IRAQI Academic Scientific Journals

Samarra Journal of Pure and Applied Science

SJPAS

ISSN:2663-7405

www.sjpas.com

Applications of aluminum oxide and nano aluminum oxide as adsorbents: review

Hawraa Kassem Hami, Ruba Fahmi Abbas*, Emad Mahmoud Eltayef , Neda Ibrahim Mahdi
Department of Chemistry, College of Science, Al-Mustansiriyah University, Baghdad, Iraq (suha_rrr_1983@yahoo.com)

Article Information

Received: 24/01/2020
Accepted: 05/04/2020

Keywords:

Aluminum oxide, Nano Aluminum oxide, adsorbents, Dyes and Antibiotics

Abstract

Metal oxides are widely used in adsorption technology as adsorbent surfaces because of their efficiency, low cost and unique physical properties. The aim of this review to clarify the role of aluminium oxide and Nano aluminium oxide in removing some chemicals contain that influence on human health such as dyes, antibiotics, and heavy metals. This paper also includes the affective of some adsorption parameters like pH, contact time, removal percentageand temperature. The Adsorption nature, kinetic adsorption models and isotherm models are also reported here.

Introduction

Pollution is currently one of the most widespread environmental problems that began to emerge in the 20th century because of industrial growth associated with the industrial revolution, all this lead to the emergence of new categories of previously unknown chemicals[1]. Thus, it is necessary to find cheap and effective ways that contribute to decontamination and maintain a clean and healthy environment for future generations.

Over the past years, adsorption has emerged as an efficient technique widely used in removing pollutants from the environment .This technology is simple, cheap and environmentally friendly, one of the most important things for effective adsorption is chosen the right surface[2,3]. For all these reasons, there is an increasing trend of research papers published in adsorption removals in the aqueous phase[4].

Metal oxides are the most commonly used surfaces in the removal of contaminants; they are cheap and widely manufactured, In addition to their high mechanical properties and resistance to thermal decomposition compared to biological surfaces[5].One of the renowned oxides is Aluminium oxide (Al_2O_3) which is an amphoteric oxide known as alumina and found in many crystalline structures like 'α-Al_2O_3, γ-Al_2O_3, θ-Al_2O_3, η-Al_2O_3' etc. "Fig. 1 and 2". different in physical and chemical properties as well as applications[6]. Aluminium oxide is characterized by its non-toxic, easy used, chemical stability and has many hydroxide groups all these property mad it efficient adsorbent. From 1923 Aluminium oxide had usage as adsorbed to remove Pigments, antibiotics, heavy metals, dissolved organics etc.[7,8].

In the light of the continuous development in the field of nanotechnology and its use in treatment pollution of the environment, interest increasing in the use of metal oxides as nanoparticles as absorbers to remove pollutants from the environment[9], especially Aluminium oxide nanoparticles inasmuch to it inexpensive, high surface area, surface reactivity, well adsorption ability, surface acidity and thermal stability[10,11].There are many techniques to prepared aluminium oxide nanoparticles powder including ball milling, hydrothermal, sol-gel, co-precipitation, pyrolysis, laser ablation, vapour phase reaction and combustion methods[12].

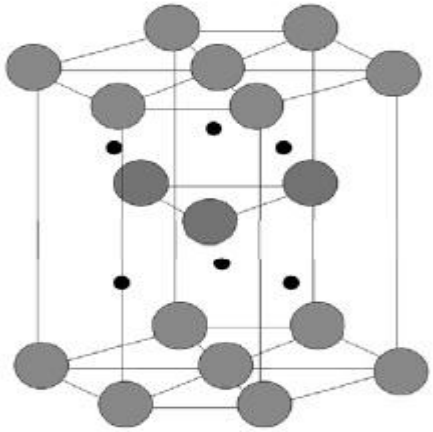
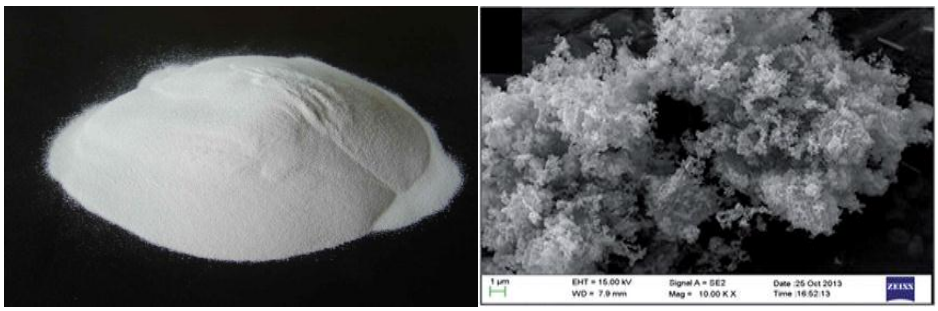


Fig. 1: Structure of α-Al_2O_3



a **b**

Fig. 2: Characterization of alumina oxide (a)- Al_2O_3 powder (b)- SEM form at enlargement of 10.00 KX.14428 for Al_2O_3nanoparticle[13].

Chemicals Pollution

All living and non-living substances consist of chemicals and every manufactured product we use in our daily lives includes chemicals. These substances can contribute to improving our health and well-being when used duly. In contrast, hazardous chemicals can cause health and environmental damage when used improperly[14].

International organizations such as "WHO, USEPA, ATSDR and EU" analysis of the impact of toxic metal ions and pollutants on human health ،the increase of concentration of these substances cause serious health damage. Table 1 summarizes some of the toxic elements and their admissible limits in water and their impact on human health according to these organizations.

