The reconstruction of a novel biodegradation pathway, *Water Res.*, 187, 116397.
- Zhang, R., Zhou, Z., Xie, A., Dai, J., Cui, J., Lang, J., Wei, M., Dai, X., Li, C., dan Yan, Y., 2017, Preparation of hierarchical porous carbons from sodium carboxymethyl cellulose via halloysite template strategy coupled with KOH-activation for efficient removal of chloramphenicol, *J. Taiwan Inst. Chem. Eng.*, 80, 424–433.
- Zhang, Y., Xu, Q., Zhang, S., Liu, J., Zhou, J., Xu, H., Xiao, H., dan Li, J., 2013, Preparation of thiol-modified $\text{Fe}_3\text{O}_4@\text{SiO}_2$ nanoparticles and their application for gold recovery from dilute solution, *Sep. Purif. Technol.*, 116, 391–397.
- Zhang, Z., Liu, H., dan Qiao, W., 2020, Reduced graphene-based superhydrophobic sponges modified by hexadecyltrimethoxysilane for oil adsorption, *Colloids Surf. A Physicochem. Eng. Asp.*, 589, 124433.
- Zhao, D., Liu, Y., dan Wu, C., 2023, Adsorption of Cr(VI) polluted water by $\text{Fe}_3\text{O}_4@\text{SiO}_2\text{-APTMS}$ nanocomposites prepared in the presence of ultrasonic irradiation for sustainable water resources utilization, *Ultrason. Sonochem.*, 96, 106439.
- Zhao, H., Liu, X., Cao, Z., Zhan, Y., Shi, X., Yang, Y., Zhou, J., dan Xu, J., 2016, Adsorption behavior and mechanism of chloramphenicol, sulfonamides, and non-antibiotic pharmaceuticals on multi-walled carbon nanotubes, *J. Hazard. Mater.*, 310, 235–245.

- Zhou, M., Li, C., Zhao, L., Ning, J., Pan, X., Cai, G., dan Zhu, G., 2021, Synergetic effect of nano zero-valent iron and activated carbon on high-level ciprofloxacin removal in hydrolysis-acidogenesis of anaerobic digestion, *Sci. Total Environ.*, 752, 142261.
- Zhou, Y., Cao, S., Xi, C., Li, X., Zhang, L., Wang, G., dan Chen, Z., 2019, A novel Fe₃O₄/graphene oxide/citrus peel-derived bio-char based nanocomposite with enhanced adsorption affinity and sensitivity of ciprofloxacin and sparfloxacin, *Bioresour. Technol.*, 292, 121951.
- Zhu, N., Ji, H., Yu, P., Niu, J., Farooq, M.U., Akram, M.W., Udego, I.O., Li, H., dan Niu, X., 2018, Surface modification of magnetic iron oxide nanoparticles, *Nanomaterials*, 8(10), 810.
- Zhu, X., Gao, Y., Yue, Q., Song, Y., Gao, B., dan Xu, X., 2018, Facile synthesis of hierarchical porous carbon material by potassium tartrate activation for chloramphenicol removal, *J. Taiwan Inst. Chem. Eng.*, 85, 141–148.