RESEARCH ARTICLE

Adsorption Study of Cephalexin Monohydrate Drug in Solution on Poly (vinyl pyrrolidone-acryl amide) Hydrogel Surface

Waleed K. Abdulsahib[1], Hussam H. Sahib[2], Makarim A. Mahdi[3], Layth S. Jasim*[3]

[1]*Department of Pharmacology, College of Pharmacy, Al-Farahidi University, Baghdad, Iraq*
[2]*Department of Clinical Laboratory Sciences, College of Pharmacy, University of Al-Qadisiyah, Diwaniya, Iraq*
[3]*Department of Chemistry, College of Education, University of Al-Qadisiyah, Diwaniya, Iraq*

Received: 18th August, 2021; Revised: 28th September, 2021; Accepted: 20th November, 2021; Available Online: 25th December, 2021

ABSTRACT

This study has implications for physical pharmacy, medical, and biochemistry due to its use of surface chemistry. This paper describes how drug-adherent hydrogels and their pH levels influence drug adsorption on Poly (vinyl pyrrolidone-acryl amide) Hydrogel Surface. The adsorption phenomenon was examined as a function of temperature (5, 15, 25, and 37.5°C). The temperature of the solution increased, adsorption of cephalexin. H_2O on the surface has increased as the temperature increased, the adsorption uptake of cephalexin.H_2O increased on hydrogel (endothermic adsorption). Basic thermodynamic functions for the adsorption process were calculated and used for the interpretation of the results. Using the Freundlich and Temkin models, the results show that the drug had full applicability for adsorption on hydrogel. The adsorption isotherms have an S-shaped configuration, which was determined by Giles' classification. Freundlich isotherm n-value was found to be 2.057, meaning good adsorption.

Keywords: Acryl amide, Adsorption, Cephalexin, H_2O, Hydrogel, Thermodynamic, Vinyl pyrrolidone.

International Journal of Drug Delivery Technology (2021); DOI: 10.25258/ijddt.11.4.9

How to cite this article: Abdulsahib WK, Sahib HH, Mahdi MA, Jasim LS. Adsorption Study of Cephalexin Monohydrate Drug in Solution on Poly (vinyl pyrrolidone-acryl amide) Hydrogel Surface. International Journal of Drug Delivery Technology. 2021;11(4):1169-1172.

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Adsorption is a surface phenomenon most often observed at interfaces, in comparison to a bulk phase, where a particular component has been concentrated. Ions, atoms, or molecules may accumulate on a surface due to adsorption.[1] The widespread utility of adsorptive properties is the primary driving factor in the importance of active surface materials in medicine and pharmacy. This material's use in many diverse processes such as separation and purification of diverse biochemical and pharmaceutical products,[2] protein,[2] antibiotics pharmacology,[3-5] vitamin and mineral,[6-8] chromatography, and extraction of drugs from urine or serum, to be detected by different methods, is evident.[9-11] To treat poisoning, adsorbents found in medical journals like adsorbents had several publications discussing their medical uses. The most stable, physically sturdy surface was used as an antidote for poison and drug overdose treatment, using charcoal.[12-14] Past research has investigated a wide range of other active surface materials, such as hydrogels,[1,15] composites,[16] clay,[17] and biomass.[18,19] This study aims to learn more about adsorption and a special kind of adsorption is used to make physical antidotes and sustained-release tablets.

EXPERIMENTAL

Materials and Methods

The drug (cephalexin.H_2O) employed in this study was obtained from ACAI Company. These acids, potassium persulfate (KPS) and N, N'-methylene-bis acrylamide (MBA), were purchased from Kemiou Chemical Reagent Co., Ltd., China. No further purification was required because all reagents were analytical grade pure.

Synthesis of P(VP–AM) Hydrogel Surface

P(VP–AM) Copolymerization of free radicals is used to prepare hydrogels. MBA (1% w/v), and 2 mL of potassium per sodium sulphate solution ($K_2S_2O_5$) were added (4% w/v). To accomplish matrix formation, the free radical polymerization was carried out in a 50 mL beaker, which was kept at 60°C temperature.

