

REFERENCES

- Adam, F., Osman, H., and Hello, K.M., 2009, The immobilization of 3-(chloropropyl) triethoxysilane onto silica by a simple one-pot synthesis, *J. Colloid Interface Sci.*, 331, 143–147.
- Ao, H., Cao, W., Hong, Y., Wu, J., and Wei, L., 2020, Adsorption of Sulfate Ion from Water by Zirconium Oxide-Modified Biochar Derived from Pomelo Peel, *Sci. Total Environ.*, 708, 135092.
- Al-Harashsheh, M., Batiha, M., Kraishan, S., Al-Zoubi, H., 2014, Precipitation Treatment of Effluent Acidic Wastewater from Phosphate-containing Fertilizer Industry: Characterization of Solid and liquid products, *Sep. Purif. Technol.*, 123, 190-199.
- Anal, A.K., Tobiassen, A., Flanagan, J., and Singh, H., 2008, Preparation and Characterization of Nanoparticles formed by Chitosan-Caseinate Interaction, *Colloid Surf. B*, 64, 104-110.
- Arkles, B., 2011, Hydropobicity, Hydrophilicity and Silane Surface Modification, Gelest, Inc., Maidstone, United Kingdom.
- Beamson, G., and Briggs, D., 1992, *High Resolution XPS of Organic Polymers*, Wiley, Chichester.
- Bilgiç, A., and Çimen, A., 2019, Removal of Chromium(VI) from Polluted Wastewater by Chemical Modification of Silica Gel with 4-Acetyl3-Hydroxyaniline, *RSC Adv.*, 9, 37403–37414.
- Boukhelkhal, A., Benkortbi, O., Hamadache, M., Ghalem, N., Hanini, S., And Amrane. A., 2016, Adsorptive Removal of Amoxicillin from Wastewater Using Wheat Grains: Equilibrium, Kinetic, Thermodynamic Studies and Mass Transfer, *Desalination Water Treat.*, 1944-3994.
- Bozorgpour, F., Ramandi, H.F., Jafari, P., Samadi, S., Yazd, S.S., and Aliabadi, M., 2016, Removal of Nitrate and Phosphate Using Chitosan/Al₂O₃/Fe₃O₄ Composite Nanofibrous Adsorbent: Comparison with Chitosan/Al₂O₃/Fe₃O₄ Beads, *Int. J. Biol. Macromol.*, 93, 557–565.
- Brinker, C.J., and Scherer, W.J., 1990, Sol-Gel Science: *The Physics and Chemistry of Sol-Gel Processing*, Academia Press, New York.
- Budnyak, T.M., Pylypchuk, I.E., Tertykh, V.A., Yanovska, E.S., and Kolodynska, D., 2015, Synthesis and Adsorption Properties of Chitosan-Silica Nanocomposite Prepared by Sol-Gel Method, *Nanoscale Res. Lett.*, 10, 87.

- Buhani, Narsito, Nuryono, and Kunarti, E.S., 2010, Production of Metal Ion Imprinted Polymer from Mercapto-Silica Hybrid, *Eksakta*, 12(01), 32-37.
- Castillo, X., Pizarro, J., Ortiz, C., Cid, H., Flores, M., Canck, E.D., Voort, P.V.D., 2018, A Cheap Mesoporous Silica from fly Ash as An Outstanding Adsorbent for Sulfate in Water, *Microporous Mesoporous Mater.*, 272, 184–192.
- Coradin, T., and Lopez, P.J., 2003, Biogenic Silica Patterning Simple Chemistry or Subtle Biology, *Chem.Bio.Chem.*, 72,80-84.
- De Conto, J.F., Oliveira, M.R., Oliveira, M.M., Brandão, T.G., Campos, K.V., Santana, C.C., and Egues, S.M., 2017, One-Pot Synthesis and Modification of Silica Nanoparticles With 3-Chloropropyl-Trimethoxysilane Assisted by Microwave Irradiation, *Chem. Eng. Commun.*, 1563-5201.
- Diosa, J., Guzman, F., Bernal, C., and Mesaa, M., 2020, Formation Mechanisms of Chitosan-Silica Hybrid Materials and Its performance As Solid Support for KR-12 Peptide Adsorption: Impact on KR-12 Antimicrobial Activity and Proteolytic Stability, *J. Mater. Res. Technol.*, 9, 890–901.
- Ebisike, K., Okoronkwo, A.E., Alaneme, K.K., 2020, Synthesis and characterization of Chitosan–silica Hybrid Aerogel Using Sol-Gel Method, *J. King Saud Univ. Sci.*, 32, 550-554.
- Etienne, M., and Walcarius, A., 2003, Analytical Investigation of The Chemical Reactivity and Stability of Aminopropyl-Grafted Silica in Aqueous Medium, *Talanta*, 59, 1173-1188.
- Farahmand, E., Rezai, B., Ardejani, F.D., and Tonekaboni, S.Z.S., 2015, Kinetics, equilibrium, and thermodynamic studies of sulfate adsorption from aqueous solution using activated carbon derived from rice straw, *Bulg. Chem. Commun.*, 47, 72 –81.
- Gromadskaya, L.I., Romanova, I.V., Vyshnevskiy, O.A., and Kirillov, S.A., 2013, Near-Stoichiometric Adsorption of Phosphate by Silica Gel Supported Nanosized Hematite, *ISRN Inorg. Chem.*, 969746.
- Han, B., Chen, N., Deng, D., Deng, S., Djerdj, I., and Wang, Y., 2015, Enhancing Phosphate Removal From Water by Using Ordered Mesoporous Silica Loaded with Samarium Oxide, *Anal. Methods*, 7, 10052–10060.
- Holleman, W., 1995, *Lehrbuchde Anorganischen Chemie*, Berlin, Germany.