Table 1: Toxic contaminants in drinking water and their influence on human health

Contaminant	Allowable Limits of concentration mg/l	Possible impact of toxic elements on human health	Ref.
Arsenic	0.01	Skin harm or circulatory problems, may increase the risk of cancer,black foot disease	15
Azo dyes		Causes chromosomal damage and cancer.	16
Cadmium	0.05	Kidney damage, lowering red blood cells, hypertension,	17
Chromium	0.1	Loss Calcium from the bone, staining the yellow teeth (forming a cadmium ring) and damage to the bone marrow, renal failure, lung irritation	18
Copper	1.3	Short-term exposure: digestive distress Long-term exposure: damage in liver or kidney	18
Fluoride	4	Bone diseases and children may lose their teeth	18
Eosin yellow	-	Skin irritation	5
Lead	0.015	Infants and children: delay in physical or mental development, high level cause coma and die Adults: kidney problems, Hypertension, Memory or focus problems	17
Iron	0.3	Lung cancer	19
Nickel	0.02	Cancer of the lung , nose, laryngeal and nickel itch	20
Nitrate	11.3	It poses a risk to infants younger than 6 months and pregnant women	18
Malachite green dye	-	Lung cancer	9
Mercury		Affects the digestive and immune systems, Cancer	18
Molybdenum	10–15	Joint pain, gout-like symptoms, and high uric acid in the blood	18
Phenol	-	Extremely Toxic, mutagenic and absorbed by skin	16
Phosphate	-	Affect the calcium in the body and cause damage to the kidneys	21
Selenium	0.05	Hair loss and nails circulatory problems, cancer	18
Thallium	0.0005	Hair loss; Blood changes, Problems with the kidney, intestine and liver.	16
Zinc	5	Short time: stomach cramps, nausea, vomiting may occur. Long time : anemia, pancreatic damage, and low-density lipoprotein cholesterol levels	22

Continuing the production and use of chemicals worldwide requires a safety system to dispose of these chemicals. In this article, we will talk about some hazardous chemicals that removed by adsorption technology on the surface of Al_2O_3 and Nano Al_2O_3.

Adsorption parameter

Adsorption process happens either in one step or in a set of steps like Film or external diffusion, pore spreading, surface spreading and adsorption on the surface of the pores. Fig. 3 shows the pathways of adsorption process[23].

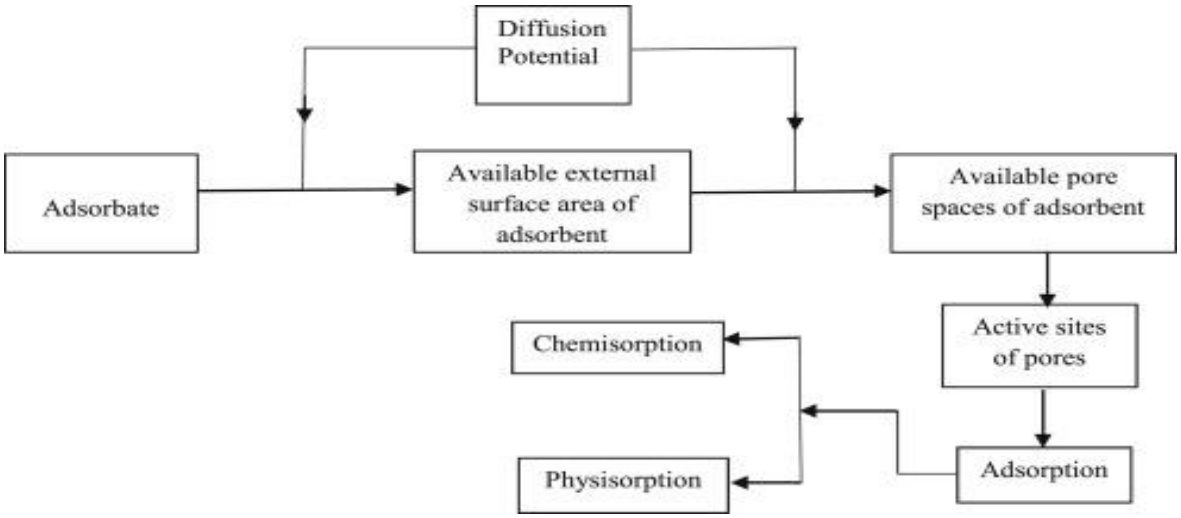


Fig. 3: Pathways of adsorption process Knowing the optimum conditions will help increase the efficiency of the adsorption process and choose the right surface for best results.

There are several parameters that impact in the adsorption process which are studied to reach optimal conditions that give the highest removal percentage. In this review we take removal percentage, pH, temperature, time, and isotherm.

1. Removal percentage: It is known that the higher the percentage of removing pollutants from the environment, the more efficient the adsorption process. Therefore, knowing the percentage of removing pollutants contributes in choosing the appropriate conditions that give the highest efficiency [4].
2. pH of solution is vital factor that impact in the adsorption efficiency. It enhances adsorption removal of cationic or basic adsorbate but reduces that of anionic or acidic adsorbate[13].
3. Temperature: An increase in the adsorption capacity with an increase in temperature is recognized as an endothermic and a low absorption capacity with an increase in the temperature of the solution is called exothermic. So Temperature reinforces adsorption removal of water pollutant by increasing activity of the surface and kinetic energy of the adsorbate but may damage adsorbent physical structure[10].
4. Contact time: as shown in Fig. 4 the reinforces adsorption removal rate of adsorption pollutant by less its mass transfer resistance[10].
5. Isotherm modelling: It helps to know the adsorption mechanism, clarify surface properties and also helps in designing an effective adsorption system[16].

