Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Der Chemica Sinica, 2014, 5(4):25-29

ISSN: 0976-8505
CODEN (USA) CSHIA5

Adsorption characteristics of manganese (II) on granular activated carbon

Yogita K. Meshram[1], N. T. Khati[2] and R. U. Khope[1]

[1]Department of Chemistry, S. S. E. S. Amt's Science College, Congress Nagar, Nagpur(M.S), India
[2]Department of Chemistry, Priyadarshini College of Engineering, Hingna Nagpur(M.S), India

---

ABSTRACT

In the present investigation the surface of granular activated carbon was modified by organic ligand for removal of Mn^{2+} ions from aqueous solution. Experiment was carried out in batch mode at constant temperature of 25 ± 1^0C. Some readily available derivatives of benzene were used for surface modification of GAC. To enhance the capacity to adsorb manganese. GACs were loaded with organic ligand. The equilibrium adsorption data was better fitted to the Langmuir and Freundlich adsorption model. Study was also extended to evaluate the surface area occupied by manganese in the formation of monolayer on GAC.

Keywords: Adsorption, Mn (II), Granular Activated Carbon(GAC), 3-Nitrophthalic Acid (3-NPTA), Filtrasorb100 (F-100), Filtrasorb 816 (F-816).

INTRODUCTION

In present day context water pollution is the biggest hazard for all forms of life. The environmental pollution has been the most remarkable side effect of rapid industrialization and growing population of the world. Today, almost all the things, which are most necessary to the human beings, are more or less contaminated by toxic substances.

Manganese is common contaminant in ground water, as a divalent ion Mn^{2+} and it is considered a pollutant mainly because of its organoleptic properties. The World Health Organization (WHO) has set a guideline value 0.05 mg/L of manganese in drinking water [1]. Water gets polluted by manganese ions coming from many industries mainly pyrulusite MnO_2 treatment, steel alloy, dry cell batteries, glass and ceramic, paint and varnish, ink and dyes, match and fireworks. A substantial part of water used for potable use shows contamination significantly exceeding the maximum contaminant level. Thus it is an important and necessary for the researchers to develop appropriate methods to check the deterioration of the environment. Numbers of methods have been developed by the workers for the removal of heavy metals like ion exchange, solvent extraction, chemical precipitation, biological operation, filtration etc [2-8]. But adsorption of heavy metals by activated carbon and modified activated carbon proved to be the most economically viable technique in this application.[9-19]. In present study adsorption isotherms were established and the results modeled by the Langmuir and Freundlich isotherm.

MATERIALS AND METHODS

All the chemicals used in experiment were analytical reagent grade. The manganese solution was prepared by dissolving requisite $MnSO_4$ (E-Merck) in freshly prepared distilled water. In present study granular activated carbons namely F-816 and F-100 supplied by Calgon Carbon Corporation Ltd. Pittusberg PA USA were used as adsorbent. Each grade of carbons was first subjected to size fractionation to obtain a particles of desired size using a sieve shaker (M/s Jayant Test Siever Mumbai) and the particles retained in between 840ų-1400ų were used in all experiment. These particles were washed several times with boiled distilled water until clear lechate was obtained and collected in petridish. Finally the samples were dried in an oven at a temperature of 100-110˚C, cooled at room temperature and stored in desiccators until use.

A ten solutions of known concentration of Mn^{2+} ions were prepared from main stock solution by diluting with distilled water. Potassium periodate method was used to form the complex with Mn^{2+} ions[20]. Then absorbance of each solution was measured spectrophotometrically at 525 nm of wavelenght using Chemito-spectoscan UV 2700, Double beam UV-Vis Spectrophotometer.The Beer's law calibration curve was established by plotting the graph between absorbance versus concentration. In the present work 3-Nitrophthalic acid was selected as organic ligand to modify the surface of GAC. It was first purified and recrystallized by standard method. The experimental melting point of 3-Nitropthalic acid (218.5˚C) compared with literature value (219˚C) [21].For determining adsorption isotherm, 0.5 gm of the dried GAC was taken in each clean shaking bottle and 200 ml of acid solution of a specific concentration was shaken for 5 hrs using remi stirrer at about 500 rpm. The solution was then filtered off and the carbon was washed several time thoroughly with distilled water. This carbon was transferred to shaking bottle and then 200 ml Mn^{2+} ion solution of P^H =5 was added to it. The mixture was then stirred for 5 hrs at constant temperature of 25 ±1°C. The initial and final concentration of the Mn^{2+} ion in mg /L was then estimated using mathematical equation obtained from calibration curve. The batch adsorption experiments were repeated to ensure reproducible result.

