International Journal of Petroleum and Petrochemical Engineering (IJPPE)
Volume 2, Issue 1, 2016, PP 16-19
ISSN 2454-7980 (Online)
DOI: http://dx.doi.org/10.20431/2454-7980.0201004
www.arcjournals.org

Role of Adsorption in Petroleum Industries and Refineries

Sunil Jayant Kulkarni

Datta Meghe College of Engineering,
Airoli, Navi Mumbai, Maharashtra, India
suniljayantkulkarni@gmail.com

Abstract: *Adsorption finds application in reaction engineering, environmental engineering and petrochemical engineering. Removal of many components of flue gases can be carried out by adsorption. The research on removal of heavy metals, dyes has also been carried out by number of investigators. The studies on batch adsorption mainly include isotherm, kinetics and effect of various parameters. In petrochemical industries, the catalyzed reactions involve adsorption. Also the recovery of oil from wastewater can be carried out by adsorption. The removal of sulphur or desulphurization also can be carried out by adsorption. Removal of various pollutants from flue gases and wastewater can be carried out by adsorption. The present review summarizes the research carried out on adsorption related to its application in petrochemical and refining industries.*

Keywords: *desulphurization, adsorbent, wastewater treatment, kinetics, equilibrium.*

1. INTRODUCTION

Adsorption is one of the easiest and efficient separation methods used in chemical, petrochemical and pharmaceutical industries. Adsorption is classified based on the mechanism as physical and chemical adsorption. Physical adsorption is because of Vanderwaal's forces and chemisorption is due to chemical forces, bonds. Adsorption finds application in reaction engineering, environmental engineering and petrochemical engineering. Removal of many components of flue gases can be carried out by adsorption [1,2,3,4]. Reactive adsorption is also important area of investigation [5,6,7,8]. In catalysis, adsorption is very important phenomenon [9,10]. Removal of organic matter by using adsorption is widely studied research area [11,12,13]. The research on removal of heavy metals, dyes has also been carried out by number of investigators [14,15]. The studies on batch adsorption mainly include isotherm, kinetics and effect of various parameters [16,17,18]. The packed bed studies include effect of affecting parameters like bed height, initial concentration and flow rate [19,20]. Also the modeling for breakthrough is very important aspect of this research. Removal of many pollutants from petroleum industries and refineries can be carried out by using adsorption. Adsorption can also be used for recovery of oil from wastewater. Removal of sulphur can also be accomplished by adsorption. It can be realized that adsorption has huge potential regarding its application in petroleum industries and refineries. The present review summarizes the application of adsorption in petroleum refineries and petroleum industries.

2. RESEARCH ON ADSORPTION IN PETROLEUM INDUSTRIES AND REFINERIES

Adey et.al. carried out an investigation on desulphurization of crude oil by using different materials for adsorption [21]. They used manganese dioxide and zinc oxide for the adsorption. They also carried out kinetic and equilibrium studies. They observed that manganese dioxide has more adsorption capacity than zinc oxide. Also the adsorption followed pseudo second order kinetics. The analysis indicated that chemisorption may be rate limiting step. Alavi and Hashemi reviewed the research and studies on use of adsorption for desulphurization[22].These studies indicated that the sorbents like alumina, silica gel, zeolite molecular sieves, active carbon (AC), carbon molecular sieves, impregnated carbons (Cu-chlorides - CO separation), clays (natural and pillared clays), resins, polymers (biological, ions, large molecules) and carbon nanotube have ability to adsorb sulphur on them. They discussed the adsorption process step wise. The steps they identified included addition of feed solution to adsorbents, mixing, separation and elution. Emam used activated carbon and bentonite clay from hydrocarbon treatment of waste [23]. They prepared synthetic wastewater by emulsifying oil in water. They analyzed usual batch adsorption parameters like contact time,

adsorbent dose, initial concentration and pH. They observed that the adsorption of the oil depends heavily on pH. They observed that organic bentonite was best among the adsorbents used.