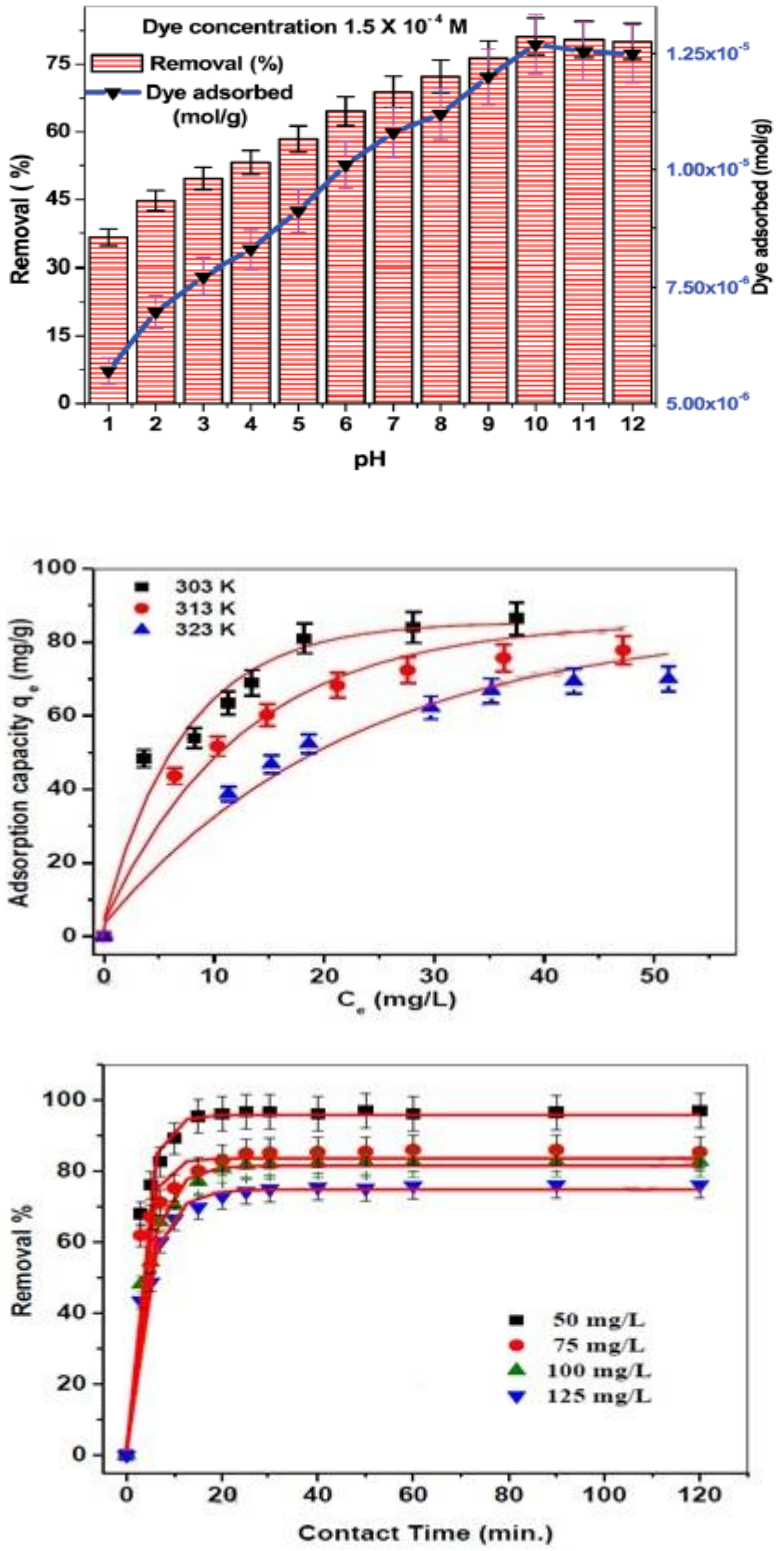


Fig. 4: Sample of adsorption parameter that effect of adsorption in Al_2O_3 and Nano Al_2O_3 surface[10, 13].

Applications

1-Dyes

Dyes are dangerous and carcinogenic organic pollutants that affect living organisms. Dyes are used in many industries like food colouring, cosmetics, paper and textile industries and they are characterized by being light-stable and non-biodegradable as well as causing water

discoloration. There were many techniques to depose dyes . Adsorption technology is most efficiency among them[24,25].

The dye adsorption process involves two mechanics (adsorption and ion exchange) and impacted by numerous parameters like dye/adsorbent reaction, Surface area of adsorbents, pH, contact time, particle size and temperature. The adsorption feature has become a cheap use of sorbents, which reduces the cost of the step[26].
Many Azo dyes like"Methylene Blue, Orange G, Acid Orange-7 and Eriochrom Black T" had removed by Al_2O_3 and Nano Al_2O_3 surface, Fig. 5. Table 2 listed the removal of some dyes in these two surfaces.

