Journal of Engineering and Applied Sciences 13 (Special Issue 13): 10517-10522, 2018
ISSN: 1816-949X

Adsorption and Kinetic Studies of Miconazole on Hydroxyl Propyl Methyl Cellulose-co-Acrylic Acid from Aqueous Solutions

[1]Nadher D. Radhy and [2]Layth S. Jasim
[1]Department of Chemistry Pharmaceutical, College of Pharmacy,
[2]Department of Chemistry, College of Education, University of Al-Qadisiyah,
Al-Diwaniyah, Iraq

Abstract: The adsorption of the miconazole drug from aqueous solution has been investigated using on hydroxyl propyl methyl cellulose-co-acrylic acid cross-linked as the adsorbents. Kinetics and thermodynamic studies were carried out to estimate the effect of equilibrium time, salts, temperature and pH value. The results of our study show that higher adsorption of the miconazole for this hydrogels. The adsorption process was studied as a function of temperatures (10, 20 and 30°C). The extents of drug adsorption on the hydrogels were results found it increases with increasing temperature, i.e., endothermic process. The values of the thermodynamic functions are calculated. Adsorption on hydrogels surfaces was examined as a function of pH. The adsorbed amount of drug on the surface was decreased as the pH increased. The results of the effect of the salt showed low adsorption capacity of the drug in the presence of sodium chloride.

Key words: Adsorption, hydrogels, miconazole isotherms, thermodynamic, drug, capacity

INTRODUCTION

Hydrogels are three dimensional networks polymers with the ability to swell in water usually to equilibrium in an aqueous solution that typically carries a large amount of water while remaining insoluble. The reason for the absorption of water by hydrogels is mainly due to the presence of hydrophilic groups in the polymers chains such as -OH, NH_2, $CONH_2$, SO_3H, COOH, etc. (Ding and Wang, 2017; Singhal and Gupta, 2016). Recently hydrogels have been widely used in many potential application areas such as medicine because of their porous structure and water swell ability (Jankaew *et al*., 2015), good biocompatibility with the human body (Alvarez-Bautista *et al*., 2016). The amount of fluids or water are absorbed by the hydrogels depends mainly on the hydrophilic groups of the polymer chains, the degree of crosslinking and conditions of the polymerization. A carefully manufactured hydrogels can release the drug to the target location. Sensitive hydrogels and are responsive to surrounding environmental stimuli they are called smart or intelligent polymers. Intelligent polymers undergo physical or chemical changes in the range of minutes and hours. These changes involve modified in surface properties, dimension, shape, size, chain mobility and intermolecular associations. The hydrogel matrix that respond to pH value, ionic strength, temperature, enzymes, radiation, ultrasound and magnetic field have been progressing and applied as controlled drug delivery (Ali *et al*., 2015).

Miconazole, sold beneath the trademark name Monistat is an antifungal drug used to treatment ringworm, pityriasis vesicular and yeast contagions of the vagina or skin. It is used for ringworm of the body, groin (jock itch) and feet (Heel *et al*., 1980).

MATERIALS AND METHODS

Chemicals and materials: Acryl amide was supplied by (Himedia india). The activated N, N, N', N'-Tetra Methyl Ethylene Diamine (TEMED) was also supplied by (Himedia India), the initiator, potassium persulfate (KPS) was supplied by (Merck, Germany). The multifunctional crosslinker is N, N'-methylene biascrylamide (NMBA) was purchase from (Fluka, Germany). Sodium chloride was obtained from (Fluka, Germany). Miconazole was purchase from (Sigma-Aldrich, Germany). Sodium hydroxide and hydrocholric acid were supplied from (Fluka, Germany).