Wang et.al. used granular activated carbon for adsorption of methane [24]. They measured methane content by volumetric method. They observed that the physical characteristics such as BET surface area, micropore volume, packing density and pore size distribution play an important role in the adsorption process. Zubaidy et.al. used carbonized date palm kernel powder and commercial activated carbon for sulphur removal from diesel oil[25]. With activated carbon, they were able to remove half of the sulphur content. Mohammad et.al. used rice husk carbon for removal of phenol from petroleum refinery wastewater[26]. In packed column, they studied effect of bed depth and flow rate on adsorption. For explaining break through curves they used bed depth service time model and Yoon Nelson model. According to them, these two models can be employed for the adsorber design. They observed that, with time, there was increase in the adsorption capacity. Also they observed that the breakthrough time increased with bed depth. Feng et.al. studied the effect of pore structure and surface chemistry on adsorption of hydrogen sulphide[27]. Zubaidi et.al. carried out an investigation on adsorption of sulphur from diesel oil using granular activated carbon[28].They analyzed the adsorbent material using scanning electron microscopy (SEM) integrated with energy dispersive spectroscopy (EDS). They observed 20.9 percent sulphur reduction during adsorption. Patil et.al. carried out an investigation on removal of sulphur by adsorption[29].Stirring was done to reduce intraparticle resistance. Scanning electron microscope (SEM) and X-ray diffraction studies (XRD) analysis was carried out for analysis of adsorbent. They observed that there was an increase in adsorbed quantity with increase in sulphur concentration. It was also observed that increase in the stirring speed from 1800 rpm to 2600 rpm doesn't have any effect on adsorption. Kukwa et.al. used NH_4Cl-modified primitive clay for adsorption of Nickel and Vanadium[30]. They observed that the adsorption increased with initial concentration and adsorbent dose. They also found that the adsorption was pseudo second order. Wastewater from oil refinery was treated by using activated carbon by Hosseini et.al.[31]. They attempted to remove organic matter (COD) from the wastewater. They modeled the equilibrium data by using Langmuir adsorption isotherm. They observed that model results showed fair agreement with experimental data. Behnood et.al. used natural sorbents like phragmites australis, sugarcane leaves straw, and sugarcane bagasse for crude oil adsorption[32]. They observed that bagasse has higher adsorption capacity among these adsorbents. It was able to remove 8 gram of oil per gram of bagasse.

Li et.al. studied integrated adsorption and microbial methods for desulphurization of diesel[33].They observed that the integrated method was able to remove sulphur more efficiently than other methods. Turgman-Cohen et.al. used flat silica surfaces for the adsorption of asphaltenes[34]. They modified the silica surfaces with self-assembled monolayers (SAMs) of alkyltrichlorosilanes of varying thickness. They observed that asphaltene adsorption decreased with an increase in N_C, the number of carbon atoms. They also observed that the adsorption increased with decrease in the Hildebrand solubility parameter of the solvent. Abdel-Jabber et.al. Carried out an investigation on use of various low cost materials for adsorption in waste lubricating oil[35]. They used adsorbents such as egg shale powder, date palm kernel powder, and acid activated date palm kernel powder. The date palm kernel powder was found to be best adsorbent for refining of waste lubricating oil. They also observed that 4 hours contact time gave best results for different adsorbents. They also found that the carbon residue, ash content, and aspheltene content were decreased up to 68.2 wt%, 72.9wt%, and 92.3wt% respectively by the date palm kernels powder .

3. CONCLUSION

Adsorption is very important operation in petroleum sector. It can be used for recovery or removal of sulphur from oil. Also, in catalytic reactions, adsorption is involved. Removal of many pollutants from wastewater can be carried out by adsorption. Waste gas treatment can also be carried out by adsorption. Many of these applications are practically carried out in many industries. There is also scope for economizing these operations by using new low cost adsorbent and using efficient regeneration methods.

REFERENCES

[1] Sunil J. Kulkarni, Nilesh L. Shinde, 2014, "A Review on Hydrogen Sulphide Removal from Waste Gases", International Journal of Advanced Research in Science, Engineering and Technology, 1(4), PP.187-189.

[2] Tanmay Uttam Gound, Veena Ramachandran, Sunil Kulkarni, 2014, "Various Methods To Reduce SO_2 Emission- A Review", International Journal Of Ethics In Engineering & Management Education, 1(1), PP.1-6.

[3] Sunil Jayant Kulkarni, Ajaygiri Kamalgiri Goswami, 2014, "Adsorption For Waste Gas Treatment: A Short Review", International Journal For Research In Applied Science & Engineering Technology, 2(12), PP.513-514.

[4] Sunil Jayant Kulkarni, Ajaygiri Kamalgiri Goswami & Nilesh Shinde, 2015, "Treatment and Recovery for Flue Gases: a Review", International Journal of Research, 2(6), PP.515-519.

[5] Sunil Jayant Kulkarni,2015, " Advancements, Research and Challenges in Reactive Adsorption: A Review", International Journal of Research, 2(1), PP.477-480.

