ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Adsorption of Metformin as Anti-Diabetic Drug On Carbon Nanotube and Activated Carbon.

Hassan Lotfi[1], Raziyh Jafari Khoshan abadi[1], and Mehdi Vadi[2]*.

[1]Department of Chemistry, Firouzabad Branch, Islamic Azad University, Firouzabad, Iran.
[2]Department of Chemistry, Sarvestan Branch, Islamic Azad University, Sarvestan, Iran.

ABSTRACT

We have studied the adsorption of the isotherm of Metformin, on multi carbon nanotube. The adsorption equilibrium isotherms were fitted by Freundlich, Langmuir, and Temkin models. It was found that the Langmuir model described the adsorption process better than other two isotherm models. The amount of Metformin adsorbed on carbon nanotube surface more than of activtad carbon surface also adsorption on both adsorbent increased with the increase of the initial Metformin concentration.

Keywords: Adsorption, Isotherm, Multi-wall carbon nanotube, Activated Carbon, Metformin

Corresponding author

ISSN: 0975-8585

INTRODUCTION

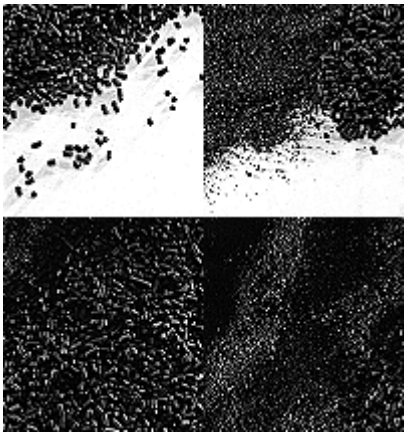
Carbon nanotubes exhibit several technologically important characteristics. Metallic (m) nanotubes can carry extremely large current densities [1,2]; semiconducting (s) nanotubes can be electrically switched on and off as field-effect transistors (FETs) [3,4]. The two types may be joined covalently [5,6].

Applied quantum chemistry, specifically, orbital hybridization best describes chemical bonding in nanotubes. The chemical bonding of nanotubes is composed entirely of sp^2 bonds, similar to those of graphite. These bonds, which are stronger than the sp^3 bonds found in alkanes and diamond, provide nanotubes with their unique strength.

Activated carbon adsorption

Adsorption is a process where a solid is used for removing a soluble substance from the water. In this process active carbon is the solid. Activated carbon is produced specifically so as to achieve a very big internal surface (between 500 - 1500 m^2/g). This big internal surface makes active carbon ideal for adsorption. Active carbon comes in two variations: Powder Activated Carbon (PAC) and Granular Activated Carbon (GAC). The GAC version is mostly used in water treatment, it can adsorb the following soluble substances.

- Adsorption of organic, non-polar substances such as:
  - Mineral oil
  - BTEX
  - Poly aromatic hydrocarbons (PACs)
  - (Chloride) phenol
- Adsorption of halogenated substance: I, Br, Cl, H en F
- Odor
- Taste
- Yeasts
- Various fermentation products
- Non-polar substances (Substances which are non soluble in water)



Process description

Water is pumped in a column which contains active carbon; this water leaves the column through a draining system. The activity of an active carbon column depends on the temperature and the nature of the substances. Water goes through the column constantly, which gives an accumulation of substances in the filter. For that reason the filter needs to be replacing periodically. A used filter can be regenerated in different ways; granular carbon can be regenerated easily by oxidizing the organic matter. The efficiency of the active carbon decreases by 5 - 10% 1). A small part of the active carbon is destroyed during the regeneration process and must be replaced. If you work with different columns in series, you can assure that you will not have a total exhaustion of your purification system [6].

Metformin

Metformin is primarily used for type 2 diabetes, but is increasingly being used in polycystic ovary syndrome,[7] non-alcoholic fatty liver disease (NAFLD)[8] and premature puberty,[9] three other diseases that feature insulin resistance; these indications are still considered experimental. The benefit of metformin in NAFLD has not been extensively studied and may be only temporary;[10] although some randomized controlled trials have found significant improvement with its use,the evidence is still insufficient [11,12].

Chemistry of Metformin

The usual synthesis of metformin, originally described in 1922 and reproduced in multiple later patents and publications, involves the reaction of dimethylamine hydrochloride and 2-cyanoguanidine (dicyandiamide) with heating figure 1 and structure of Metformin figure 2 [13,14].

