Advancements, Research and Challenges in Reactive Adsorption: A Review

Sunil Jayant Kulkarni[1*]
[1*]Chemical Engineering Department, Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India.
*E-mail: suniljayantkulkarni@gmail.com

Abstract:

Adsorption is very important separation technique in chemical industries. Adsorption can be a physical or chemical operation. In physical adsorption, there is no chemical interaction. Chemisorption is accompanied by chemical interaction between adsorbent and adsorbate. In reactive adsorption, adsorption is accompanied by chemical interaction. This process finds wide application for reactive dyes, thiophene, radioactive, alkaline, oxidative decontamination solutions. The present review summarizes the studies and research carried out on reactive adsorption.

Keywords:

Adsorbent; concentration; adsorbate; concentration; application

Introduction

In the chemical industry, many times, downstream processing accounts to about 70-80 percent of the product cost. Also many times, the raw material also needs purification. Various separation methods widely used in the chemical industry includes extraction, distillation, adsorption and membrane separation techniques [1, 2, 3,4,5,6]. Distillation and other modifications like membrane distillation, solar distillation, extractive distillation and reactive distillation have been used successfully for various purposes [7, 8, 9, 10]. Adsorption has been used successfully for removal of various metal ions from the water [11, 12,]. Compounds like organic matter, phenol and acetic acids have been removed successfully by various investigators [13, 14]. Biofiltration has been used to remove various gases from waste gas streams[15].Reactive adsorption is widely studied method for carrying out desired seperation for reactive dyes, thiophene, radioactive, alkaline, oxidative decontamination solutions, textile reactive dyes etc. The present review summarizes the studies and research carried out in this field.

Research on Application and Affecting Factors in Reactive Adsorption

Reactive adsorption on $Ni/SiO_2$and Ni/ZnO of thiophene was studies by Bezverkhyy et.al.[16]. Their emphasis was on kinetics of reactive adsorption. According to them , this is two step process where first step is a rapid surface interaction and second is a slow bulk transformation into Ni_3S_2. The reaction was found to be first order. They observed that the reaction between Ni/ZnO and thiophene showed a more complex pattern. In this three steps were clearly observed, first was fast sulfur chemisorptions, the second one, nucleation-controlled sulfidation of ZnO surface and third, sulfur species, formed through thiophene decomposition, react preferably with ZnO. Marton et.al. carried out investigation on reactive adsorption for the removal of radioactive nuclides from nuclear power plant decontamination solutions[17]. Due to difficulties in storing, it was very essential to treat the radioactive waste in situ. They observed that reactive adsorption was promising method for this purpose. According to Sharma et.al. reactive adsorption finds many application in environmental field[18]. They also delved into the inadequately researched grey areas of reactive adsorption. According to the authors, there is necessity to carry further research with respect to modeling and adsorbent regeneration so as to make the process more economical. Djordjevic et.al. discussed thermodynamics of reactive dye adsorption from aqueous solution[19]. They used the ashes from city heating station for the purpose. According to them thermodynamic parameters are indicators of practical application of the process. They observed that entropy change (–2 to –3 J/K·mol) increased with increasing initial concentration of the adsorbate. Also it decreased with increasing amount of adsorbent. An investigation on reactive adsorption of sulfur containing gases on $Zn(OH)_2$ /graphite oxide composites was carried out by Seredych et.al.[20].They used visible light to enhance the process. According to them the terminal groups were activated by light. The graphite oxide component helped in electron transfer owing the chemical bonds with the zinc(oxy)hydroxide phase and conductive properties. According to them the formation of various sulphur compounds also helped in increasing surface activity. Zhang et.al. studied the reactive adsorption of thiophene on Ni/ZnO adsorbent[21]. Their research was concentrated on studying effect of ZnO textural structure on the desulfurization activity. They observed that calcination temperature affected the crystalline size and structure of ZnO. They observed better desulfurization activity in ZnO with larger surface area and smaller crystal particles. According to Goldburg et. al. the empirical approaches were not capable of accounting for the effects of variable chemical conditions[22]. Chemical models were useful in this purpose. They used surface complexation models for single mineral phases. It is important to simplify the adsorption model, so that adsorption is still calculated with mass laws. Few parameters that are difficult to characterize can be lumped with other parameters. Sako et.al investigated the reactive adsorption of thiophene on Au(III) They studied vaccum deposition of thiophene on Au[23]. According to them Au-thiolate chemical bonding appears duting this processes.