Table 2: Adsorption of different dyes in Al_2O_3 and Nano Al_2O_3 surface

Dyes	Adsorbed	Removal %	Contact Time (min.)	Isotherm	Temp.	Adsorption nature	pH	Ref.
Methylene Blue	Nano Al_2O_3	81.2	25	Langmuir	Endothermic	Physical	10	13
Orange G	Nano Al_2O_3	-	30	Langmuir	-	Physical	-	10
Malachite green	Al_2O_3	-	60	Langmuir	-	Physical	7	3
Eosin yellow	Nano Al_2O_3	99.3	120	Langmuir	Endothermic	Chemical	4	27
Acid Orange-7	Nano Al_2O_3	100	60	-	Endothermic	-	2	28
Eriochrom Black T	Al_2O_3	88	30	Langmuir	Endothermic	Chemical	7	29

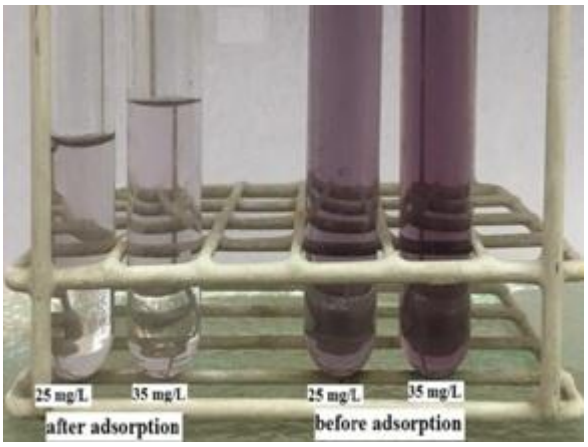


Fig.5: photographs of Eriochrom Black T before and after adsorption[29]

2-Antibiotics

Antibiotics are deeming as an environmental and health challenges due to their genotoxic and mutagenic influences and continuance in natural ecosystem[30].

The widespread use of antibiotics in the treatment of human and animal infections has led to the throw of these antibiotics in the form of wastes that cause soil and water contamination, So it is of vital to remove the antibiotic Waste from source like house, hospitals and pharmaceuticals factories before release them to ecological. One of these antibiotics is the tetracycline family which widely used in the treatment of many infections ،The cheapness and availability of these antibiotics as well as their therapeutic effect has led to their widespread

use in developing countries. The majorities of these antibiotics are not absorbed by the body and released into the environment causing environmental pollution[31,32].

Previous studies have shown a strong relationship between tetracycline derivatives and the surface of aluminium oxide that made aluminium oxide surface is one of the best surfaces used in the removal of these antibiotics from the environment, as shown in table 3. The adsorption of tetracycline group on the surface of Al_2O_3 is chemical adsorption and ligand-promoted dissolution is obtained during the adsorption process[33]. The adsorption of tetracycline hydrochloride, chlortetracycline hydrochloride and oxytetracycline hydrochloride show that the deformation energy is much less than their non-bonding energy and the adsorption happen by non-bond reaction[34]. Other research reveals existence strong transformation reaction rate correlates by the formation of surface complex between tetracycline and Al_2O_3[35], also the nature of adsorption for this Antibiotics is physical.

Table 3: Adsorption of tetracycline derivatives in Al_2O_3 and Nano Al_2O_3 surface

Antibiotics	Adsorbed	Removal %	Contact Time (min.)	Isotherm	Temp.	Adsorption nature	pH	Ref.
Chlorotetracycline	Al_2O_3	22	180	-	-	-	5	35
Chlortetracycline hydrochloride	Al_2O_3	66.21	120	Freundlich	Endothermic	Physical	5	34
Doxycycline	Al_2O_3	81.32	90	-	-	Physical	10	36
Oxytetracycline	Al_2O_3	15.8	180	-	-	-	5	35
Oxytetracycline hydrochloride	Al_2O_3	69.48	120	Freundlich	Endothermic	Physical	5	34
Tetracycline	Al_2O_3	18.8	180	-	-	-	5	35
Tetracycline hydrochloride	Al_2O_3	95	1440	-	-	Physical	5.3	34
Oetracycline hydrochloride	Al_2O_3	72.62	120	Freundlich	Endothermic	Physical	7	34

3-Heavy metals

One of the serious environmental problems is the pollution of Heavy metal even when it is present in low concentrations significantly and non-degradability affects in the environment around us and accumulate in the food chain and causes many risks on human's health, These metals discharged into water and soil in the form of liquid waste from various industrial processes causing water and soil pollution. Also it cannot bio degradable and tends to piling up in living organisms[37-38].

World Health Organization "WHO" had list arsenic, cadmium, mercury and lead in its list of ten chemicals of a major public health concern in 2018 [39]. Also cadmium, mercury, and arsenic are deem as the most toxic (Big Three) group of heavy metals with the utmost potential risk to humans and ecological [4]. Adsorption is one of the best methods used to remove heavy metals from waste water because of sorbent regeneration, chemical and biological sludge reduction, high efficiency, and possibility to recover metals. Also the adsorption process is appropriate even when metal ions are present low concentration up to 1 mg/L [23].

Metal oxide like Al_2O_3 and Nano Al_2O_3 is efficiency in separation of menace metal ion from aqueous solutions and that can see in table 2.

It is observed from 'Table 2' is that the contact time is reduced for same heavy metals when we used nano aluminum oxide surface instead of aluminum oxide, the contact time of adsorption Cd decrease by "25%, 16.6% for Pb, 33.3% for Ni and 55% for Zn" when we used nano Al_2O_3, also the % removal was found to be in order:

For Al_2O_3:
Ar (II)>Zn(II)>Ar(V)> Cd(II)>Pb(II)> Cu(II)> Ni(II)

For Nano Al_2O_3:
Cu(II)> Fe(III)> Cr (VI)>Pb(II)>Th(II) ~Se(VI)>Se (IV)>Cd(II)> Mo(II) ~ Zn(II)> Ni(II).