RESULTS AND DISCUSSION

Adsorption isotherms are essential for the description of how metal ion concentration interact with carbon surface and also useful to optimize the use of granular activated carbon as a adsorbent for the removal of manganese.

Adsorption of Mn^{2+} ions on ligand loaded GAC was studied by batch technique. The uptake of of Mn^{2+} on the loaded GAC was calculated from equation

$$q_e = (C_0 - C_e) \times \frac{V}{W}$$

Where,
q_e = Concentration of Mn^{2+}on the ligand loaded GAC in mg/mmol of ligand at equilibrium,
C_o = Initial concentration of Mn^{2+} in solution in mg/L,
Ce = Equilibrium concentration of Mn^{2+} in solution in mg/L,
V = Volume of solution in Lit,
W = Weight of the carbon .

The adsorption isotherms of ligand loaded GAC obtained by plotting q_e and C_e are shown in Fig-1and Fig-2.

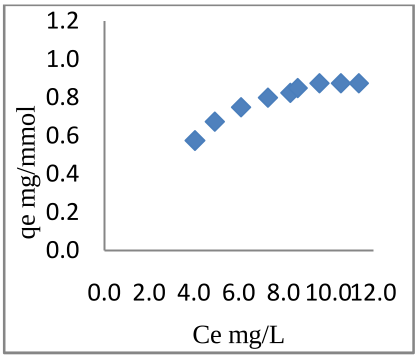

Fig-1 Adsorption Isotherm
System: F-816-3NPTA-Mn^{2+}

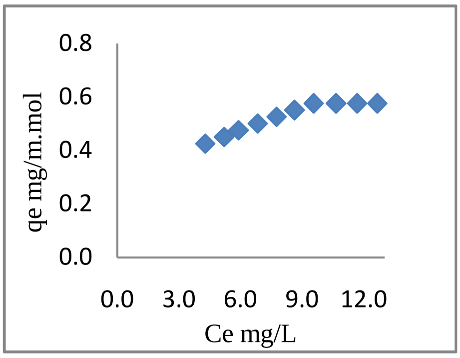

Fig-2 Adsorption Isotherm
System: F-100-3NPTA-Mn^{2+}

Adsorption isotherm:
The adsorption equilibrium data were fitted to the Langmuir and Freundlich isotherm.

The most important Langmuir model of monolayer adsorption of manganese ions on the surface of carbon sites is expressed in the linear form. As per Langmuir theory, the non linear equation can be represented by

$$q_e = Q^0 b \times \frac{Ce}{1 + bCe}$$

The linearised form of Langmuir isotherm can be expressed as

$$\frac{1}{q_e} = \frac{1}{bQ^0} \times \frac{1}{Ce} + \frac{1}{Q^0}$$

Where, Q^0 =(monolayer adsorption capacity) amount adsorbed per unit weight of the carbon forming a complex monolayer on the adsorbent surface, b = Langmuir constant. A plot of 1/Ce versus 1/qe found to be linear indicating the applicability of Langmuir model.

The Freundlich model is an empirical equation describes the heterogeneous surfaces and multilayer adsorption and is expressed in non linear form as

$$q_e = k \cdot Ce^{\frac{1}{n}}$$

It may be linearised as

$$\log q_e = \log K_f + \frac{1}{n} \log Ce$$

Where the constant K_f and 1/n of the Freundlich model related to the adsorption capacity and adsorption intensity respectively ,which depends on the heterogeneity of the material. A plot of log q_e versus log C_e was fairly showing validity of Freundlich equation over a range of concentration. The slope of 1/n ranging between 0and 1 is a measure of the surface heterogeneity, becoming more heterogeneous as its value gets closer to zero. Fig-3 to Fig- 6 illustrate the plot of Langmuir and Freundlich isotherm for F-816-3-NPTA-$Mn^{2+}$and F-100-3-NPTA-Mn^{2+} . The value of K_f, 1/n, b, q_{max} and Q° for F-816-3-NPTA-$Mn^{2+}$and F-100-3-NPTA-Mn^{2+} are shown in Table No.1. F-816-3-NPTA-Mn^{2+}systems show the superiority over F-100 -3-NPTA-Mn^{2+} for the adsorption process.