ISSN: 0975-8585

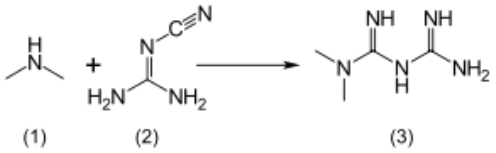


Figure 1: Synthesis of Metformine

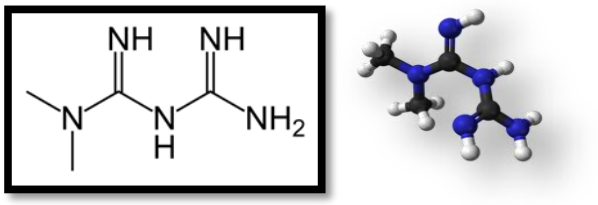


Figure 2: Structure of N'N-Dimethylimidodicarbonimidicdiamide (Metformin)

According to the procedure described in the 1975 Aron patent,[15] and the *Pharmaceutical Manufacturing Encyclopedia*,[16] equimolaramounts of dimethylamine and 2-cyanoguanidine are dissolved in toluene with cooling to make a concentrated solution, and an equimolar amount of hydrogen chloride is slowly added. The mixture begins to boil on its own, and after cooling, metformin hydrochloride precipitates with a 96% yield.

In this research, metformin as anti-diabetic drug on multi walled carbon nanotube were studied and tried to find out how this drugs can be adsorbed by carbon nanotube and activated carbon. We also want to find out if we can affect the metformin molecule by putting these drugs on adsorbents without damaging the safe molecules.

MATERIALS AND METHODS

Metformin with purity of 90% was purchased from Merck Co., Germany.

Multi-walled carbon nanotubes (MWCNTs) are produced by outer diameter of 10 to 20 nm, surface space of 250 of 280 m2 /g and high purity of 99%, and were purchased from Aldrich. Adsorption experiments A stock solution of about 100 mg/L celebrex was prepared. Therange of metformin concentration used is from 1o to 80 mg/L. Equilibrium adsorption experiments were performed using 40 ml screw-capped glass centrifuge tubes as batch reactor systems. Each tube containing 0.05 g SWCNTs was filled with 25 ml metformin solution of different concentrations. All tubes were immediately sealed with PTFE-lined caps and were then mechanically shaken for 24 h in a thermostated rotary shaker at temperature of 295 ± 1 K, except for the adsorption experiments, in which temperatures of 300 and 305 K were adjusted. After equilibration, all tubes were placed vertically for 4 h at the same temperature to ensure complete sedimentation of MWCNTs from the bulk solutions. By using spectrophotometer tool adsorption rate, metformin was obtained figure 3.

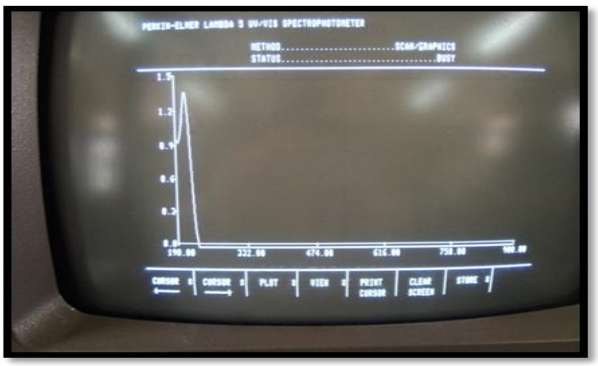


Figure 3: Adsorption of Metformin (20 ppm)

Modeling of the adsorption isotherms

Equilibrium study on adsorption provides information on the capacity of the adsorbent. An adsorption isotherm is characterized by certain constant values, which express the surface properties and affinity of the adsorbent and can also be used to compare the adsorptive capacities of the adsorbent for different pollutants. Equilibrium data can be analyzed using commonly known adsorption systems. Several mathematical models can be used to describe experimental data of adsorption isotherms. The Freundlich, Langmuir and Temkin models are employed to analyse the adsorption that occurred in the experiment.

Langmuir model

The Langmuir model assumes uniform energies of adsorption onto the surface and no transmigration of adsorbate in the plane of the surface. The Langmuir equation may be written as:

$$C_e/q_e = 1/q_m b + 1/q_m * Ce \qquad (1)$$

Where $q_e$is the amount of solute adsorbed per unit weight of adsorbent (mg/g), C_e the equilibrium concentration (mg/L), q_m is the monolayer adsorption capacity (mg/g) and b is the constant related to the free energy of adsorption.