- Hu, Q., Chen, N., Feng, C., and Hu, W.W., 2015, Nitrate Adsorption from Aqueous Solution Using Granular Chitosan-Fe³⁺ Complex, *Appl. Surf. Sci.*, 347, 1-9.
- Inam, E., Etim, U.J., Akpabio, E.G., and Umoren, S.A., Process Optimization for The Application of Carbon from Plantain Peels in Dye Abstraction, *J. Taibah Univ. Sci.*, 11, 173-185.
- Jing, X., Wang, Y., Chen, L., Wang, Y., Yang, X., Jiang, Y., and Yan, Y., 2019, Free-Standing Large-Mesoporous Silica Films Decorated with Lanthanum as New Adsorbents for Efficient Removal of Phosphate, *J. Mol. Liq.*, 296, 111815.
- Kamiyango, M.W., Masamba, W.R.L., Sajidu, S.M.L., and Fabiano, E., 2009, Phosphate Removal From Aqueous Solution Using Kaolinite Obtained From Linthipe, *Phys. Chem. Earth*, 34, 850-856.
- Kasaai, M., Arul, J., and Charlet, G., 2013, Fragmentation of Chitosan by Acids, *Sci. World J.*, 508540.
- Kumar, I.A., and Viswanathan, N., 2018, Development and Reuse of Amine-Grafted Chitosan Hybrid Beads in the Retention of Nitrate and Phosphate, *J. Chem. Eng. Data*, 63, 147-158.
- Lee, H.W., Cho, H.J., Yim, J.H., Kim, J.M., Jeon, J.-K., Sohn, J.M., Yoo, K.-S., Kim, S.-S., and Park, Y.-K., 2011, Removal of Cu(II)-Ion Over Amine-Functionalized Mesoporous Silica Materials, *J. Industrial and Eng. Chem.*, 17, 504-509.
- Li, F., Li, X.M., and Zhang, S.S., 2006, One-pot Preparation of Silica-Supported Hybrid Immobilized Metal Affinity Adsorbent with Macroporous Surface Based on Surface Imprinting Coating Technique Combined with Polysaccharide Incorporated Sol-gel Process, *J. Chromatogr. A*, 1129, 223-230.
- Lin, Y.F., Chen, H.W., Chang, C.C., Hung, W.C., and Chioud, C.S., 2011, Application of Magnetite Modified with Aluminum/Silica to Adsorb Phosphate in Aqueous Solution, *J. Chem. Technol. Biotechnol.*, 86, 1449-1456.
- Liu, B., Yu, Y., Han, Q., Lou, S., Zhang, L., and Zhang, W., 2020, Fast and Efficient Phosphate Removal On Lanthanum-Chitosan Composite Synthesized by Controlling the Amount of Cross-Linking Agent, *Int. J. Biol. Macromol.*, 157, 247-258.

