



Experimental Investigation of Moisture Sorption Isotherms for Mefenamic Acid Tablets

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Abstract

The moisture sorption isotherms of Mefenamic acid tablets were investigated by measuring the experimental equilibrium moisture content (EMC) using the static method of saturated salt solutions at three temperatures (25, 35, and 45°C) and water activity range from 0.056 to 0.8434. The results showed that EMC increased when relative humidity increased and the sorption capacity decreased, the tablets became less hygroscopic and more stable when the temperature increased at constant water activity. The sorption curves had a sigmoid shape, type II according to Brunauer's classification. The hysteresis effect was significant along with the whole sorption process. The results were fitted to three models: Oswin, Smith, and Guggenheim - Anderson and de Boer. According to the fitting results, the GAB model was the most appropriate model to describe the sorption behavior of Mefenamic acid; it had a regression coefficient range (0.9803-0.994), %E (0.69-4.06), and low values of SEE (0.85-2.2). The monolayer moisture content was calculated using the GAB model and it was concluded that the tablets should be stored at moisture content equal or slightly higher than (0.2046, 0.1843, and 0.1437 %) for desorption and (0.2073, 0.1269, and 0.1452 %) for adsorption for the three temperatures.

Keywords: Sorption isotherms, Equilibrium moisture content, relative humidity, water activity, Mathematical modeling, Mefenamic acid.

Received on 08/10/2020, Accepted on 17/11/2020, published on 30/12/2020

<https://doi.org/10.31699/IJCPE.2020.4.2>

1- Introduction

1.1. Sorption Isotherms

Sorption Isotherms are known as a classical approach technique to describe the relationship between the relative humidity and equilibrium moisture content (EMC) at constant temperature and pressure. It is an important characteristic to describe the interaction between components and water; it gives information in the modeling of the drying process, predicting the product shelf life, selection of the material packaging and storage conditions [1].

Adsorption isotherm has many benefits in wastewater treatment i.e. removal of Fluoroquinolones antibiotic by adsorption using activated carbon [2, 3]. If a sample comes into equilibrium with the surrounding atmosphere, the water activity of a sample becomes equal to the relative humidity of the surrounding or in which it is stored. When this equilibrium is reached, the material neither loses nor gains moisture over time. The product moisture loss or gain to/from depends on the environment relative humidity, temperature, and time [4].

Moisture sorption isotherms curves can be divided into sections that describe the material behavior and help to understand the changes that taking place in the product, these sections are not static, they change according to the experimental conditions and material kind.

Desorption data is used for drying analysis and adsorption data for choosing the storage conditions [5, 6].

The moisture content reached equilibrium when the partial pressure of water vapor in the material became equal to the partial pressure of water vapor of surrounding air; it is the limiting moisture content after the exposure of a product to a fixed condition for a very long time. EMC is useful for determining water gain or loss under certain conditions of relative humidity and temperature, it is directly related to storage and drying ventilation.

There are two equilibrium moisture contents at constant air relative humidity and temperature depending on the experimental conditions, whether the moisture content of the material is higher or lower than the equilibrium for environmental conditions (desorption or adsorption) [6, 7].

The water activity (a_w) concept has been used as a reliable practical indication of the quality of a material. It is a thermodynamic property and defined as the ratio of the equilibrated vapor pressure to the saturation vapor pressure of pure water at the same temperature. Its value ranges $0 < a_w < 1$ and can be expressed as:

$$a_w = \frac{p}{p_s} \quad (1)$$

$$a_w = \frac{ERH}{100} \quad (2)$$

The water activity changes with temperature and the products are exposed to a wide range of humidity and temperatures during transporting and storage. Temperature affects the water molecule's mobility and the dynamic equilibrium between water vapor and adsorbents phases, thus both relative humidity and temperature must be specified for the sorption process. For certain water activity, the values of equilibrium moisture content, in desorption isotherm is higher than in adsorption [5, 6, 8].

Moisture sorption hysteresis is defined as the phenomena where two different paths are noticed between adsorption and desorption isotherms [9]. The hysteresis occurrence indicates that either the desorption or adsorption curve was not a true equilibrium or a composition in the material was in a changed state during the process [10].

The main factors affecting hysteresis are isotherm temperature, the composition of the material, storage time before measurement, drying temperature, pretreatments, and the number of successive desorption cycles [11]. The width and shape of sorption hysteresis loops were dependent on material type and temperature [12]. The reduction in the hysteresis loop area indicates a decrease in the sorption process of free energy and an improvement in stability [13].

The hysteresis occurs due to non-reversible changes in the structure and non-equilibrium effects, during adsorption, the porous began to swell up because of the increase in relative humidity and when partial pressure of the water vapor became higher than the vapor pressure of the capillaries, the water moved toward the interior of the pore. During desorption, the pores were saturated at the beginning then water diffusion occurred from the periphery to the surface and that when the partial pressure of the water vapor in the surrounding air became lower than the vapor pressure inside the capillary. The value of hysteresis is the difference of equilibrium moisture content between desorption and adsorption [14, 15, 16].

