RESEARCH ARTICLE

Role of Sodium Alginate-g-poly (Acrylic acid-fumaric acid) Hydrogel for Removal of Pharmaceutical Paracetamol from Aqueous Solutions by Adsorption

Mohammed A. Jawad,[1*] Abed J. Kadhim,[1] Nadher D. Radia[2]

[1]*Al-Nisour University College, Baghdad, Iraq*
[2]*Department of Chemistry, College of Education, University of Al-Qadisiyah, Diwaniya, Iraq*

Received: 07th June, 2021; Revised: 03rd July, 2021; Accepted: 22nd August, 2021; Available Online: 25th September, 2021

ABSTRACT

Background: The hydrogel is a polymer hydrophilic that can absorb but not dissolve in water at optimum conditions (concentration of drug, temperature, and PH). Thus, this study was conducted to study adsorption-desorption systems of the drug (paracetamol) on the carefully chosen (hydrogel) surface at mutable conditions of the weight of hydrogel and pH.

Methods: The surface properties of the prepared hydrogel were studied using several techniques fourier transform infrared spectroscopy (FTIR), field emission scanning electron microscopy (FESEM).

Results: The adsorption isotherms were studied, such as the Friendling model isotherm and the Langmure model isotherm, and through the results, it was found that it obeys the Friendling model and this is valuable (R2= 0.9744), Also study three Kinetic models such as a first model, second model, and Elkovuch model through the results it was found that it follows a First model as is evident through the value of (R2 = 0.9661).

Keywords: Adsorption, Drug, Hydrogel, Kinetic, Paracetamol, Polymer.

International Journal of Pharmaceutical Quality Assurance (2021); DOI: 10.25258/ijpqa.12.3.7

How to cite this article: Jawad MA, Kadhim AJ, Radia ND. Role of Sodium Alginate-g-poly (Acrylic acid-fumaric acid) Hydrogel for Removal of Pharmaceutical Paracetamol from Aqueous Solutions by Adsorption. International Journal of Pharmaceutical Quality Assurance. 2021;12(3):202-205.

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

The industrial development of some industries, such as the pharmaceutical, chemical, and petrochemical industries, the food and agricultural industries, generate waste that poses a threat to the environment and human health when it cannot be recovered (recycled), so burying this waste can lead to problems of groundwater pollution, which leads to leachate leakage.[1-7] Therefore, this liquid waste requires pre-treatment, and the consumption of medicines is increasing in developing and increasingly developed countries, which leads to the release of these pollutants into the environment, water, and soil.[8-10] These medicines are present in huge quantities, including antibiotics, antidepressants, anti-inflammatories, aspirin, and paracetamol, where many medicines containing paracetamol are available. Without a medical prescription, it is commonly used, as this drug is leaked in enormous quantities in water, and it is considered to have very high toxicity and stability in water.[11-13] There are several techniques, the most important of which is adsorption, used to remove pollutants from water, even in low concentrations.[14,15] The adsorption technology uses very high efficiency and cheap surfaces such as activated carbon, nanotube carbon, clay, hydrogel, carven oxide, and other surfaces.[16-18]

In this study, a high-efficiency, cheap, and environmentally friendly hydrogel surface was used. Several techniques were used to determine the properties of the prepared surface, including (FTIR, FESEM,) adsorption isotherms, and kinetic models were studied.

Batch Adsorption Experiments

The standard 100 ppm paracetamol solution was prepared via dissolving 0.1 g paracetamol in 100 mL D.W. An aqueous solution (100 mL) with 0.05 g hydrogel. After removing the hydrogel via filtration through a centrifuge of 5000 rpm, the concentrations of paracetamol drug were estimated through a UV-vis spectrophotometer. The adsorption efficiency (qe, mg/g) and the percentage (%) removal was estimated by using the following equation

$$qe = V_{sol.}\,(Co - Ce)\ W \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$E\% = (Co - Ce)\ Co * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

**Author for Correspondence: mohammed.a.medical.lab@nuc.edu.iq*

Where Co and Ce are the initial and final concentrations of paracetamol drug (mg/L), at the same order, V is the volume of the solution (mL), and W is the weight of hydrogel (g).

Determination of Calibration Curve

To estimation the calibration curve of the paracetamol drug, the absorption U-V spectrophotometer of the solution drug (100mg/L) Solutions of different concentrations of drug prepared by sequential dilutions from (1–70 mg/L) as appears in Figure 1

RESULTS AND DISCUSSION

Characterization of Hydrogel

The spectrum of FTIR appears in Figure 2. The bands range at about 1700 cm^{-1} due to the shift in the stretching vibration connected with the hydrogen directly overtone for bonded labor absorption strong C=O group. The sharp peak at 1650 cm^{-1} duo to the C=O group and associated with the amide group. On a much wider absorption peak in 3100 and 3450 cm^{-1} due to N-H and O-H bands because consider wider, this attributed to associated with the polymer chains.[19,20] The wide peak at 3450 cm^{-1} is duo to a representative peak of the primary amine. The weak peak at 1550 cm^{-1} is attributed to O-H band in the –COOH group. The bands at 1720–1700 cm^{-1} duo to a characteristic are carbonyl groups in the carboxylic acids. The weak peaks at 1020 and 1200 cm^{-1} due to C-N bands and the weak peaks at 2800 and 1410 cm^{-1} are attributed to -CH_2- groups on the polymer chains.[19,20]