Table 4: Adsorption of different heavy metals in Al_2O_3 and Nano Al_2O_3 surface

Heavy metals	Adsorbed	Removal %	Contact Time (min.)	Isotherm	Temp.	Adsorption nature	pH	Ref
Arsenite	Al_2O_3	-	60	Langmuir	-	-	6	40
Arsenic(III)	Al_2O_3	99	60	Langmuir	-	-	6	41
Arsenate(V)	Al_2O_3	95	60	Langmuir	-	-	6	41
Cadmium (II)	Al_2O_3	94.25	120	Langmuir	Exothermic	Chemical	5	2
Cadmium (II)	Nano Al_2O_3	87	30	Freundlich	-	-	5	42
Cupper(II)	Al_2O_3	85.42	60	Langmuir	-	Physical	6	43
Cupper(II)	Nano Al_2O_3	100	360	-	-	-	7.5	44
Chrome(VI)	Nano Al_2O_3	99	60		Exothermic	Physical	3	45
Iron (III)	Nano Al_2O_3	99.99	50	Langmuir	Exothermic	Physical	4	46
Led (II)	Al_2O_3	92.10	120	Langmuir	Endothermic	Chemical	5	2
Led (II)	Nano Al_2O_3	97	20	Freundlich	-	-	5	42
Nickel(II)	Nano Al_2O_3	7.75	240	Langmuir		-	5	45
Nickel	Al_2O_3	84.8	720	-	-	-	7.5	38
Nickel-Zinc	Al_2O_3	92.6	360	-	-	-	6	38
Mercury (II)	Nano Al_2O_3	-	1440	Langmuir	-	-	6	7
Molybdenum	Nano Al_2O_3	80	30	Langmuir		-	5	47
Selenite(VI)	Nano Al_2O_3	95	2160	Langmuir	-	-	6.5	5
Selenate(IV)	Nano Al_2O_3	90	2160	Langmuir	-	-	6.4	5
Thallium(IV)	Nano Al_2O_3	95	70	Langmuir	Endohermic	-	4	48
Zinc(II)	Al_2O_3	98.9	180	-	-	-	7.5	38
Zinc(II)	Nano Al_2O_3	80	10	Freundlich	-	-	6.5	49

3- Other compounds

There are many hazardous compounds that the surface of aluminium oxide used to remove them efficiently such as phenol, carboxylic acids in vegetable oils etc.[50-51]. Materials such as fluorine, phosphate and phosphorus are widely used in our daily life and the increasing of them poses a health hazard and causes environmental pollution[52-53], these materials can also remove by adsorption technique in Al_2O_3 and Nano Al_2O_3 surface, table 5.

Table 5: Adsorption of some other compounds in Al_2O_3 and nano Al_2O_3 surface

Other	Adsorbed	Removal %	Contact Time (min.)	Isotherm	Temp.	pH	Ref.
Andiroba oil	Al_2O_3	40.29	30	Langmuir	-	-	51
Carbondots	Al_2O_3	50	1440	Freundlich	-	3	54
Ferrocyanide	Al_2O_3	100	1980			7	55
Fluoride	Al_2O_3	99	180	-	-	6.5	56
Fluoride	Nano Al_2O_3	94	60	Freundlich	Endothermic	4	52
Nitrate	Nano Al_2O_3		60	Langmuir	Endothermic	4.4	57
Palm oil	Al_2O_3	21.7	30	Langmuir	-	-	51
Phenols	Al_2O_3	14.7	1440	Frendluich	-	4.5	50
Phosphorus	Nano Al_2O_3	38	180	Langmuir	Endothermic	4	53
Phosphate	Al_2O_3	86.3	-	Langmuir	-	5	58
Sodium dodecyl sulfate	Al_2O_3	90	180	-	-	4	59
Sodium tetradecyl sulfat	Al_2O_3	80	180	-	-	4	59

Kinetic studies

Research in the adsorption kinetics helps clarify the mechanism that controls absorption Processing. Adsorption kinetics is important as it provides value insight into the interaction paths and mechanism reactions[36].

In this review the studies of kinetic adsorption of dye, Antibiotics and heavy metals in Al_2O_3 and Nano Al_2O_3 surface show agreement with the pseudo second-order except the adsorption of Cd (II) in Nano Al_2O_3 surface was fit to pseudo first –order[45]. Adsorption mechanism of "Pd(II), Cd(II)[2], Cu(II)[43], Fe(III)"[46] were complex and involve two or more steps such as surface adsorption and intraparticle diffusion, Fig. 6. Nano Al_2O_3 surface had contact time less than Al_2O_3 surface.

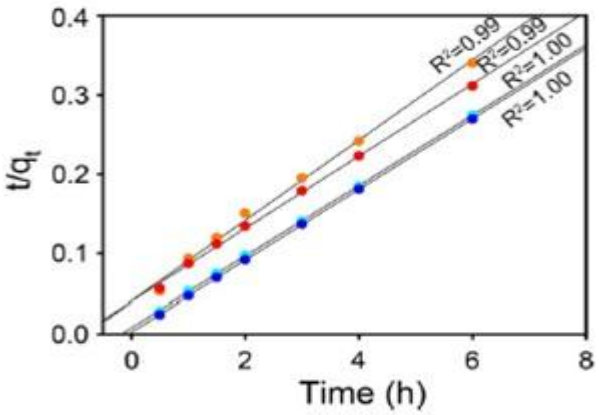


Fig. 6: kinetic plots of "Ni" and "Zn" adsorption on γ-Al_2O_3; pseudo second-order[36].