Liu et.al. carried out research on surface modification of argon-plasma-pretreated poly(tetrafluoroethylene) (PTFE) film [24]. They carried out UV-induced graft copolymerization with glycidyl methacrylate (GMA), then they reactively adsorbed γ-aminopropyltriethoxysilane (APS) on GMA graft-copolymerized PTFE (GMA-g-PTFE) film surface. They observed that The T-peel adhesion strength of the evaporated Cu on the PTFE film with the reactively adsorbed organosilane was about 10 times that of the assembly involving evaporated Cu on the Ar-plasma-treated PTFE film. Gamal et.al carried out investigation aimed at determining the adsorption capability of cotton fiber to reactive dyes.[25]. They optimized the variables like dye concentration, pH, and temperature. They observed that presence of organic salts increased the dye uptake. Monolayer coverage of the two reactive dyes on surface of cotton fiber was evident from Langmuir isotherm. Also the data followed second order isotherm.

Conclusion

Reactive adsorption is very efficient process for reactive dyes, thiophene, radioactive, alkaline, oxidative decontamination solutions, textile reactive dyes etc. The separation is more effective than the normal adsorption. Also it is possible to regenerate the original material by desorption cycle. The affinity for adsorbate increases many folds in reactive adsorption. The review reveals that there is need for further research in order to know the mechanism of adsorption, intraparticle diffusion and complexation.

References

1. Sunil Jayant Kulkarni, "Recycle and Reuse of Water", International Journal of Research (IJR) Vol-1, Issue-11, pp.802-806,December 2014.
2. Sunil J. Kulkarni, Ajaygiri K. Goswami, "Applications and Advancements in Treatment of Waste Water by Membrane Technology- A Review", International Journal Of Engineering Sciences & Research Technology,Vol.3,Issue 9,pp,446,450, 2014.
3. Rashmi Vinod Dahake, A.K.Goswami, Dr. V. Kalyanraman, S.J.Kulkarni , "Performance evaluation of hybrid membrane bioreactor for low strength wastewater treatment", International Journal of Science, Engineering and Technology Research (IJSETR) ,Volume 2, Issue 12, pp.2167-2170,December 2013.
4. Sunil J. Kulkarni, "Removal of phenol from Effluent in Fixed Bed: A Review", nternational Journal of Engineering Research and General ScienceVolume 2, Issue 5, pp.35-39,August – September 2014.
5. Kulkarni Sunil J., Patil Suhas V. Tapre Ravi W., Goswami Ajaygiri K, "Adsorption of Chromium from Wastewater on Different Adsorbents", International Journal of Research in Chemistry and Environment ,Vol. 3, Issue 1, pp.231-236,January 2013.
6. Marco Stoller, Olga Sacco , Diana Sannino and Angelo Chianese, "Successful Integration of Membrane Technologies in a Conventional Purification Process of Tannery Wastewater Streams", Membranes ,Vol.3, pp.126-135,2013.
7. Sunil Jayant Kulkarni, "Solar Distillation- A Review", International Journal of Research (IJR)Vol-1,Issue-11,pp.1171-1176,December 2014.
8. Jinesh S. Machale,Prachi D. Thakur,Piyush S. Lalwani And Gayatri M. Apte,"Solar Water Purification With The Help Of CSP Technology",Sci.Revs.Chem.Commun.Vol.3,Issue 2,pp.128-132, 2013.
9. R.P.Bhatt, Prof. S.B.Thakore,"Extractive Distillation of Acetic Acid from its Dilute Solution using Lithium Bromide", International Journal of Scientific Engineering and Technology, Vol.1,Issue 2 ,pp.46-50, 2012.
10. H. Demiral and M. Ercengiz Yildirim, "Recovery of acetic acid from waste streams by extractive distillation", Water Science & Technology,Vol. 47, Issue, 10 pp 183-188, IWA Publishing 2003.
11. Ajaygiri. K.Goswami, Sunil .J.Kulkarni, S.K.Dharmadhikari, "Adsorption of Copper (II) ions from Synthetic Waste Water By Teak Leaves", International Journal of Science, Engineering and Technology Research (IJSETR) Volume 2, Issue6, pp.1346-1360,June 2013.
12. A. K. Goswami, S. J. Kulkarni, S. K. Dharmadhikari, "Adsorption of Copper (II) ions from Synthetic Waste Water By Flyash", International Journal of Science, Engineering and Technology Research (IJSETR) Volume 2, Issue6, pp.1353-1355,June 2013.
13. Sunil J. Kulkarni, Ajaygiri K. Goswami, "Adsorption Studies for Organic Matter Removal from Wastewater by Using Bagasse Flyash in Batch and Column Operations", International Journal of Science and Research (IJSR), Vol. 2, Issue 11,pp.180-184, November 2013.
14. Sunil J. Kulkarni, "Removal Of Organic Matter From Domestic Waste Water By Adsorption", nternational Journal of

Science, Engineering and Technology Research (IJSETR),Volume 2, Issue 10, pp.1836-1840,October 2013.