Determination of Maximum Absorption (l_{max}) and Calibration Curves

Absorption spectra of each drug have been recorded as maximum absorption wavelengths are 258 nm for the antibiotic Cephalexin.H_2O. Drug solutions were prepared by diluting solutions of different concentrations. To show this, a concentration graph was made for the selected optimal

*Author for Correspondence: layth.alhayder@gmail.com

wavelength, and absorbance values were measured for each drug and plotted against the concentration values. Calibration curves for Beer-law Lambert's were used that fall within the concentration range in which the law is relevant.

Equilibrium Times of Adsorption Systems

This method was used to find out how long it takes for adsorption to reach equilibrium at a certain temperature. In the beginning, there was a fixed concentration of each drug solution (100 ppm). Then, 0.05 g of hydrogels was added, and the mixture was shaken at 37.5°C. The concentrations of drug solutions were determined using a spectrophotometer, with measurements taken at different times (1–180 minutes), and that for this system, reaching equilibrium takes the same amount of time.

Adsorption Isotherm

From 10 to 100 ppm solutions of drug were added to stoppered flasks containing 0.05 g of hydrogels, which contained 10 mL of solution. Turbidity was caused by the flasks being shaken in a thermostatically controlled water bath at a speed of 60 cycles per minute. This approach achieves turbidity equilibrium. The suspensions were centrifuged at 4000 rpm for 10 minutes or filtered using double filter papers after the equilibrium time had elapsed. Assayed for drugs, which had been diluted appropriately, spectrophotometrically, the transparent supernatants were found to be clear. Experimental data were used to construct a calibration curve and then compared to find the equilibrium concentrations, after that the quantity of drug adsorbed was calculated.

Effect of Temperature

The basic thermodynamic functions were estimated using the adsorption experiment, which was conducted in the same manner at five different temperatures: 5, 15, 25, and 37.5°C.

RESULTS AND DISCUSSION

Fourier Transform Infrared Spectroscopy (FTIR) Analysis

Figure 1 showed that the OH-band overlapped with the NH-band at 3240. At 2850 to 2940 cm^{-1}, and the $-CH_2$, $-CH_3$ groups of the aliphatic compounds vibrate because of the presence of CH-bonds.[20,21] The presence of bands between the wavenumbers 1680 to 1750 cm^{-1}. It is found when carbonyl bonds (C=O) are present, further confirms the presence of carboxyl groups and shows that bands between the wavenumbers of 1025–1440 cm^{-1}, which is seen due to vibration of bonds C-N, C-O, and C-C are present as well.[22,23]

It is a common practice to use the FESEM technique to find the surface morphology of hydrogel containing P(VP–AM) before and after adsorption. the FESEM image of hydrogel sheets presents a closely stacked layered structure as well as illustrating a layered structure with clearly defined layers.[24] In hydrogels, aggregates that form multiple layers are very common. After adsorption, the surface is roughened and the hydrogels have bright dots uniformly distributed on their surface (Figure 2).

The shapes of cephalexin.H_2O adsorption isotherms were found to coincide with the S-type (Figure 3) isotherm reported by Giles *et al.*[25]

Adsorption Cephalexin.H_2O, has been studied at the human body temperature (37.5°C) and three other temperatures (5, 15, and 25°C) in 0.1 M hydrochloric acid (pH 1.2) (Figure 4) to simulate the pH of the stomach fluid.[26,27] At the higher cephalexin concentrations, the adsorptive capacities of the three clays increased. Water raised to a limited level. Decent surface activity was found in the adsorption of some materials and drugs from solution.[28] At the higher cephalexin concentrations, the adsorptive capacities of the hydrogels increased. drugs raised to a limited level. Decent surface activity was found in the adsorption of some interaction between hydrogels and drugs in solution.[29]

In hydrogel of lower positive position replaces, resulting in a deficit of positive charge, or in other words, an excess of negative charge. This excess of negative layer charge is externally compensated by the adsorption on the layer surfaces of cations, which are too large to be accommodated in the interior of the crystal.[30] In an aqueous solution, the compensating cations on the layer surfaces may easily be exchanged by other cations when available in solution.[31] The experimental adsorption data were applied to both the empirical Freundlich, Langmuir, and Temkin isotherm equation. These results indicated the applicability of Freundlich and Temkin isotherm as shown by the linear relationships (Table 1 and Figure 5).