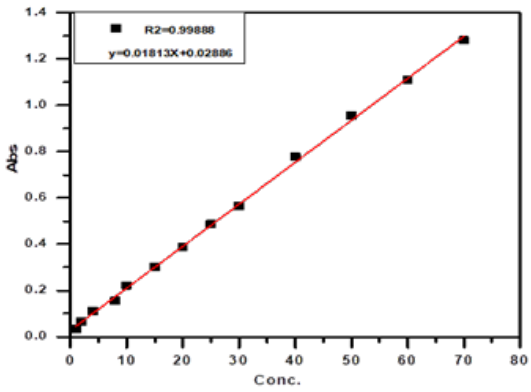
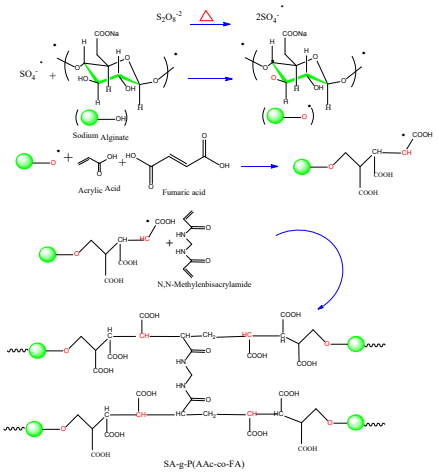


Figure 1: Calibration curves of paracetamol drug

Preparation of Hydrogel



Scheme 1: Preparation of (Sodium alginate-g-poly (Acrylic acid-fumaric acid) hydrogel

FESEM

To study the surface properties of the prepared hydrogel, the technique (FESEM) was used before and after the adsorption process. It was observed from Figure 3 that the surface before the adsorption process contains many unsaturated active sites, but after adsorption, all the surface sites were filled. And some white spots appeared on the surface as evidence of paracetamol loading on the hydrogel surface and the occurrence of the adsorption process.[12,21]

Effect of Concentration of Paracetamol Drug

The effect of paracetamol concentration is considered one of the most important factors affecting the adsorption process. The effect of concentration was studied under experimental conditions such as temperature 25°C, hydrogel weight 0.05 g, equilibrium time 60 minutes, and pH 5.8, as shown in Figure 4.

Results reveal that the higher the concentration of Paracetamol drug, the greater the adsorption efficiency depending on the following results (19.22 to 158.4 mg/g). However, it was noticed that with higher drug concentration, the removal percentage E% decreased depends on the following results (73.55% to 99.6%), and this has clear evidence that the higher the concentration leads to the saturation of all the active sites.[22,23]

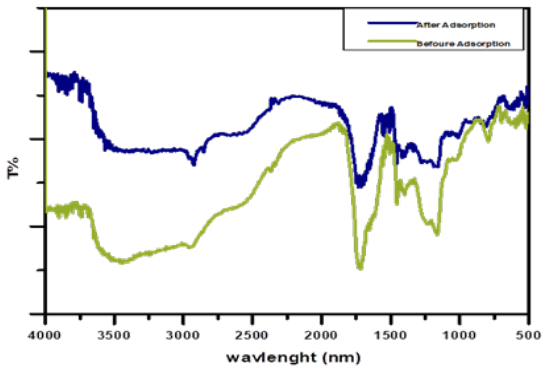


Figure 2: FTIR spectrum of hydrogel before and after adsorption of AMX drug.

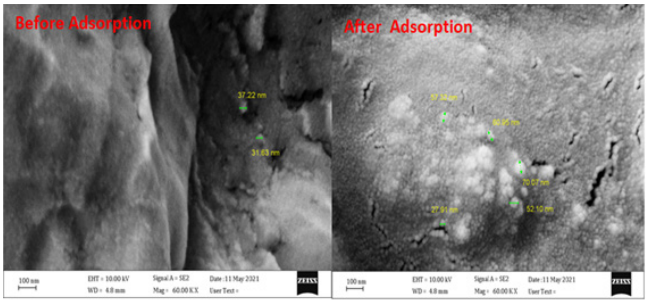


Figure 3: Effect of FESEM of the adsorption onto hydrogel

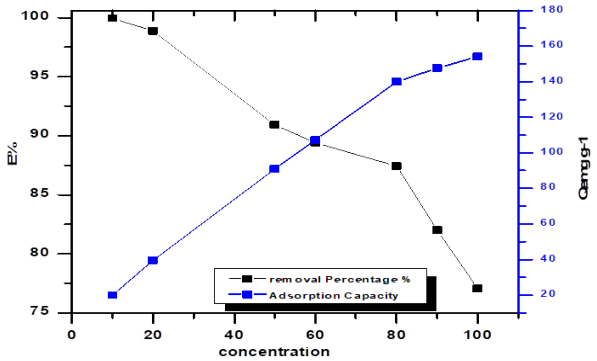


Figure 4: Effect of paracetamol concentration adsorption using hydrogel (weight of hydrogel 0.05 g, 25ºC and pH 5.8).