Preparation of HPMC-co-AA: The co-polymer of HPMC co AA was prepared by solving of 0.25 g from HPMC powder to 50 mL of distilled water with vigorous stirring at temperature range 60-70°C, then it cooled at room

Corresponding Author: Nadher D. Radhy, Department of Chemistry Pharmaceutical, College of Pharmacy, University of Al-Qadisiyah, Al-Diwaniyah, Iraq

temperature to form the HPMC solution. The 0.0556 mol of AA was added to 20 g of HPMC solution under constant stirring in 60°C for 20 min then the cross-linked (N, N-methylene-bisacrylamide) and initier (KPS) were added under nitrogen gas stream for 5 h. The prepared co-polymer was several washed by deionized water and dried at 60°C in oven. The grinding and sieving of bulky co-polymer follow that for resulting co-polymer with particle size of 150 μm. The hydrogels surface was used without further treatment. Wavelength of maximum absorbancy (λ_{max}) for Miconazole was selected at 550 nm. These values were utilized for estimation of quantity of Miconazole adsorbed.

Adsorption isotherm: Solutions of drug (10 mL) from (1-50 ppm) at pH 1.2 were added to the closed bottles containing 0.05 g of hydrogel. Put all the solutions in the shaker in a thermostatically controlled water bath and start stirring for equilibrium time at 90 min. The end is the separation of the solutions by the centrifuge at 3000 rpm for 15 min. and measurement of absorbance after adsorption using a UV-Visible spectrophotometer.

The quantity of drug adsorbed q_t and the removal percent of drug were determined by the following Eq. 1 and 2 (Birdi, 2015):

$$q_t = \frac{V_{sol}\,(C_0 - C_e)}{m} \quad (1)$$

$$\text{Removal}\% = \frac{(C_0 - C_e)}{C_0} \times 100 \quad (2)$$

Where:

C_0 and C_e = The initial and equilibrium concentrations of drug in the solution (mg/L)
m = The mass of hydrogel (mg)
V = The Volume of the solution (L)

Effect of temperature: The effect of several temperatures on the adsorption process was studied at temperatures of 10, 20 and 30°C, so as determined of quantities thermodynamic functions.

Effect of pH: The effect of the pH values was studied in the adsorption process. Where taken 0.05 g of hydrogel and added a constant concentration of the drug at different pH values (1-10) at constant other conditions concentration, temperature and time. The pH value was measured using the pH meter and results were obtained by drawing the amount of the adsorption versus the pH values and their effect on the adsorption process.

Effect of ionic strength: The effect of the salt was studied by taking different weights 0.1-0.5 g of sodium chloride NaCl and adding a constant concentration of the drug solution containing 0.05 g of the prepared hydrogel and placed thermostatically controlled water bath at 25°C for 90 min to obtain equilibrium time at constant other conditions (concentration, temperature, time and pH), the effect of salt was obtained by drawing the amount of the adsorption versus the salt concentration and their effect on the adsorption process.

RESULTS AND DISCUSSION

Characterization: Before adsorption process the hydrogel, the infrared spectra in Fig. 1 showed the appearance of a broad absorption band at the range 3197-3500 cm^{-1} indicating that there was overlapping between the OH^- band and the NH band. The bands shown at the 2800-2950 cm^{-1} represents the mass vibration of the CH_2-CH_3 groups due to the presence of CH bonds in the aliphatic compounds. Also, the presence of bands at the wavenumber 1600-1750 cm^{-1}, indicates the presence of carbonyl bonds (C = O) for carboxyl groups and the bands that appear at the range of 1000-1400 cm^{-1} due to the vibration of bonds C-N, C-O and C-C.

After adsorption, FTIR spectra in Fig. 2 show the appearance of new peaks with the disappearance of other peaks demonstrating a clear association between the drug and the polymer.

The morphologies of the prepared hydrogel before adsorption was studied by FE-SEM. Figure 3 shows FE-SEM analysis of HPMC-co-AA tend to congregate together to form multilayer agglomerates. After adsorption, shows roughen surface and Miconazole uniformly distributed as bright dots on the surface of the hydrogel. These observations demonstrate the presence of both HPMC-co-AA and Miconazole.

Adsorption experiments

Effect of adsorbent weight: An adsorption experiment of Miconazole removal is performed using different weights (0.01-0.2 g) of the hydrogel. Note that Miconazole increase the removal percentage with increasing weight of the hydrogel due to the increase surface area of hydrogel because the increase ready active sites for drug adsorption. Consequently, so that, the level of the drug to the extent of saturation at 0.05 g hydrogel. For subsequent experiments, 0.05 g of adsorbent weight was selected (Alwan *et al*., 2018).