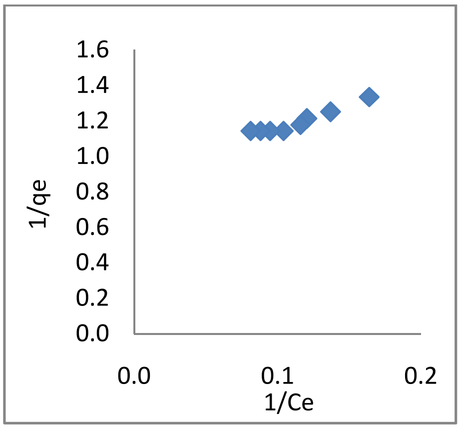

Fig-3Langmuir Adsorption Isotherm System:GAC-F-816-3-NPTA-Mn^{2+}

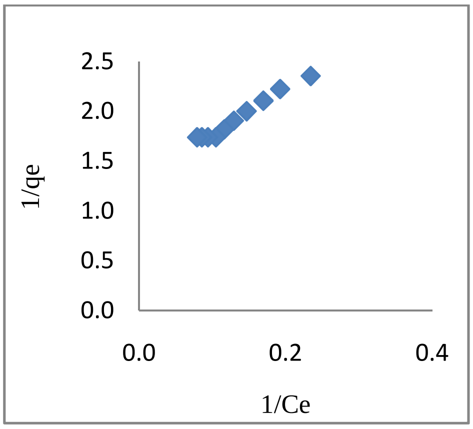

Fig-4 Langmuir Adsorption Isotherm System:GAC-F-100-3-NPTA-Mn^{2+}

The saturation of monolayer by adsorbate gave the value of q_e was used for determination of surface area of the adsorbent. For this purpose a plot of 1/q_e versus 1/C_e helped in determination of 1/Q^o and hence Q^o .The surface area of the carbon through Mn^{2+} adsorption can then be represented as

$S = N Q^o A$

Where,
S =Surface area of adsorbent cm^2 /g
N =Avogadro number
A =Cross section area of the adsorbate molecule

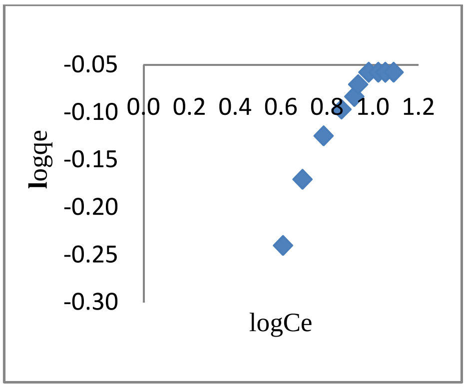

Fig-5 Freundlich Adsorption Isotherm System:GAC-F-816-3-NPTA-Mn^{2+}

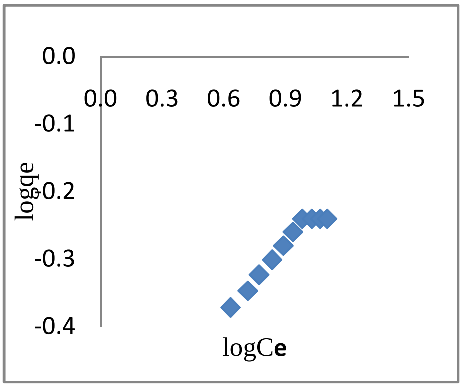

Fig-6 Freundlich Adsorption Isotherm System:GAC-F-100-3-NPTA-Mn^{2+}

Thus it is possible to determine the surface area of ligand loaded GAC at the saturation level when a monolayer of the Mn^{2+} would cover entire surface of GAC adsorbent.

The determination of surface area occupied by a single Mn^{2+} ion, were calculated using the expression given by Bruanauer and Emmet.

$$A = 4\times0.866\ [M/\sqrt{4N_a}\ .d]^{2/3}$$

Where,
M=Atomic weight of Manganese [22]
N = Avogadro number
d = Density of Manganese (7.3 gm/cm^3) [23]

The values of S obtained from Q^o and S′ obtained from q_{max} are fairly comparable and are reported in the Table-2.

Table-1 Langmuir and Freundlich Isotherm Constants

Sr.No	System	Langmuir Constant		Freundlich Constant		qmax(mg/m.mole)
		Q^0	**b**	**1/n**	**Kf**	
1	GAC-F-816-3-NPTA-Mn^{2+}	1.1494	0 .3020	0.3650	0.3724	0.8750
2	GAC-F-100-3-NPTA -Mn^{2+}	0.7468	0 .3030	0.3060	0.2761	0.5750

The numerical value of K_f and 1/n for GAC F-816 are 0.3724 and 0.3650 respectively. The fractional value of 1/n indicates that the surface of GAC is of the heterogeneous type with an exponential distribution of energy site. The higher numerical value of K_f confirms the significant affinity of Mn^{2+} ions for granular activated carbon. The value of Freundlich and Langmuir constants indicate the superiority of GAC –F-816 over GAC-F-100, in the removal of Mn^{2+} from aqueous phase.