The adsorption of cephalexin.H_2O on the hydrogels was estimated by determining the average adsorption (X_m) for different temperatures. The table and charts show these calculations (Table 2 and Figure 6).

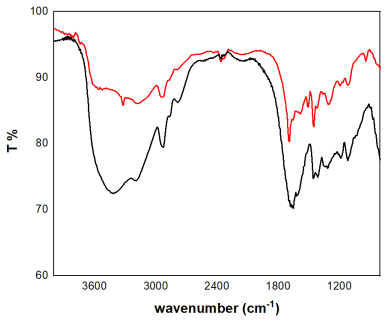

Figure 1: FTIR spectra of a- P(VP–AM) Hydrogel Surface b- P(VP–AM) Hydrogel Surface after drug adsorption

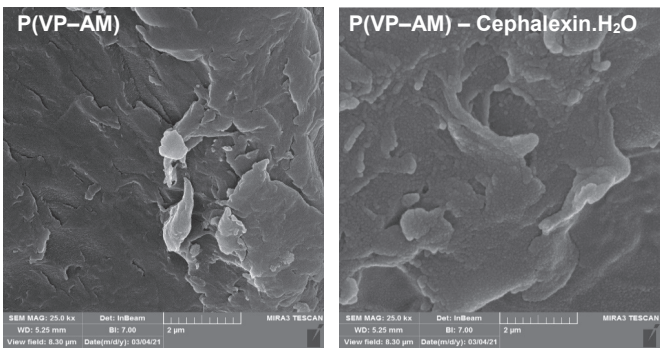

Figure 2: FE-SEM image of P(VP–AM) before and after adsorption

Adsorption of cephalexin.H_2O can be calculated by following the line drawn on this hydrogel. The values of basic thermodynamic functions of adsorption of the drug on hydrogel are given in Table 3.

The effect of cephalexin.H_2O on hydrogel interaction with the high enthalpy values was found. It is suggested that adsorption of the van der Waals type takes place, based on these data.[32] The heat of adsorption in the thermodynamic system with cephalexin-hydrogels dissolved in water exhibited endothermic characteristics. In contrast, the entropy of the system was positive. This can be explained by the hydrophobic bonding being disrupted, showing an increase in randomness as a result.[33]

CONCLUSIONS

- Hhydrogel surface appeared of the highest activity in the adsorption from a solution of the drug.
- Due to the higher activity of hydrogel surface in adsorption of the drug, it may be used as an antidote for the treatment of acute poisoning by this drug if taken in dosages greater than the therapeutic quantities.
- The adsorption isotherms of cephalexin.H_2O on hydrogel obeyed Freundlich and Temkin isotherm.
- All drug-hydrogel reactions exhibited low enthalpy values (endothermic).

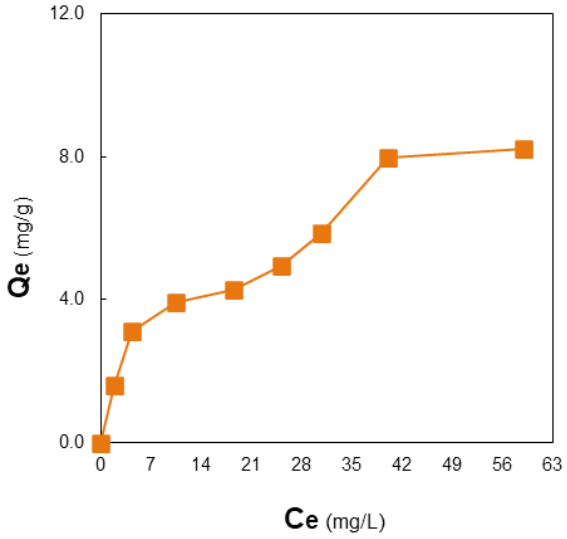

Figure 3: Adsorption isotherms of cephalexin.H_2O on hydrogels at pH » 1.2 and 37.5°C