[6] Sabine Goldberg, Louise J. Criscenti, David R. Turner, James A. Davis, and Kirk J. Cantrel,2007,"Adsorption–Desorption Processes in Subsurface Reactive Transport Modeling", www.vadosezonejournal.org·,6(3), PP. 407-435.

[7] Erica Sako,Kenta Amimiya,Hiroshi Kondoh, Tohru Nakamura,Hitoshi ABE, Toshiaki OHTA,2007, "Reactive Adsorption of thiophene on Au(III)",Photon Factory Activity Report 2006, 24, Part B, Surface and Interface,2007.

[8] Igor Bezverkhyy, Andrey Ryzhikov, Geoffroy Gadacz, Jean-Pierre Bellat, 2008, "Kinetics of thiophene reactive adsorption on Ni/SiO2and Ni/ZnO", Catalysis Today, 130, PP.199-205.

[9] Eman A. Emam, 2013, "Clays As Catalysts In Petroleum Refining Industry", ARPN Journal Of Science And Technology, 3(4), PP.356-375.

[10] Mu Xuhong, Wang Dianzhong, Wang Wengrui, Lin Min, Cheng Shibiao, Shu Zigtian, 2013, "Nanosized Moleculer Sieves As Petrolium Refining And Petrochemical Catalyst", Chinese Journal Of Catalysis, 34, PP.69-79,2013

[11] Sunil Jayant Kulkarni, Ajaygiri Kamalgiri Goswami, 2014, "Characterization,Treatment and Disposal of Sludge: A Review", International Journal for Research in Applied Science & Engineering Technology (IJRASET), 2(2), PP. 516-517.

[12] Sunil J. Kulkarni, Ajaygiri K. Goswami,2013, "Adsorption Studies for Organic Matter Removal from Wastewater by Using Bagasse Flyash in Batch and Column Operations",International Journal of Science and Research, 2(11), PP.180-183.

[13] Sunil J. Kulkarni, 2013, "Removal Of Organic Matter From Domestic Waste Water By Adsorption", International Journal of Science, Engineering and Technology Research (IJSETR), 2(10), PP.1836-18840.

[14] K.Murali, P.L.Karuppiah, M.Nithish, S.Sajith Kumar and V.Suresh Raja, 2013, "COD Reduction Using Low Cost Biosorbent as Part of Cleaner Production", International Journal of Scientific and Research Publications, 3(7), PP. 1-3.

[15] Sunil J. Kulkarni, Suhas V Patil, and Y. P. Bhalerao, 2011, "Fly ash Adsorption Studies for Organic Matter Removal Accompanying Increase in Dissolved Oxygen", International Journal of Chemical Engineering and Applications, 2(6), PP.434-438.

[16] Bhise R.M., Patil A.A., Raskar A.R., Patil P.J. and Deshpande D.P.,2012, "Removal of Colour of Spent Wash by Activated Charcoal Adsorption and Electro coagulation", Research Journal of Recent Sciences , 1(6), PP.66-69.

[17] Pallavi Amale, Sunil Kulkarni, Kavita Kulkarni, 2014, " A Review on Research for Industrial Wastewater Treatment with Special Emphasis on Distillery Effluent", International Journal of Ethics in Engineering & Management Education, 1(9), PP.1-4.

[18] Sunil Jayant Kulkarni, 2015, " A Review on Packed Bed Removal of Organic Matter from Wastewater", International Journal on Scientific Research in Science and Technology, 1(2), PP. 27-30.

[19] Sunil J. Kulkarni,2014, "Modeling for Adsorption Columns for Wastewater Treatment: a Review", International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences, 2(2), PP.7-11.

[20] Pallavi Amale, Sunil Kulkarni, Kavita Kulkarni, 2014, "Studies on Packed Bed Treatment for Organic Matter in Distillery Effluent" ,International Journal of Engineering Science and Innovative Technology, 3(5), PP.268-272.

[21] Adeyi, Abel Adekanmi and Aberuagba, Folorunsho, 2012, "Comparative Analysis of Adsorptive Desulphurization of Crude Oil by Manganese Dioxide and Zinc Oxide", Research Journal of Chemical Sciences, 2(8), PP.14-20.

[22] Seyed Abolhasan Alavi, and Seyed Reza Hashemi, 2014, "A Review on Diesel Fuel Desulfurization by Adsorption Process",International Conference on Chemical, Agricultural, and Biological Sciences (ICCABS'2014), Oct. 9-10, 2014 Antalya (Turkey).

[23] Eman Abdelwahab Emam, 2013, "Modified Activated Carbon And Bentonite Used To Adsorb Petroleum Hydrocarbons Emulsified In Aqueous Solution", American Journal of Environmental Protection, 2(6), PP.161-169.