Effect of temperature and calculation of thermodynamic functions: The results showed in Fig. 4 that removal percentage of Miconazole increases with increasing temperature, i.e., the adsorption is a process endothermic,

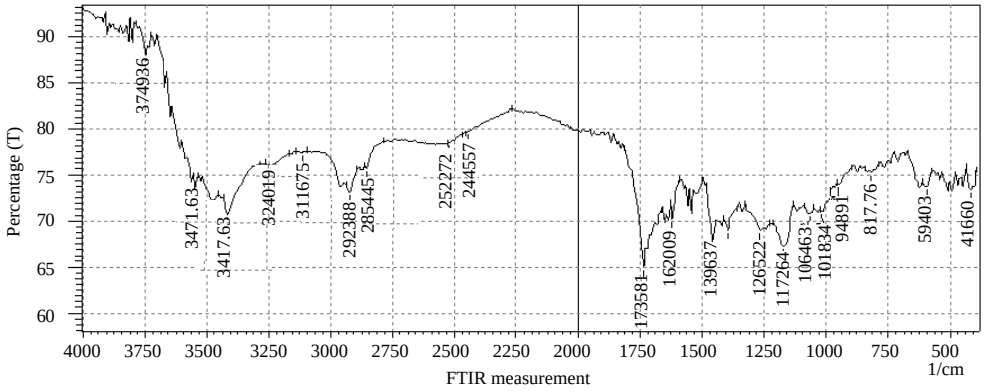

Fig. 1: FTIR analysis of HPMC-co-AA before adsorption

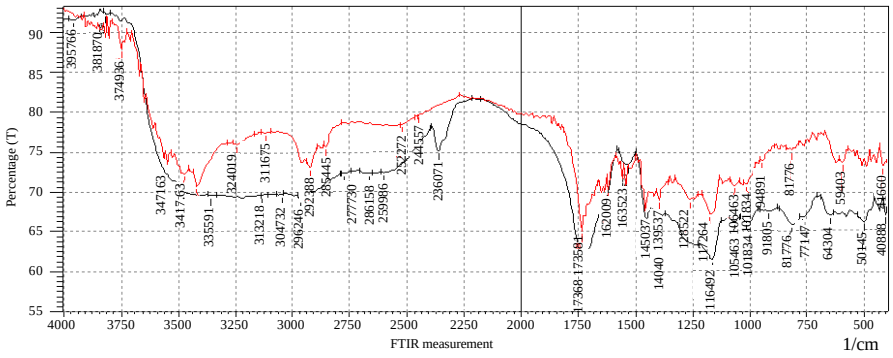

Fig. 2: FTIR analysis of HPMC-co-AA after adsorption

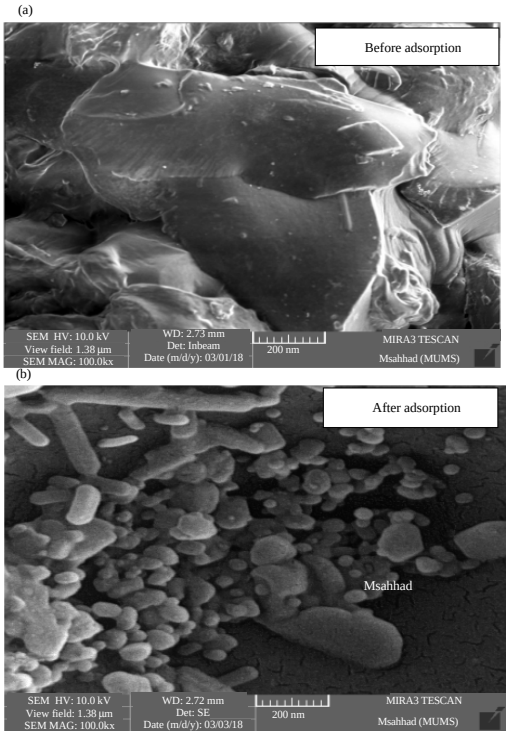

Fig. 3: a, b) FE-SEM analysis of HPMC-co-AA before and after adsorption

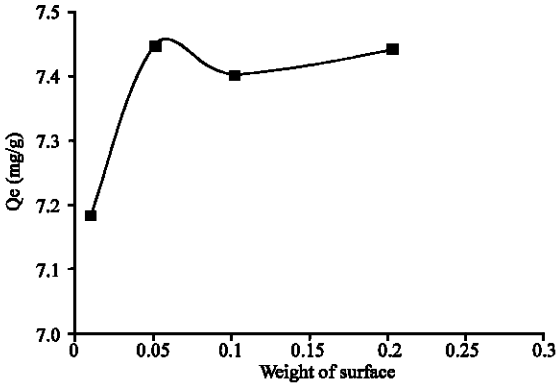

Fig. 4: Effect of adsorbent dose on the removal percentage of Miconazole

the highest removal percentage occurring at 30°C after an equilibrium period of 90 min. However, a further increase in temperature has shown a decrease in sorption which may have resulted from poor physical bonds between Miconazole molecules and the active site of the hydrogels (Sharma *et al*., 2017).

The values of thermodynamic functions are very important because they explain many interactions, especially in the process of adsorption were determined

and the results showed in Table 1. The value of the enthalpy (ΔH) showed that the observed values of the are <40 kJ.mol^{-1}). This means that the adsorption of the drug under study on the surface of hydrogel is a nature physical adsorption. It was also observed that the value of free