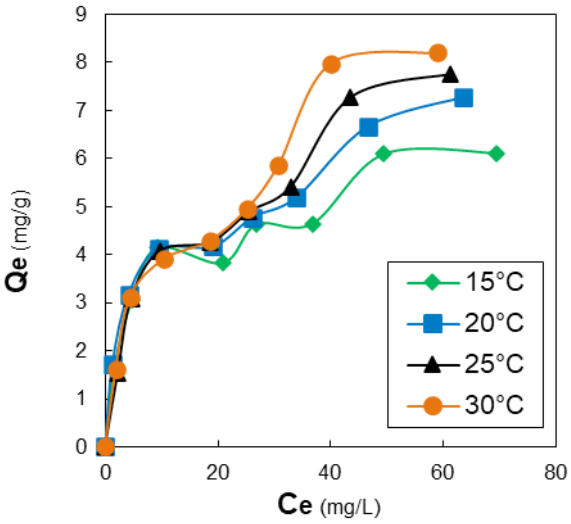

Figure 4: Adsorption isotherms of cephalexin.H_2O red on hydrogels at pH » 1.2 and different temperatures

Table 1: Langmuir, Freundlich and Tempkin isotherm constants for Cephalexin.H_2O drug uptake by hydrogels

	Langmuir eq.			*Freundlich eq.*			*Temkin eq.*		
Drug	K_L	q_m	R^2	K_F	n	R^2	K_T	B	R^2
Ceph. H_2O	0.094	8.857	0.886	1.166	2.057	0.963	1.004	1.82	0.919

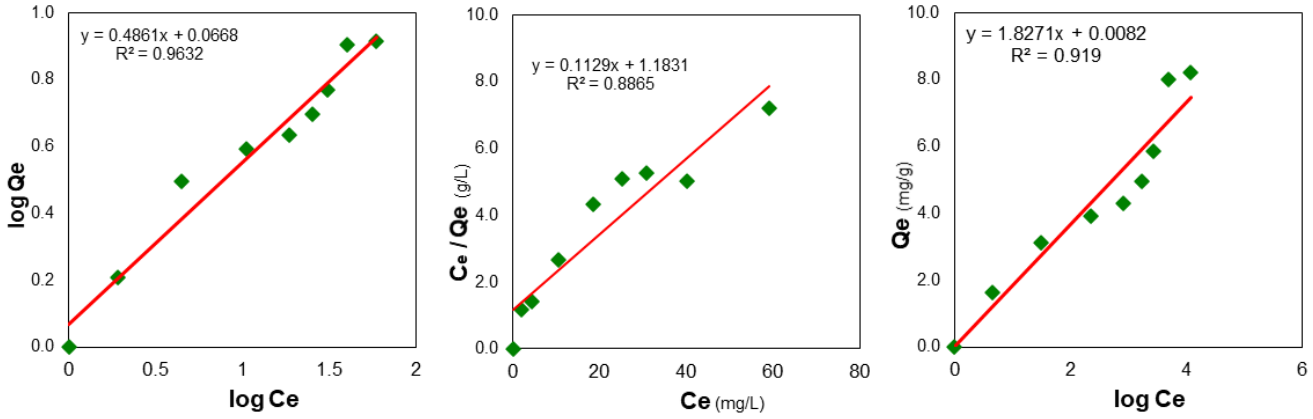

Figure 5: Linear form of a- Freundlich, b- Langmuir and c- Temkin isotherm of cephalexin.H_2O on hydrogels at pH » 1.2 and 37.5°C