Table 1: The Freundlech model, Langmuair model, the isotherm factors for paracetamol drug absorbed on to hydrogel at 25°C.

Isotherm models	*Parameters*	*Paracetamol*
Langmauir	qm ($mg.g^{-1}$)	180.33 ± 26.005
	$K_L(L.mg^{-1})$	0.266 ± 0.1408
	R^2	0.8997
Freundlech	K_F	64.772 ± 5.411
	1/n	0.291 ± 0.032
	R^2	0.9741

Adsorption Model

The data appear that the adsorption method corresponds to (S) class according to the Giles classification, as appear in Figure 5. This kind is characterized via the particles of the adsorbate material being vertically or slanted on the hydrogel surface. The hydrogel is not homogeneous. The isotherm Langmuir model and isotherm Freundlich model.The data show that the adsorption method of the paracetamol drug on the hydrogel surface obeys the Freundlich model the best (R^2=0.9741) comparative isotherm Langmuir model (R2=0.8997). Table 1 appears the constants and correlation coefficients of isotherm Langmuir model and isotherm Friendlies model.[12,24]

Adsorption Kinetics

Kinetics model of paracetamol the amount of paracetamol drug adsorbed onto hydrogel per unit of time. It can be attained by measuring the change in hydrogel's drug adsorption efficiency over overtime, presented in a rate constant of the adsorption drug. The first model, second model, and Elcovich model look through Eqs. Table 2, in the same order, was taken into account to obtain the rate constant of drug adsorption through the hydrogel, as shown in Figure 6 and Table 2. The data appears that the first model's kinetic model is extra compatible with the kinetic adsorption of the drug onto the hydrogel surface. The best (R^2) obey the First model as shown in Table 2.[25-30]

CONCLUSION

- The use of a prepared surface that is less costly, economical, and highly efficient in removing pharmaceutical pollutants from wastewater.

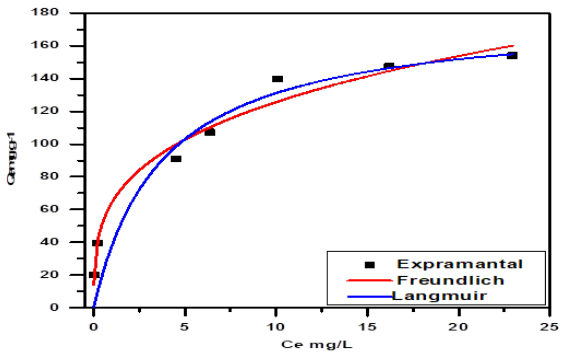


Figure 5: Different absorption model patterns non-linear fit for absorbing the paracetamol drug on hydrogel, conc. = 100 mg.L-1, Temp. = 25°C, the adsorbent = 0.05 g

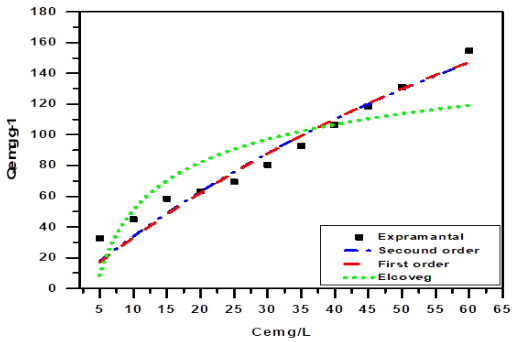


Figure 6: Kinetics model of paracetamol drug adsorption on hydrogel.

Table 2: Kinetic model first second and Elcovich model correlation coefficients for paracetamol drug adsorption onto hydrogel.

Model	*Equation*	*Parameters*	*Value*
First model	qt = qe [1 – exp (kf t)]	Kt (min^{-1})	0.012 ± 0.005
		Qe (calc)(mgg^{-1})	272.906 ± 82.85
		R2	0.9661
Second model	qt= K2qe2t/ (1+K2qet)	K2 (g/mg/min)	0.0084 ± 0.0031
		Qe (calc)(mgg^{-1})	939.88 ± 14.33
		R2	0.9468
Elcovich model	qt= 1/β 1βln(αβ) + 1/β lnt	α (mg g^{-1} min^{-1})	0.668 ± 0.098
		β (g min^{-1})	118.36 ± 22.64
		R2	0.724

- The use of several techniques to study the properties of the prepared surface and the efficiency of the surface in the adsorption process
- The study of adsorption isotherms found that it obeys the Frendlich model
- Studying the Kinetic model, it was found that it obeys the first- model
- It was found that by increasing the concentration of the drug, the adsorption efficiency decreased, and the removal percentage increased

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