Table No-2 Surface Area of GACs

Sr. No.	System	Area	S	S'
1	GAC-F-816-3-NPTA-Mn^{2+}	$5.875\times10^{-16}cm^2$	$2.961\times10^2\ cm^2/g$	$2.254\times10^2\ cm^2/g$
2	GAC-F-100-3-NPTA-Mn^{2+}	$5.875\times10^{-16}cm^2$	$1.89\times10^2\ cm^2/g$	$1.481\times10^2\ cm^2/g$

CONCLUSION

In the present investigation, it is concluded that GACs are unique adsorbents for the removal of manganese ions from aqueous phase . The adsorptive ability of F-816 is higher than F-100. This is due to the fact that activated carbon have high surface area and high microporous characters.

The results indicate the GAC is an effective adsorbent for the removal of Mn(II) ions from aqueous solution under the tested experimental condition and could be useful in the treatment process of industrial wastes or the analytical application.

Acknowledgement
The authors are thankful to the Principal, Priyadarshini College of Engineering, Hingna, Nagpur and the Principal, Science College Congress Nagar, Nagpur for providing laboratory facilities to carry out the experimental work.

REFERENCES

[1] WHO “Guidelines for Drinking Water Quality. World Health Organization”, Germany. **2003**
[2] Komewska E, Lach J, Kacpzak M, Neeza E. *Desalinatio*n,**2007,**206,251-258.
[3] Knocke WR, Clevenger T, Ghosh MM, Novak JT., Proc. 33rd Purdue Industrial waste conf**,1978,** 33,415-426.
[4] McDonald CW, Bajwa RS., *Sep Sci*,**1977,** 12. 435-445.
[5] Bhattachayya D, Jumawan A, Sun G, Schwitzebel K., Precipitation of sulphide: AICHE symposium series**, 1980** Water 77, 31-42.
[6] Linstedt KD, Houck CP, O’Connor JT., *J Water Pollut Control Fed*,**1971,** 43,1507-1513.
[7] Chang SY, Huang JC, Liu YC., (1984. Summer National AICHE meeting, Philadelphia PA,**1984**, 19-22.
[8] De Mora SJ, Harrison RM,. *Water Res***, 1983**, 17, 723-733.
[9] Youssef AM., El-wakil AM., El-Sharkawy WA., Farag AB., Toggan KH., *Adsorpt Sci Technol*,**1996,** 13, 115-124.
[10] Youssef AM., El-Nabarawy Th., Samra SE., *Colloids and surfaces*, **2004,** 235, 153-163.
[11] Youssef AM, El-Khouly S, El-Nabarawy. Carbon Lett,**2008,** 9, 8-17.
[12] Alaya MN., Youssef AM., Karman M., Abdel-Al H., *carbon Sci*, **2006**, 7, 9-18.
[13] Alaya MN, Youssef AM, Karman M, Abdel-Al H. *carbon Sci*,**2006**, 7: 9-18.
[14] Hete Y.V., Gholse S.B.and Khope R.U., *Der chemica Sinica*,**2012**, 3(4):787-793.
[15] Gawande N.J.,Choudhari A.R. and Khope R.U., *Advances in applied science Research*,**2012**,3 (3): 1836-1841.
[16] Komewska E, Lach J, Kacpzak M, Neeza E *Desalination*, **2007**, 206, 251-258.
[17] Meena, A.K., Mishra, G.K., Rai, P.K., Rajagopal, C., Nagar P.N., *Journal of Hazardous Materials*, **2005**, 122 (1–2), 161–170.
[18] Hete Y. V., Gholse S.B.and Khope R.U., “*Journal of Materials Science and* Engineering, **2011** ,**1**, 117-120.
[19] Gunjate J.K., Gholse S.B.and Khope R.U., *Der chemica Sinica*, **2014**, 5(3),5-9
[20] Vogel,A.I.;Quantitative Inorganic Analysis,4th Edn. Longman Group Ltd.England ,pp., **1978**, pp746- 747.
[21] Furniss BS, Hannaford AJ, Smithn Peter WG,Tatchell AR, Vogel’s Textbook of practical organic chemistry (5thedition), pp **1348** ,Pearson publication.
[22] Vogel’ Textbook of Quantitative Analysis, 5th Edn. ELBS with Longman Group, **1989**, pp.819
[23] Handbook of fine chemicals (Aldrich Chemistry) pp .No.1753