Conclusions

There are many researchers studied the use of Al_2O_3 and nano Al_2O_3 surface for removal some chemical compounds such as dyes, antibiotics and heavy metals through the discussing of some adsorption factor such as time, isotherm, removal percentage, isotherm, temperature and pH.

The results showed:

1- That most of these compounds prefer the pH in the range 4-7.
2- Adsorption isotherms of Freundlich and Langmuir isotherms were used for studies and it was observed that most of them preferred Langmuir isotherms; also in general the result gave good agreement withendothermic and physical adsorption for most compounds.
3- Nano Al_2O_3 surface gave best removal percentage and lesscontact time in comparison with Al_2O_3 surface.
4- Adsorption kinetics for the adsorption processes follows the pseudo-second-order kinetic mode except "Cd (II)" in nano Al_2O_3 surface was fit to pseudo first –order.

Acknowledgements

We gratitude University of Mustansirriyah, College of Science, Department of Chemistry for helping to do this study.

Hawraa Kassem Hami, RubaFahmi Abbas*, Emad Mahmoud Eltayef and Neda Ibrahim Mahdi
E-mail: rubaf1983@uomustansiriyah.edu.iq
Ruba Fahmi Abbas* (Department of Chemistry, College of Science, Al-Mustansirriyah University, Baghdad, Iraq)

References

1. Hassan, S. A., & Ali, F. J. (2014). Determination of kinetics, thermodynamics and equilibrium parameters of ciprofloxacin adsorption from aqueous solution onto wastes of spent black tea leaves and pomegranate peel. *Int. J. Adv. Sci. Tech. Res*, *2*, 237-253.
2. Naiya, T. K., Bhattacharya, A. K., & Das, S. K. (2009). Adsorption of Cd (II) and Pb (II) from aqueous solutions on activated alumina. *Journal of colloid and interface science*, *333*(1), 14-26.
3. Aazza, M., Moussout, H., Marzouk, R., & Ahlafi, H. (2017). Kinetic and thermodynamic studies of malachite green adsorption on alumina. *Journal of Materials*, *8*(8), 2694-2703.
4. Afroze, S., & Sen, T. K. (2018). A review on heavy metal ions and dye adsorption from water by agricultural solid waste adsorbents. *Water, Air, & Soil Pollution*, *229*(7), 225.
5. Yamani, J. S., Lounsbury, A. W., & Zimmerman, J. B. (2014). Adsorption of selenite and selenate by nanocrystalline aluminum oxide, neat and impregnated in chitosan beads. *Water research*, *50*, 373-381.
6. Yang, J., Hou, B., Wang, J., Tian, B., Bi, J., Wang, N., ... & Huang, X. (2019). Nanomaterials for the removal of heavy metals from wastewater. *Nanomaterials*, *9*(3), 424.
7. Wang, X., Zhan, C., Kong, B., Zhu, X., Liu, J., Xu, W., ... & Wang, H. (2015). Self-curled coral-like γ-Al2O3 nanoplates for use as an adsorbent. *Journal of colloid and interface science*, *453*, 244-251.
8. Hawksworth, D., K. (2013). Fluxless brazing of aluminium, Woodhead. *Canada*, 566-585.
9. Dhawale, V. P., Khobragade, V., & Kulkarni, S. D. (2018). Synthesis and Characterization of Aluminium Oxide (Al2O3) Nanoparticles and its Application in Azodye Decolourisation. *chemistry*, *27*, 31.
10. Banerjee, S., Dubey, S., Gautam, R. K., Chattopadhyaya, M. C., & Sharma, Y. C. (2019). Adsorption characteristics of alumina nanoparticles for the removal of hazardous dye, Orange G from aqueous solutions. *Arabian Journal of Chemistry*, *12*(8), 5339-5354.

