Advancements, Research and Challenges in Reactive Adsorption: A Review

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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 separation 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/SiO2 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 NiS2. 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 vacuum deposition of thiophene on Au[23]. According to them Au-thiolate chemical bonding appears during 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


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 July 1996; American Institute of Chemical Engineers, 345 East 47th Street, New York, NY 10017 (United States).


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