15. Veena Ramachandran, Tanmay Uttam Gound, Sunil Kulkarni, "Biofilteration for waste gas treatment – a review", International Journal of Ethics in Engineering & Management Education,Volume 1, Issue 2, pp.8-13,February 2014.
16. Igor Bezverkhyy, Andrey Ryzhikov, Geoffroy Gadacz, Jean-Pierre Bellat, "Kinetics of thiophene reactive adsorption on Ni/SiO2and Ni/ZnO", Catalysis Today,Vol. 130,pp.199-205, 2008.
17. Marton, G.; Szanya, T.; Hanak, L, "Reactive adsorption: A cleaner technology in nuclear power plants", pp. 254-259; American Institute of Chemical Engineers; New York, NY (United States); 5. world congress of chemical engineering; San Diego, CA (United States); 14-18 Jul 1996; American Institute of Chemical Engineers, 345 East 47th Street, New York, NY 10017 (United States).
18. Manisha Sharma, Raj Vyas, Kailash Singh, "A review on reactive adsorption for potential environmental applications ",Adsorption, Vol. 19,Issue 1,pp.161-188,2013 .
19. Dragan Djordjevic, Dejan Stojkovic, Novica Djordjevic And Miodrag Smelcerovic, "Thermodynamics Of Reactive Dye Adsorption From Aqueous Solution On The Ashes From City Heating Station", Ecological Chemistry And Engineering , Vol. 18, Issue 4,pp.527-526,2011.
20. M. Seredych, O. Mabayoje, T.J. Bandosz, "Visible light-enhanced reactive adsorption of sulfur containing gases on $Zn(OH)_2$ /graphite oxide composites", https://elsevier.conference.services.net/programme.asp/conferenceID=3159&action=prog_titles.
21. Jingcheng Zhang, Yunqi Liu, Shuang Tian, Yongming Chai, Chenguang Liu, "Reactive adsorption of thiophene on Ni/ZnO adsorbent: Effect of ZnO textural structure on the desulfurization activity[J] Journal of Natural Gas , 2010,Vol,19, Issue3,pp.327-332,2010.
22. Sabine Goldberg, Louise J. Criscenti, David R. Turner, James A. Davis, and Kirk J. Cantrell, "Adsorption–Desorption Processes in Subsurface Reactive Transport Modeling", www.vadosezonejournal.org· Vol. 6, Issue 3, pp. 407-435,August 2007.
23. Erica Sako,Kenta Amimiya,Hiroshi Kondoh, Tohru Nakamura,Hitoshi ABE, Toshiaki OHTA, "Reactive Adsorption of thiophene on Au(III)",Photon Factory Activity Report 2006, #24, Part B, Surface and Interface,2007.
24. Liu, Y.X.; Kang, E.T.; Neoh, K.G.; Tan, K.L., "Reactive adsorption of aminosilane onto the glycidyl methacrylate graft-copolymerized poly(tetrafluoroethylene) film surface for adhesion enhancement with evaporated copper", Journal of Polymer Science, Part A: Polymer Chemistry,200.
25. A. M. Gamal, S. A. Abo Farha, H. B. Sallam, G. E. A. Mahmoud and L. F. M. Ismail, "Kinetic Study and Equilibrium Isotherm Analysis of Reactive Dyes Adsorption onto Cotton Fiber", Nature and Science, Vol.8, Sissue 11,pp.95-110,2010.

About Author

Mr. Sunil Jayant Kulkarni has completed his Masters in Chemical Engineering from Tatyasaheb Kore Institute of Engineering and Technology, Warananagar. He is working as Assistant Professor in Chemical Engineering Department of Datta Meghe College of Engineering, Airoli, Navi Mumbai, India. He has published 35 international review and research papers and presented 15 research papers in international conferences. His area of research includes adsorption, distillation, environmental engineering. He is on the reviewer/editorial board of 16 international journals and reviewed many international papers.