11. Sharma, Y. C., Srivastava, V., & Mukherjee, A. K. (2010). Synthesis and application of nano-Al2O3 powder for the reclamation of hexavalent chromium from aqueous solutions. *Journal of Chemical & Engineering Data*, *55*(7), 2390-2398.
12. Ismail, R. A., Zaidan, S. A., & Kadhim, R. M. (2017). Preparation and characterization of aluminum oxide nanoparticles by laser ablation in liquid as passivating and anti-reflection coating for silicon photodiodes. *Applied Nanoscience*, *7*(7), 477-487.
13. Banerjee, S., Gautam, R. K., Jaiswal, A., Chattopadhyaya, M. C., & Sharma, Y. C. (2015). Rapid scavenging of methylene blue dye from a liquid phase by adsorption on alumina nanoparticles. *RSC Advances*, *5*(19), 14425-14440.
14. Elliott, M., Day, J. W., Ramachandran, R., & Wolanski, E. (2019). A synthesis: what is the future for coasts, estuaries, deltas and other transitional habitats in 2050 and beyond?. In *Coasts and Estuaries* (pp. 1-28). Elsevier.
15. Arsenic Free Water to pave way for a Healthy Life. (2019). World Health Organization
16. Singh, N. B., Nagpal, G., & Agrawal, S. (2018). Water purification by using adsorbents: a review. *Environmental technology & innovation*, *11*, 187-240.
17. ATSDR Agency for Toxic Substances and Disease Registry. (2011). *U.S. Department of Health and Human Services.*
18. United States Environmental Protection Agency.(2009). *U.S. Department of Health and Human Services.*
19. United States Department of Health and Human Services. (2019). *U.S. Department of Health and Human Services.*
20. ATSDR Agency for Toxic Substances and Disease Registry.(2011). *U.S. Department of Health and Human Services.*
21. ATSDR Agency for Toxic Substances and Disease Registry. (2011). *U.S. Department of Health and Human Services.*
22. United States Department of Health and Human Services. (2019). *U.S. Department of Health and Human Services.*
23. Lata, S., & Samadder, S. R. (2016). Removal of arsenic from water using nano adsorbents and challenges: a review. *Journal of environmental management*, *166*, 387-406.
24. AL-Abady, F. M. H. (2020). Prediction the effect of the most efficient factors on the adsorption process of some azo dyes compounds on carbon surface using quantum mechanical methods. *Samarra Journal of Pure and Applied Science*, *2*(1), 35-45.
25. Mi, X., Shang, Z., Du, C., Li, G., Su, T., Chang, X. & Tie, J. (2019). Adsorption of an Anionic Azo Dye Using Moringa oleifera Seed Protein-Montmorillonite Composite. *Journal of Chemistry*, *2019*.
26. Kyzas, G. Z., & Kostoglou, M. (2014). Green adsorbents for wastewaters: a critical review. *Materials*, *7*(1), 333-364.
27. Thabet, M. S., & Ismaiel, A. M. (2016). Sol-Gel γ-Al 2 O 3 Nanoparticles Assessment of the Removal of Eosin Yellow Using: Adsorption, Kinetic and Thermodynamic Parameters. *Journal of Encapsulation and Adsorption Sciences*, *6*(03), 70.
28. Khosla, E., Kaur, S., & Dave, P. N. (2013). Mechanistic study of adsorption of acid orange-7 over aluminum oxide nanoparticles. *Journal of Engineering*, *2013*.

29. Khosla, E., Kaur, S., & Dave, P. N. (2013). Mechanistic study of adsorption of acid orange-7 over aluminum oxide nanoparticles. *Journal of Engineering*, *2013*.
30. Naeimi, S., & Faghihian, H. (2018). Remediation of pharmaceutical contaminated water by use of magnetic functionalized metal organic framework. Physicochemical study of doxycycline adsorption. *Water and Environment Journal*, *32*(3), 422-432.
31. Tian, X., Liu, J., Wang, Y., Shi, F., Shan, Z., Zhou, J., & Liu, J. (2019). Adsorption of antibiotics from aqueous solution by different aerogels. *Journal of Non-Crystalline Solids*, *505*, 72-78.
32. Ghaemi, M., & Absalan, G. (2015). Fast removal and determination of doxycycline in water samples and honey by Fe 3 O 4 magnetic nanoparticles. *Journal of the Iranian Chemical Society*, *12*(1), 1-7.
33. Gu, C., & Karthikeyan, K. G. (2005). Interaction of tetracycline with aluminum and iron hydrous oxides. *Environmental Science & Technology*, *39*(8), 2660-2667.
34. Chen, Y., Duan, L., Wang, F., Yang, H., Mao, C., & Gao, J. (2018). Tetracyclines adsorption onto alumina: A comparative experimental and molecular dynamics simulation study. *Journal of Dispersion Science and Technology*, *39*(9), 1376-1384.
35. Chen, W. R., & Huang, C. H. (2010). Adsorption and transformation of tetracycline antibiotics with aluminum oxide. *Chemosphere*, *79*(8), 779-785.
36. Abbas, R. F., Hami, H. K., & Mahdi, N. I. (2019). Removal of doxycycline hyclate by adsorption onto cobalt oxide at three different temperatures: isotherm, thermodynamic and error analysis. *International Journal of Environmental Science and Technology*, *16*(10), 5439-5446.
37. Bedemo, A., Chandravanshi, B. S., & Zewge, F. (2016). Removal of trivalent chromium from aqueous solution using aluminum oxide hydroxide. *SpringerPlus*, *5*(1), 1288.
38. Gou, W., Siebecker, M. G., Wang, Z., & Li, W. (2018). Competitive sorption of Ni and Zn at the aluminum oxide/water interface: an XAFS study. *Geochemical transactions*, *19*(1), 9.
39. Ten chemicals of major public health concern. (2019). World Health Organization
40. Weidner, E., & Ciesielczyk, F. (2019). Removal of Hazardous Oxyanions from the Environment Using Metal-Oxide-Based Materials. *Materials*, *12*(6), 927.
41. Iervolino, G., Vaiano, V., Rizzo, L., Sarno, G., Farina, A., & Sannino, D. (2016). Removal of arsenic from drinking water by photo-catalytic oxidation on MoOx/TiO2 and adsorption on γ-Al2O3. *Journal of Chemical Technology & Biotechnology*, *91*(1), 88-95.
42. Tabesh, S., Davar, F., & Loghman-Estarki, M. R. (2018). Preparation of γ-Al2O3 nanoparticles using modified sol-gel method and its use for the adsorption of lead and cadmium ions. *Journal of Alloys and Compounds*, *730*, 441-449.
43. Naeema, H., Y. (2014). Removal of toxic copper ions using alumina. *Int. J. Curr. Microbiol. App. Sci, 3*, 415-431.
44. Li, X., Zhou, S., & Fan, W. (2016). Effect of nano-Al2O3 on the toxicity and oxidative stress of copper towards Scenedesmus obliquus. *International journal of environmental research and public health*, *13*(6), 575.
45. Poursani, A. S., Nilchi, A., Hassani, A. H., Shariat, M., & Nouri, J. (2015). A novel method for synthesis of nano-γ-Al 2 O 3: study of adsorption behavior of chromium, nickel, cadmium and lead ions. *International Journal of Environmental Science and Technology*, *12*(6), 2003-2014.