The Langmuir model considers several assumptions: the adsorption is localized, all the active sites on the surface have similar energies, none interaction between adsorbed molecules exist, and the limiting reaction step is the surface reaction as in the heterogeneous catalytic reaction.

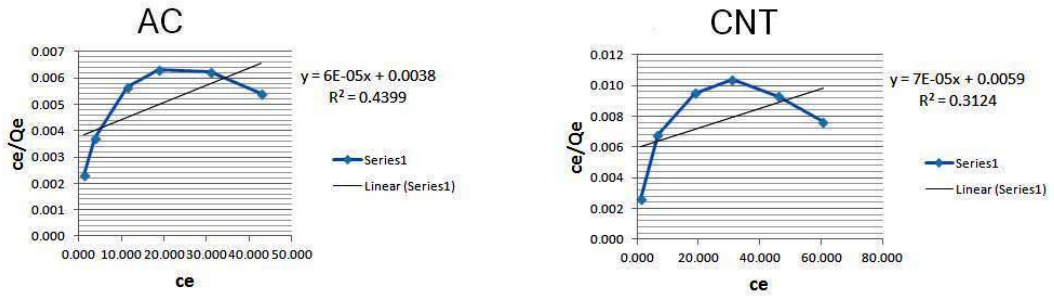


Figure 4: Diagram of Langmuir model **adsorption of metformin on AC and CNT**

Freundlich model

The Freundlich model is an empirical equation based on sorption on heterogeneous surface through a multilayer adsorption mechanism. It is given as:

$$q_e = k_f C_e^{1/n} \qquad (2)$$

where q_e is the amount of solute adsorbed per unit weight of adsorbent (mg/g), C_e is the equilibrium concentration (mol/L), $k_f$is the constant indicative of the relative adsorption capacity of the adsorbent (mg/g(mg/L) and 1/n is the constant, indicative of the intensity of the adsorption. The linearized form of the Freundlich equation is:

$$Lnq_e = Lnk_f + 1/nLnC_e$$

The value of k_f and n can be calculated by plotting lnq_e versuslnC_e figure 5.

ISSN: 0975-8585

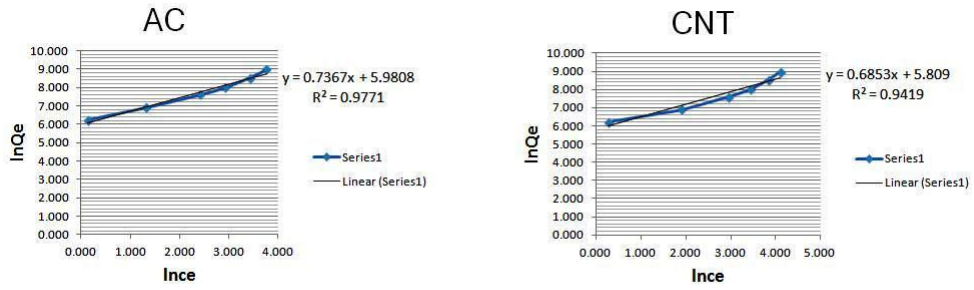


Figure 5: Diagram of Freundlich model adsorption of metformin on AC and CNT

Temkin model

Temkin suggested that, because of the existence of adsorbent-adsorbate interactions, the heat of adsorption should decrease linearly with the surface coverage. The Temkin isotherm equation assumes that the adsorption is characterized by a uniform distribution of the binding energies, up to some maximum binding energy. The corresponding adsorption isotherm can thus be adjusted by the following equation:

$$q=B\ln A+B\ln C \quad (4)$$

Where B is related to the heat of adsorption (L/g) and A is the dimensionless Temkin isotherm constant. The Temkin parameters (B and A) can be determined from the linear plots of qe and lnCe figure 6.