REFERENCES

1. Abd Alrazzak, A.M.A.N., et al., Adsorption Of Pollutants By Using Low-Cost (Environment-Friendly): Equilibrium, Kinetics And Thermodynamic Studies: A Review. 2020;11(12):1988-1997.
2. Karoyo AH, Wilson LD. A Review on the Design and Hydration Properties of Natural Polymer-Based Hydrogels. Mater. Lett. 2021;14(5):1095.
3. Onichimowski D, Ziółkowski H, Nosek K, Jaroszewski J, Rypulak E, Czuczwar M. Comparison of adsorption of selected antibiotics on the filters in continuous renal replacement therapy circuits: in vitro studies. J Artif. Organs. 2020;23(2):163-70.
4. Abood, S.J., W.K. Abdulsahib, and M.Y.J.O.A.M.J.o.M.S. Al-Radeef, Prevalence of Home Storage of Medicines and Associated Factors in Iraq. 2021;9(E):356-363.
5. Abdulsahib, W.K., et al., Antimicrobial susceptibility pattern isolated from different clinical samples in Baghdad hospitals. 2020;10(1).
6. Žmitek K, Hribar M, Hristov H, Pravst I. Efficiency of vitamin D supplementation in healthy adults is associated with body mass index and baseline serum 25-hydroxyvitamin d level. Nutrients. 2020;12(5):1268.
7. Aseel M. Aljeboree NAA, Mohammed B. Alqaraguly, Makarim A. Mahdi, Layth S. Jasim, Ayad F. Alkaim, Adsorption of Pollutants By Using Low-Cost (Environment-Friendly): Equilibrium, Kinetics And Thermodynamic Studies: A Review. Sys Rev Pharm 2020;11(12):1988-1997.
8. Aseel M. Aljeboree, A.Y.A.-B., Saifaldeen M. Abdalhadi, Ayad F. Alkaim, Investigation Study of Removing Methyl Violet Dye From Aqueous Solutions Using Corn-Cob as A Source of Activated Carbon. Egypt. J. Chem., 2021;64(6):2873-2878.
9. Farjadian F, Azadi S, Mohammadi-Samani S, Ashrafi H, Azadi A. A novel approach to the application of hexagonal mesoporous silica in solid-phase extraction of drugs. Heliyon. 2018;4(11):e00930.
10. Rahbar N, Nazernezhad L, Asadinezhad M, Ramezani Z, Kouchak M. A novel micro-extraction strategy for extraction of bisphosphonates from biological fluids using zirconia nanoparticles coupled with spectrofluorimetry and high performance liquid chromatography. J Food Drug Anal. 2018;26(4):1303-1311.
11. Jasim M, Salman EAA, Al-Kaim AF, Effect of pesticide Glyphosate on some biochemical features in cyanophyta algae Oscillatoria limnetica. Int. J. Pharmtech Res., 2016.9(8):355-365.
12. Aljeboree AM, HYA-G., Said MH, Alkaim AF, The effect of different parameters on the removal of vitamin B12 drug (as a model biochemical pollutants) by AC/clay. Biochem. Cell. Arch., 2019;19(1):755-759.
13. Ghosh P, Peters JF. Impulsive differential equation model in methanol poisoning detoxification. J. Math. Chem. 2020;58(1): 126-145.
14. Zellner T, et al., The use of activated charcoal to treat intoxications. 2019;116(18):311.
15. Abdulsahib WK, Ganduh SH, Radia ND, Jasim LS. New approach for sulfadiazine toxicity management using carboxymethyl cellulose grafted acrylamide hydrogel. Int J Drug Delivery Technol. 2020;10:1-7.
16. Awad MA, Al-Hayder LSJ. Removel of a Bsoprolol drug from Aqueous Solutions onto Graphene Oxide/Carboymethyl cellulose sodium/Acryl acid polymer Composite by Adsorption. In IOP Conference Series: Mater. Sci. Eng.. 2020: IOP Publishing.
17. Kausar A, Iqbal M, Javed A, Aftab K, Bhatti HN, Nouren S. Dyes adsorption using clay and modified clay: a review. Journal of Molecular Liquids. 2018;256:395-407.