energy change (ΔG) for adsorption is negative, i.e., adsorption is spontaneous. The value of the change in entropy (ΔS) for adsorption is positive and this indicates that the adsorbed molecules are in a continuous movement on the surface rather than in the solution.

Table 1: Thermodynamic parameters of adsorption of Miconazole on surface

Equilibrium constant (K)	ΔS (J.mol^{-1}.K^{-1})	ΔG (kJ.mol^{-1})	H (kJ.mol^{-1})	Drug
22.66	+50.68	-7.602	+7.246	Miconazole

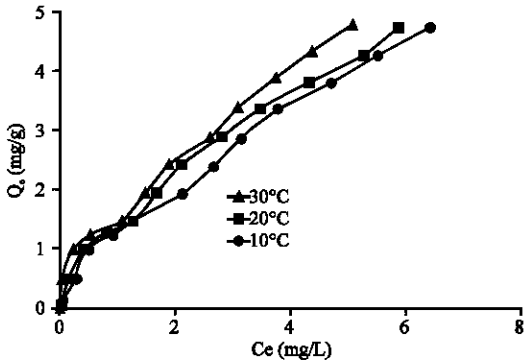

Fig. 5: a, b) Effect of temperture on the removal percentage of Miconazole

Effect of equilibrium time and study of adsorption kinetics: The study of adsorption drug at different times (1-180 min) after the stabilization of all conditions affecting. In drug adsorption capacity was increased with increasing the time to its maximum value (saturation state) but sometimes the adsorption capacity decreases with increasing time due to a desorption process (Fig. 5).

The kinetic models of the adsorption process which describe the experimental data were carefully selected for adsorption of drug on the hydrogel. The kinetic models were used to analyze the experimental data, namely the pseudo first model and the pseudo second order as illustrated in the Fig. 5 and 6.

The correlations coefficients (R^2) of both models were calculated as shown in Table 2. The results showed that