[24] Y. Wang, Mohammed Hashim, C. Ercan, Anwar Khawajah, Rashid Othman,2011, "High Pressure Methane Adsorption on Granular Activated Carbons", 21st Annual Saudi-Japan Symposium Catalysts in Petroleum Refining & Petrochemicals Dhahran, Saudi Arabia – November 2011,1-8.

[25] Isam A. H. Al Zubaidy, Fatma Bin Tarsh, Noora Naif Darwish, Balsam Sweidan Sana Abdul Majeed, Aysha Al Sharafi, and Lamis Abu Chacra,2013, "Adsorption Process of Sulfur Removal from Diesel Oil Using Sorbent Materials", Journal of Clean Energy Technologies, 1(1), PP.66-68.

[26] Y.S. Mohammad, E.M. Shaibu-Imodagbe, S.B. Igboro, A. Giwa, C.A. Okuofu,2014, "Adsorption of Phenol from Refinery Wastewater Using Rice Husk Activated Carbon", Iranica Journal of Energy & Environment, 5 (4), PP. 393-399.

[27] Wenguo Feng , Seokjoon Kwon , Eric Borguet , An D Radisa Vidic,2005, "Adsorption Of Hydrogen Sulfide Onto Activated Carbon Fibers: Effect Of Pore Structure And Surface Chemistry", Environ. Sci. Technol., 39, PP.9744-9749.

[28] Isam Al Zubaidi, Noora Naif Darwish, Yehya El Sayed, Zarook Shareefdeen, and Ziad Sara,2015, "Adsorptive Desulfurization of Commercial Diesel oil Using Granular Activated Charcoal", Int'l Journal of Advances in Chemical Engg., & Biological Sciences (IJACEBS), 2(1), PP. 15-18.

[29] M.S.Patil, Y.C.Bhattacharyulu, S.R.Kulkarni, 2011,"Desulfurization Of Hydrocarbon Liquid Fuels By Adsorption", Journal of Engineering Research and Studies, 2(1), PP.81-98.

[30] Donald T. Kukwa, Rose E. Ikyereve, Sylvester O. Adejo and Chris O. Ikese,2014, "Kinetics of Nickel and Vanadium Adsorption from Crude Oil onto NH4Cl-modified Primitive Clay", The International Journal Of Engineering And Science (IJES), 3(4), PP. 13-20.

[31] Seyed Hosseini, Nekoo; Fatemi, Shohreh, 2013, "Experimental Study and Adsorption Modeling of COD Reduction by Activated Carbon for Wastewater Treatment of Oil Refinery", Iran. J. Chem. Chem. Eng., 32(3), PP.81-89.

[32] Reza Behnood, Bagher Anvaripour, Nematollah Jaafarzade Haghighi Fard and Masoumeh Farasati,2013, "Application of Natural Sorbents in Crude Oil Adsorption", Iranian Journal of Oil & Gas Science and Technology, 2(4), PP. 01-11.

[33] Wangliang Li , Huang Tang, Qingfen Liu, Jianmin Xing, Qiang Li, DanWang,Maohua Yang, Xin Li, Huizhou Liu,2009, "Deep Desulfurization Of Diesel By Integrating Adsorption And Microbial Method", Biochemical Engineering Journal, 44, PP.297–301.

[34] Salomon Turgman-Cohen, Daniel A. Fischer, Peter K. Kilpatrick, and Jan Genzer,2009, "Asphaltene Adsorption onto Self-Assembled Monolayers of Alkyltrichlorosilanes of Varying Chain Length", Applied Materials and Interfaces, 1(6), PP. 1347–1357.

[35] Nabil M. Abdel-Jabbar, Essam A.H. Al Zubaidy, and Mehrab Mehrvar,2010,"Waste Lubricating Oil Treatment by Adsorption Process Using Different Adsorbents", International Journal of Chemical and Biological Engineering, 3(2), PP.70-73.

AUTHOR'S BIOGRAPHY

Mr. Sunil J. Kulkarni, has completed his Masters in Chemical Engineering from Tatyasaheb Kore Institute of Engineering and Technology, Warananagar in 2006. He is currently pursuing his phD in chemical engineering. He is working as Assistant Professor in Chemical Engineering Department of Datta Meghe College of Engineering, Airoli, Navi Mumbai, India. The author has 16 years of experience in teaching and research. He has published 113 international review and research papers and presented 15 research papers in international conferences. His area of research includes adsorption, environmental engineering and catalysis. He is editorial board member of more than 25 international journals and reviewed many international papers.