18. Ahmed MB, Johir MA, Zhou JL, Ngo HH, Nghiem LD, Richardson C, Moni MA, Bryant MR. Activated carbon preparation from biomass feedstock: clean production and carbon dioxide adsorption. J. Clean. Prod. 2019;225:405-413.
19. Zhang, M., et al., High and fast adsorption of Cd (II) and Pb (II) ions from aqueous solutions by a waste biomass based hydrogel. 2020;10(1):1-13.
20. Bonelli, N., et al., Poly (vinyl alcohol)/poly (vinyl pyrrolidone) hydrogels for the cleaning of art. 2019;536:339-348.
21. Mahdi MA, Jasim LS, Mohamed MH. Synthesis And Anticancer Activity Evaluation Of Novel Ligand 2-[2-(5-Chloro Carboxy Phenyl) Azo] 1-Methyl Imidazole (1-Mecpai) With Some Metal Complexes. Syst. Rev. Pharm. 2020;11(12):1979-1987.
22. Chan KA, Kazarian SG. Detection of trace materials with Fourier transform infrared spectroscopy using a multi-channel detector. Analyst. 2006;131(1):126-31.
23. Aljeboree AM, Alshirifi AN, Alkaim AF, Removal of Amoxicillin Drug onto Nano Composites Surface Using Ultrasound Assistance. Plant Archives 2020. 20(1):3135-3140.
24. Huang Y, et al., Poly (vinyl pyrrolidone) wrapped multi-walled carbon nanotube/poly (vinyl alcohol) composite hydrogels. 2011;42(10):1398-1405.
25. Alzayd AA, Atyaa AI, Radhy ND, Al-Hayder LS. A new adsorption material based GO/PVP/AAc composite hydrogel characterization, study kinetic and thermodynamic to removal Atenolol drug from wast water. InIOP Conference Series: Materials Science and Engineering 2020;928(6):062023). IOP Publishing.
26. Mahde BW, Radia ND, Jasim LS, Jamel HO. Synthesis and characterization of polyacrylamide hydrogel for the controlled release of aspirin. J. Pharm. Sci. and Res.. 2018;10(11):2850-2854.
27. Karim AN, Jasim LS. Synthesis and Characterization of Poly (CH/AA-co-AM) Composite: Adsorption and Thermodynamic Studies of Benzocaine on from Aqueous Solutions. Int. J. Drug Deliv. Technol. 2019;9(4):558-562.
28. Li S, Jasim A, Zhao W, Fu L, Ullah MW, Shi Z, Yang G. Fabrication of pH-electroactive bacterial cellulose/polyaniline hydrogel for the development of a controlled drug release system. ES Mater. Manuf. 2018;1(23):41-49.
29. Aljeboree AM, Mahdi MA, Jasim LS. Synthesis And Characterization Of NTADCIP/P (AA-Co-AM) Composite: Adsorption And Removal Studies Of Drug From Aqueous Solutions. Syst. Rev. Pharm. 2021;12(1):282-289.
30. Khudhair ZH, Jasim LS. Adsorption Thermodynamics of a Ciprofloxacin Drug from Aqueous Solutions on [Graphene Oxide/ poly Acrylic Acid/Microcrystalline Cellulose] Composite. Syst. Rev. Pharm. 2021;12(1):384-393.
31. Abdulsahib WK, Ganduh SH, Mahdi MA, Jasim LS. Adsorptive removal of doxycycline from aqueous solution using graphene oxide/hydrogel composite. Int J Appl Pharm. 2020;12(6):100-106.
32. Abdulsahib WK, Ganduh SH, Radia ND, Jasim LS. New approach for sulfadiazine toxicity management using carboxymethyl cellulose grafted acrylamide hydrogel. Int J Drug Delivery Technol. 2020;10:1-7.
33. Hussain NA, Jasim LS. Kinetic Study of removal Zinc Oxide Nanoparticles from Aqueous Solutions on synthesized CH-gP (AAc-co-Am). InIOP Conference Series: Earth and Environmental Science 2021;790(1):012064). IOP Publishing.