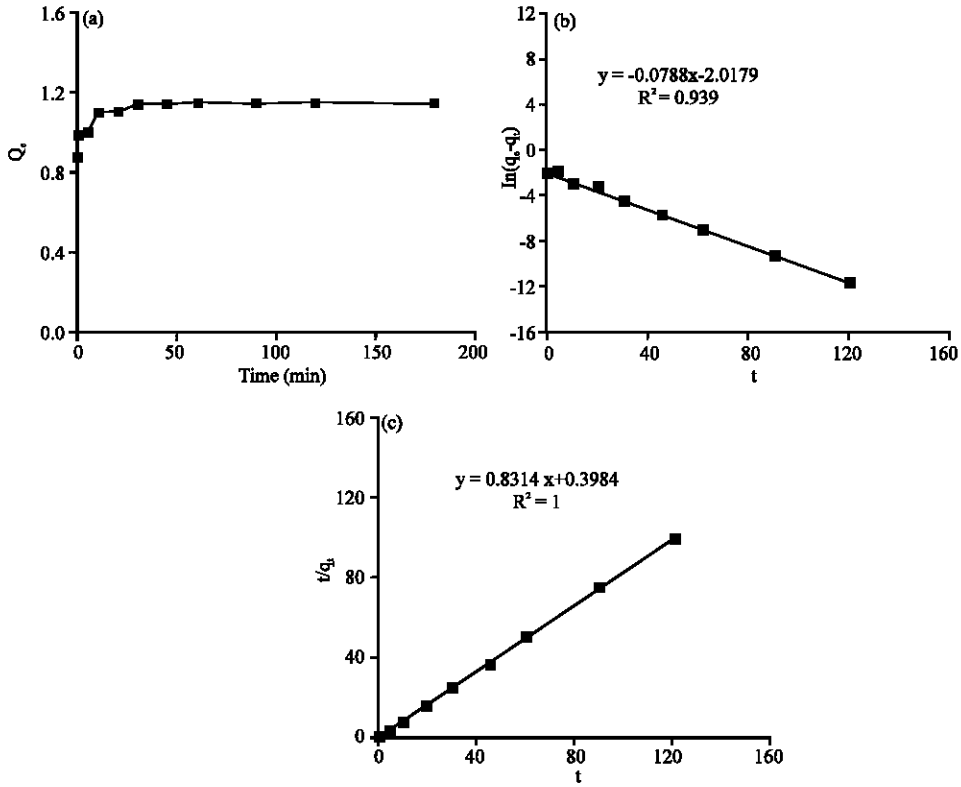

Fig. 6a-c): Effect of reaction time, pseudo-first and pseudo-second order kinetics for adsorption of Miconazole; (1 and 2 order)

Table 2: Adsorption kinetics parameters of adsorption of Miconazole

	Pseudo-first order			Pseudo-second order			
Drug	k_1 (min^{-1})	q_e (mg/g)	R^2	k_2 ($g.mg^{-1}.min^{-1}$)	q_e (mg/g)	R^2	h ($mg.g^{-1}.min^{-1}$)
Miconazole	0.078	0.132	0.939	1.735	1.202	1.0000	2.51

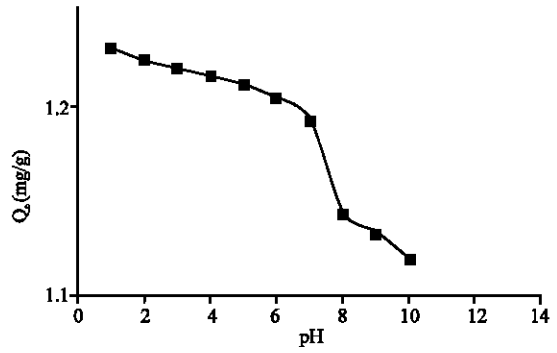

Fig. 7: Effect of pH solution on adsorption Miconazole

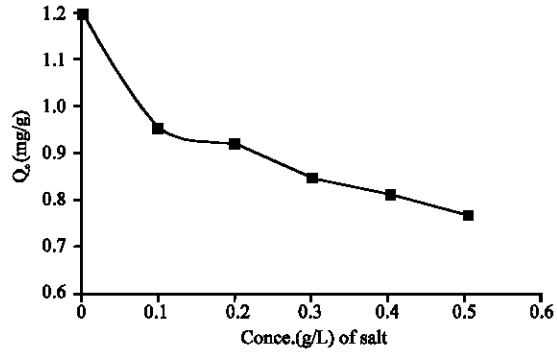

Fig. 8: Effect of ionic strength on adsorption miconazole on HPMC-co-AA

the value of the correlation coefficient (R^2) was high for the pseudo second order model compared to the pseudo first order of this model to the adsorption processes of Miconazole adsorption by the hydrogel is feasible (Zhang *et al*., 2017).