- Liu, Y.L., Su, Y.H., Lai, J.Y., 2004, In Situ Crosslinking of Chitosan and Formation of Chitosan–Silica Hybrid Membranes with Using γ -Glycidioxypropyltrimethoxysilane as a Crosslinking Agent, *Polymer*, 45, 6831–6837.
- Lowell, S., Shields, J.E., 1984, *Powder Surface Area and Porosity*, Chapman and Hall, London.
- Ma, H., Wang, M., Zhang, J., and Sun, S., 2019, Preparation Mechanism of Spherical Amorphous $\text{ZrO}(\text{OH})_2/\text{AlOOH}$ Hybrid Composite Beads For Adsorption Removal of Sulfate Radical from Water, *Mater. Lett.*, 247, 56–59.
- Mahaninia, M.H., and Wilson, L.D., 2017, Phosphate Uptake Studies of Cross-linked Chitosan Bead Materials, *J. Colloid Interface Sci.*, 458, 201–212.
- Mohammadi, E., Daraei, H., Ghanbari, R., Athar, S.D., Zandsalimi, Y., Ziaee, A., Maleki, A., and Yetilmezsoy, K., 2019, Synthesis of Carboxylated Chitosan Modified with Ferromagnetic Nanoparticles for Adsorptive Removal of Fluoride, Nitrate, and Phosphate Anions from Aqueous Solutions, *J. Mol. Liq.*, 273, 116–124.
- Muflikhah, Rusdianto, B., Putra, E.G.R., and Nuryono, 2017, Modification of Silica Coated on Iron Sand Magnetic Material with Chitosan for Adsorption of $\text{Au}(\text{III})$, *Indones. J. Chem.*, 17, 264 – 273.
- Nuryono, Indriyanti, N.Y., Manuhutu, J.B., Narsito, and Tanaka, S., 2013, Sorption of $\text{Au}(\text{III})$ and $\text{Ag}(\text{I})$ on Amino and Mercapto-Silica Hybrid Columns, *J. Anal. Sci.*, 17, 244–245.
- Nuryono, Rosiati, N.M., Rusdianto, B., Sakti, S.C.W., and Tanaka, S., 2014, Coating of Magnetite with Mercapto Modified Rice Hull Ash Silica in a One-pot Process, *SpringerPlus*, 3:515.
- Oscik, J., 1982, *Adsorption*, John Wiley & Sons, New York.
- Osifo, P.O., Webster, A., van der Merwe, H., Neomagus, H.W.J.P., van der Gun, M.A., and Grant, D.M., 2008, The influence of the degree of cross-linking on the adsorption properties of chitosan beads, *Bioresour. Technol.*, 99, 7377–7382.
- Pap, S., Kirk, C., Bremner, B., Sekulic, M.T., Shearer, L., Gibb, S.W., and Taggart, M.A., 2020, Low-Cost Chitosan-Calcite Adsorbent Development For Potential Phosphate Removal and Recovery From Wastewater Effluent, *Water Res.*, 173, 115573.

- Pavlikova, P., Balintova, M., and Holub, M., 2018, Study of sulphate ions removal from acidic waters using ion exchange resin, *SSP J.Civ.Eng.*, 13(1), 51-58.
- Peng, Q., Liu, M., Xie, Y., and Zhou, J., 2015, Molecular Simulations of Cytochrome c Adsorption on Positively Charge Surface: The influence of Anion Type and Concentration, *Phys. Chem. Chem. Phys.*, 1-11.
- Pylypchuk, I.V., Kołodyńska, D., Kozioł, M., and Gorbyk, P.P., 2016, Gd-DTPA Adsorption on Chitosan/Magnetite Nanocomposites, *Nanoscale Res Lett.*, 11, 168.
- Rahmi, Fathurrahmi, Lelifajri, Purnawati, F., and Sembiring, R., 2019, Preparation of Magnetic Chitosan Beads for Heavy Metal Ions Removal from Water, *conf.ser: Earth Environ. Sci.*, 276, 012004.
- Rajeswari, A., Amalraj, A., and Pius, A., 2016, Adsorption Studies for the Removal of Nitrate Using Chitosan/PEG and Chitosan/PVA polymer composites, *J. Water Process. Eng.*, 9, 123-134.
- Rathinam, A., Maharshi, B., Janardhanan, S.K., Jonnalagadda, R.R., Nair, B.U., 2010, Biosorption of Cadmium Metal Ion from Simulated Wastewaters Using *Hypnea Valentiae* Biomass: A Kinetic and Thermodynamic Study, *Bioresour. Technol.*, 101, 1466–1470.
- Ratner, B.D., and Caster, D.G., 1997, *Surface Analysis: The Principal Techniques*. Vickerman JC (ed), Wiley, Chichester, p. 43.
- Repo, E., Warchoń, J.K., Bhatnagar, A., and Sillanpää, M., 2011, Heavy Metals Adsorption by Novel EDTA-Modified Chitosan–Silica Hybrid Materials, *J. Colloid Interface Sci.*, 358, 261–267.
- Roosen, J., Spooren, J., and Binnemans, K., 2014, Adsorption Performance of Functionalized Chitosan–Silica Hybrid Materials Toward Rare Earths, *J. Mat. Chem. A*.
- Runtti, H., Luukkonen, T., Niskanen, M., Tuomikoski, S., Kangas, T., Sulfate Removal Over Barium-Modified Blast-Furnace-Slag Geopolymer, *J. Hazard. Mater.*, 317, 373–384.
- Sadeghi, S., and Sheikhzadeh, E., 2008, Solid Phase Extraction Using Silica Gel Functionalized with Sulfasalazine for Preconcentration of Uranium(VI) Ions from Water Samples, *Microchim Acta*, 163, 133-320.
- Sang, P., Wang, Y., Zhang, L., Chai, L., and Wang, H., 2016, Effective Adsorption of Sulfate Ions with Poly(M-Phenylenediamine) in Aqueous Solution and Its Adsorption Mechanism, *Trans. Nonferrous Met. Soc. China*, 23, 243–252.