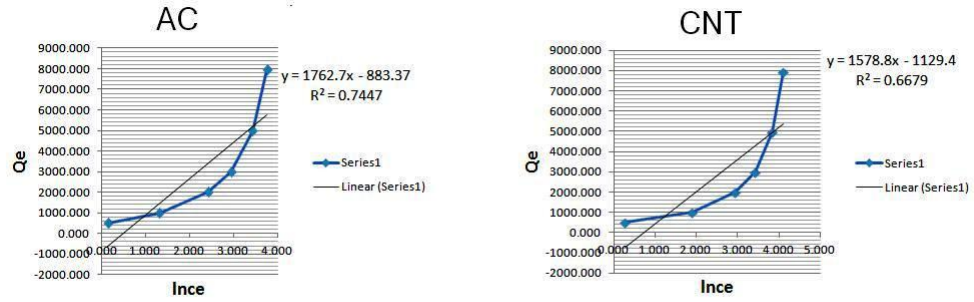


Figure 6: Diagram of Temkin model adsorption of metformin on AC and CNT

RESULTS AND DISCUSSION

Adsorption of The Langmuir, Temkin and Freundlich isotherms of the adsorption process of metformin onMWCNTs are as shown in Figures 4 to 6. It was observed that the experimental data were well represented by Langmuir, Freundlich and Temkin models. The values of the constants of the isotherms of Langmuir, q and b, and of Freundlich, k and n, and of Temkin, B, A and b, are as shown in Table 1. The results of Figures 4 to 6 show that in order to adsorb metformin on carbon nanotube in the temperature range of 295 to 305 K, the Freundlich model is followed because they have more R^2.

CONCLUSION

In this study we compare the adsorption isotherms of metformin by activated carbon and carbon nanotube. Base on obtained results we conclude that nanotube has more efficiency in removal of metformin rather than activated carbon. Results of isothermic experiments showed that the correlation coefficient of Freundlich modelisothermic's equation for carbon nanotube was more than activated carbon. Also, the values of n and K_f for carbon nanotube were higher than activated carbon and indicating that the energy of adsorption is higher than carbon nanotube. Therefore, in total, it is concluded that correlation coefficient (n and K_f) in Freundlich isotherm's models for carbon nanotube were higher and it's efficiency in the removal of metformin is better than activated carbon.

Considering that adsorption onto a solid surface due to attractive forces between functional groups on the solid surface and molecules material is absorbed.According to the results obtained on carbon nanotube(CNT) and activated carbon (AC) investigated in this study, Freundlich model for adsorption metformin by carbon nanotubes and freundlich model for adsorption metformin by activated carbon is consistent. freundlich model represents ions adsorption onto heterogeneous surfaces with multi-layer adsorption and adsorbed amount increases with increasing concentration.

Table 1: Parameters and correlation coefficients of isotherm model

Adsorption	Langmuir model			Freundlich model			Temkin model		
	Q(mg/g)	R^2	b(L/mg)	K_f(mg/g)	n	R^2	B	R^2	A(L/mg)
Adsorption of metformin on Activated carbon	72.56	0.943	0.073	9.182	2.334	0.925	13.824	0.852	0.639
Adsorption of metformin on Carbon nanotubes	79.94	0.952	0.103	17.173	2.912	0.991	14.928	0.937	1.432

REFERENCES

[1] H Dai, EW Wong, CM Lieber. Science 1996;272:523.
[2] JE Fischer et al. Phys Rev B 1997;55:R4921.
[3] SJ Tans, ARM Verschueren, C Dekker. Nature 1998;393:49.
[4] R Martel, T Schmidt, HR Shea, T Hertel, Ph Avouris. Appl Phys Lett 1998;73:2447.
[5] L Chico, VH Crespi, LX Benedict, SG Louie, M L Cohen. Phys Rev Lett 1996;76:971.
[6] Wastewater Engineering; Metcalf & Eddy; third edition; 1991; page 317
[7] Lord JM, Flight IHK, Norman RJ. BMJ 2003;327(7421):951–3.
[8] Marchesini G, Brizi M, Bianchi G, Tomassetti S, Zoli M, Melchionda N. Lancet 2001;358(9285):893–4.
[9] Ibáñez L, Ong K, Valls C, Marcos MV, 8.Dunger DB, de Zegher F. J Clin Endocrinol Metab 2006;91(8):2888–91.
[10] Nair S, Diehl AM, Wiseman M, Farr GH Jr, Perrillo RP. Aliment Pharmacol Ther 2004;20(1):23–28
[11] Angelico F, Burattin M, Alessandri C, Del Ben M, Lirussi F. Cochrane Database Syst Rev 2007;24(1).
[12] Socha P, Horvath A, Vajro P, Dziechciarz P, Dhawan A, Szajewska H. J Pediatr Gastroenterol Nutr 2009; 48(5):587–96.
[13] Werner E, Bell J. J Chem Soc Transactions 1921;121:1790–5.
[14] Shapiro SL, Parrino VA, Freedman L. J Am Chem Soc 1959;81(9):2220–5.
[15] Procédé de préparation de chlorhydrate de diméthylbiguanide. Patent FR 2322860. 1975. French.
[16] Pharmaceutical Manufacturing Encyclopedia (Sittig's Pharmaceutical Manufacturing Encyclopedia). 3rd ed. Vol. 3. Norwich, NY: William Andrew; 2007.