46. Mahmoud, M. A. (2015). Kinetics and thermodynamics of aluminum oxide nanopowder as adsorbent for Fe (III) from aqueous solution. *Beni-Suef University Journal of Basic and Applied Sciences*, *4*(2), 142-149.
47. Denkova, A. G., Terpstra, B. E., Steinbach, O. M., Dam, J. T. & Wolterbeek, H. T. (2013). Adsorption of Molybdenum on Mesoporous Aluminum Oxides for Potential Application in Nuclear Medicine. *Separation Science and Technology*, *48*(9), 1331-1338.
48. Broujeni, B. R., Nilchi, A., Hassani, A. H., & Saberi, R. (2019). Comparative adsorption study of Th 4+ from aqueous solution by hydrothermally synthesized iron and aluminum oxide nanoparticles. *International Journal of Environmental Science and Technology*, *16*(8), 4069-4082.
49. Stietiya, M. H., & Wang, J. J. (2014). Zinc and cadmium adsorption to aluminum oxide nanoparticles affected by naturally occurring ligands. *Journal of environmental quality*, *43*(2), 498-506.
50. Safwat, S. M., Medhat, M., & Abdel-Halim, H. (2019). Adsorption of phenol onto aluminium oxide and zinc oxide: A comparative study with titanium dioxide. *Separation Science and Technology*, *54*(17), 2840-2852.
51. Amaral, A. R., & Machado, N. T. (2015). Kinetic and Isotherms Adsorption of the Palm and Andiroba Vegetable Oils on γ-Alumina. *Technology*, *10*(6), 241-253.
52. Chinnakoti, P., Chunduri, A. L., Vankayala, R. K., Patnaik, S., & Kamisetti, V. (2017). Enhanced fluoride adsorption by nano crystalline γ-alumina: adsorption kinetics, isotherm modeling and thermodynamic studies. *Applied Water Science*, *7*(5), 2413-2423.
53. Moharami, S., & Jalali, M. (2014). Effect of TiO2, Al2O3, and Fe3O4 nanoparticles on phosphorus removal from aqueous solution. *Environmental Progress & Sustainable Energy*, *33*(4), 1209-1219.
54. Liu, X., Li, J., Wu, X., Zeng, Z., Wang, X., Hayat, T., & Zhang, X. (2017). Adsorption of carbon dots onto Al2O3 in aqueous: Experimental and theoretical studies. *Environmental Pollution*, *227*, 31-38.
55. Bushey, J. T., & Dzombak, D. A. (2004). Ferrocyanide adsorption on aluminum oxides. *Journal of colloid and interface science*, *272*(1), 46-51.
56. Tripathy, S. S., Bersillon, J. L., & Gopal, K. (2006). Removal of fluoride from drinking water by adsorption onto alum-impregnated activated alumina. *Separation and purification technology*, *50*(3), 310-317.
57. Bhatnagar, A., Kumar, E., & Sillanpää, M. (2010). Nitrate removal from water by nano-alumina: Characterization and sorption studies. *Chemical Engineering Journal*, *163*(3), 317-323.
58. Xie, J., Lin, Y., Li, C., Wu, D., & Kong, H. (2015). Removal and recovery of phosphate from water by activated aluminum oxide and lanthanum oxide. *Powder Technology*, *269*, 351-357.
59. Nguyen, T. M. T., Do, T. P. T., Hoang, T. S., Nguyen, N. V., Pham, H. D., Nguyen, T. D. & Pham, T. D. (2018). Adsorption of anionic surfactants onto alumina: Characteristics, mechanisms, and application for heavy metal removal. *International Journal of Polymer Science*, *2018*.

IRAQI Academic Scientific Journals
Samarra Journal of Pure and Applied Science
SJPAS
ISSN:2663-7405
www.sjpas.com

تطبيقات أوكسيد الألومنيوم وأوكسيد الألومنيوم النانوي كممتز مراجعة

حوراء قاسم حامي، ربا فهمي عباس*، عماد محمود الطيف، نداء ابراهيم مهدي
قسم الكيمياء، كلية العلوم، الجامعة المستنصرية، بغداد، العراق (suha_rrr_1983@yahoo.com)

معلومات البحث:

تأريخ الاستلام: 2020/01/24
تأريخ القبــول: 2020/04/05

الكلمات المفتاحية:

أوكسيد الالمنيوم، نانو اوكسيد الالمنيوم، الممتز، اصباغ، مضادات حيوية

الخلاصة:

تستخدم أكاسيد المعادن على نطاق واسع في تكنولوجيا الامتزاز كونها سطوح مازة بسبب كفاءتها، وانخفاض تكلفتها وخصائصها الفيزيائية الفريدة. تهدف هذه المقالة إلى توضيح دور أوكسيد الألومنيوم وأوكسيد الألومنيوم النانوي في إزالة بعض المواد الكيميائية التي تؤثر على صحة الإنسان مثل الأصباغ، والمضادات الحيوية والمعادن الثقيلة. وشملت أيضا تأثير بعض معاملات الامتزاز مثل درجة الحموضة ووقت الاتصال ونسبة الإزالة ودرجة الحرارة، وطبيعة الامتزاز، ونماذج الامتزاز الحركية ونماذج الأيزوثيرم.