Effect of pH: The amount of adsorption on the surface of hydrogel is increased with the decrease of pH value, this is due to the surface charge of the hydrogel is a positive in the acidic media and the drug molecules are charged with a negative charge and therefore, the electrostatic attraction is obtained between the Miconazole layer and the active sites on the hydrogel surface As a result, adsorption increases (Fukahori *et al*., 2011).

Effect of ionic strength: The effect of solution ionic strength NaCl for adsorption of Miconazole by hydrogel was investigated by a series of experimental studies constructed by varying weights of NaCl from 0.1-0.5 g. As depicted in Fig. 7 and 8 it can be seen that the adsorption capacities decrease with the addition of NaCl due to the electrostatic repulsion effect (Bajpai *et al*., 2014).

CONCLUSION

In this research, HPMC-co-AA hydrogel was prepared and used as an effective absorbent for removing Miconazole in aqueous solution. The Miconazole adsorption follows the pseudo first-order kinetics and the equilibrium data can be well fitted with the freundlich isotherms. Thermodynamic parameters are calculated for the removal of Miconazole and their values indicated that the process of removal is spontaneous and endothermic.

REFERENCES

Ali, L., M. Ahmad and M. Usman, 2015. Evaluation of cross-linked hydroxypropyl methylcellulose graft-methacrylic acid copolymer as extended release oral drug carrier. Cellulose Chem. Technol., 49: 143-151.

Alvarez-Bautista, A., E. Mendizabal, C.M.M. Duarte and I. Katime, 2016. Poly (N-Isopropylacrylamide-Co-Acrylic Acid) Smart nanocarriers for drug release: A study of theophylline delivery. J. Mol. Genet. Med., 9: 1-5.

Alwan, S .H., H .A.H. Alshamsi and L.S. Jasim, 2018. Rhodamine B removal on A-rGO/cobalt oxide nanoparticles composite by adsorptio from contaminated water. J. Mol. Structure, 1161: 356-365.

Bajpai, S.K., N. Chand and M. Mahendra, 2014. The adsorptive removal of a cationic drug from aqueous solution using poly (methacrylic acid) hydrogels. Water SA, 40: 49-56.

Birdi, K.S., 2015. Handbook of Surface and Colloid Chemistry. 4th Edn., Taylor & Francis, Abingdon, UK., ISBN:9781466596672, Pages: 708.

Ding, X. and Y. Wang, 2017. Weak bond-based injectable and stimuli responsive hydrogels for biomedical applications. J. Mater. Chem. B., 5: 887-906.

Fukahori, S., T. Fujiwara, R. Ito and N. Funamizu, 2011. PH-Dependent adsorption of sulfa drugs on high silica zeolite: Modeling and kinetic study. Desalin., 275: 237-242.

Heel, R.C., R.N. Brogden, G.E. Pakes, T.M. Speight and G.S. Avery, 1980. Miconazole: A preliminary review of its therapeutic efficacy in systemic fungal infections. Drugs, 19: 7-30.

Jankaew, R., N. Rodkate, S. Lamlertthon, B. Rutnakornpituk and U. Wichai *et al*., 2015. Smart carboxymethylchitosan hydrogels crosslinked with poly (N-isopropylacrylamide) and poly (acrylic acid) for controlled drug release. Polym. Test., 42: 26-36.

Sharma, G., M. Naushad, H. Ala'a, A. Kumar and M.R. Khan *et al*., 2017. Fabrication and characterization of chitosan-crosslinked-poly (alginic acid) nanohydrogel for adsorptive removal of Cr (VI) metal ion from aqueous medium. Intl. J. Boil. Macromol., 95: 484-493.

Singhal, R. and K. Gupta, 2016. A review: Tailor-made hydrogel structures (classifications and synthesis parameters). Polym. Plast. Technol. Eng., 55: 54-70.

Zhang, L., Y. Wang, S. Jin, Q. Lu and J. Ji, 2017. Adsorption isotherm, kinetic and mechanism of expanded graphite for sulfadiazine antibiotics removal from aqueous solutions. Environ. Technol., 38: 2629-2638.