- Sari, A., and Tuzen, M., 2008, Biosorption of cadmium (II) from aqueous solution by red algae (*Ceramium virgatum*): equilibrium, kinetic and thermodynamic studies, *J. Hazard Mater.*, 157, 448.
- Schubert, U., and Husing, N., 2000, *Synthesis of Inorganic Materials*, Wiley-Vch Verlag, GmbH, Weinheim.
- Shen, H., Wang, Z., Zhou, A., Chen, J., Hu, M., Dong, X., and Xia, Q., 2015, Adsorption of Phosphate Onto Amine Functionalized Nano-sized Magnetic Polymer Adsorbents: Mechanism and Magnetic Effects, *Rsc Adv.*, 5, 22080-2209.
- Singhon, R., 2014, Adsorption of Cu(II) and Ni(II) Ions on Functionalized Colloidal Silica Particles Model Studies for Wastewater Treatment, *Dissertation*, Université de Franche-Comté, France.
- Smitha, S., Shajesh, P., Mukundan, P., and Warriar, K.G.K., 2008, Sol-Gel synthesis of Biocompatible Silica-Chitosan Hybrids and Hydrophobic Coatings, *J. Mater. Res.*, 23.
- Song, J., Kang, T.H., Kim, M.W., and Hana, S., 2016, Ion Specific Effects: Decoupling Ion-Ion and Ion-Water Interactions, *Phys Chem Chem Phys.*, 17, 8306–8322.
- Weiss, I. M., and Schonitzer, V. The distribution of chitin in larval shells of the bivalve mollusk *Mytilus galloprovincialis*, *J. Struct. Biol.*, 153, 264–277.
- Weißpflog, J., Boldt, R., Kohna, B., Schelera, U., Jehnichen, D., Tyrpekl, V., and Schwarza, S., 2020, Investigation of Mechanisms For Simultaneous Adsorption of Iron and Sulfate Ions Onto Chitosan With Formation of Orthorhombic Structures, *Colloids Surfaces A*, 592, 124575.
- Wu, M., Chen, Y., Wu, R., Li, R., Zou, H., Chen, B., and Yao, S., 2010, The Synthesis of Chloropropyl-Functionalized Silica Hybrid Monolithic Column with Modification of N, N-Dimethyl-N-Dodecylamine for Capillary Electrochromatography Separation, *J. Chromatogr. A.*, 1217, 4389–4394.
- Wu, X. L., Shi, Y., Zhong, S., Lin, H., and Cheng, J. R., 2016, Facile synthesis of Fe₃O₄-graphene@mesoporous SiO₂ nanocomposites for efficient removal of Methylene Blue, *Appl. Surf. Sci.*, 378, 80-86.
- Xiong, J.B., Qin, Y., Islam, E., Yue, M., and Wang, W.F., 2011, Phosphate Removal from Solution Using Powdered Freshwater Mussel Shells, *Desalination*, 276.
- Xu, X., Cheng, Y., Wu, X., Fan, P., and Song, R., 2020, La(III)-Bentonite/Chitosan Composite: A New Type Adsorbent for Rapid Removal of Phosphate from Water Bodies, *Appl. Clay Sci.*, 190, 105547.

- Xue, J., Guo, Y., Bi, Q., Mao, W., and Li, J., 2013, Study on The Adsorption of Sulfate Ions onto Cross-Linked Chitosan, *Mod. Phys. Lett. B*, 27, 1341031.
- Yousif, A.M., Atia, A.A., Zaida, O.F., and Ibrahim, I.A., 2015, Efficient and Fast Adsorption of Phosphates and Sulfates on Prepared Modified Cellulose, *J. Dispers Sci Technol.*, 36, 150303110449007.
- Zhang, R., 2010, Can Salting-in/Salting-Out Ions Be Classified as Chaotropes/Kosmotropes?, *J. Phys. Chem. B*, 114, 643-50.