The isotherm curves are important to determine the stability criteria and prevent degradation for moisture-sensitive products i.e. pharmaceuticals. Manufacturers must specify not only the amount of moisture that exists in the products but also the moisture desorption-adsorption behavior as their products are exposed to humidity during manufacturing, storage, and in end-use. [17].

The Water in pharmaceutical products comes either from the exposure to high relative humidity or as the residual water from processing, it may affect the physical and chemical stability of products. For pharmaceutical products, stability is a critical quality and it varies with time under the effect of a variety of environmental factors such as; humidity, light, and temperature. So, the isotherm curves can be considered as a key factor to control the moisture sorption by the packages of products during shelf life, the container permeability and can be used to predict the product's stability over time in drying processes [18, 19]. Many authors have studied and modeled the EMC of food but few for pharmaceuticals [13].

The experimental EMC data of the tablets were determined using the static method. It is based on generating a fixed relative humidity environment using saturated salt solutions, where the samples are brought to equilibrium in a closed system of known relative humidity [16]. The relative humidity value depends on the salt kind. The method requires temperature stability and uniformity. It has many advantages: low cost of salts, the ease of handling, and maintenance of the humidity conditions but the main disadvantages are time and labor-consuming [17, 20].

The desiccator method with the loss on drying measurement can be considered a convenient technique for studying the EMC of tablets [18]. Tablet is the most preferred oral dosage form, due to many advantages offered to formulators as well as physicians and patients. Mefenamic acid tablets belong to a group of medicines named, Non-Steroidal Anti -Inflammatory Drugs (or NSAIDs), these medicines used for pain-relieving and inflammation*.

1.2. Mathematical models of sorption isotherms

The fitting of sorption results can be used as a tool in optimization and processing design, to solve packaging problems, an instance in drying, predicting shelf life stability, modeling moisture changes which might occur during drying, and ingredient mixing predictions. The models should meet the following requirements [4, 21]:

- 1- For functional applications, especially, drying and storing.
- 2- The relation should describe the experimental curves mathematically.
- 3- The simplicity of the model that describes the process must be obtained along with parameters limitation, as much as possible.
- 4- The parameters of the model should have a physical background.

The models used in this study were: Oswin, Smith and Guggenheim - Anderson and de Boer (GAB), their equations are shown in Table 1 [5, 6, 7, 22, and 23].

Table 1. Sorption Isotherms Models

Model Name	Model equation	Model parameters
Oswin	$M = m \left[\frac{a_w}{1-a_w} \right]^n$	m, n : Constants
Smith	$M = K_2 - K_1 \ln(1 - a_w)$	K_1, K_2 : Constants
GAB	$M = \frac{M_m C K a_w}{(1 - K a_w)(1 + (C - 1)K a_w)}$	M_m Monolayer moisture content C Guggenheim constant K constant

Three statistical parameters were used to evaluate the ability of a model to fit the experimental results, namely: The coefficient of regression (R^2), generally the values ≥ 0.98 is acceptable. The mean relative percent error (%E), Eq.(3), values lower than 5 indicate a good fit, values between 5 and 10, indicate a reasonable adjustment, and values higher than 10 indicate a poor fit. The standard error of estimate (SEE), Eq.(4), the model's ability to describe a certain physical process has an inverse proportional to SEE, low values of SEE indicate a good fit of the model to the data [15, 23, 24].

$$\% E = \frac{100}{N} \sum_{i=1}^N \left| \frac{M_i - M_i^{\wedge}}{M_i} \right| \quad (3)$$

$$SEE = \sqrt{\frac{\sum_{i=1}^N (M_i - M_i^{\wedge})^2}{df}} \quad (4)$$

Where:

M_i : Experimental equilibrium moisture content at i-th observation (g water/g dry solid).

M_i^{\wedge} : Predicted equilibrium moisture content at the same observation (g water/g dry solid).

N : Number of data points.

df : Degree of freedom.

The aim of this study was to 1- Determine the characteristics of sorption isotherms of Mefenamic acid at 25, 35, and 45°C and water activity range of (0.056 to 0.8434). 2- Select a suitable model that describes the sorption processes. 3- Calculate the monolayer moisture content and choose the suitable storing conditions of moisture content and relative humidity.

2- Materials and Method

2.1. Materials and Chemicals

The moisture sorption isotherms of Mefenamic acid were studied by measuring the equilibrium moisture content at three temperatures (25, 35, and 45C) using nine saturated salt solutions with water activity ranges from 0.056 to 0.8434 for both sorption processes leading to a total number of experiments of 54.

Mefenamic acid tablets were used in this study. There is a Caution that the tablets should be kept in a cool dry place where the temperature is below 30°C because heat and humidity destroy the drug*. Temperatures choice was according to the local weather conditions and they were suitable because they offered true ones. For the desorption process, the material was hydrated well with distilled water at room temperature and the initial moisture content was calculated and recorded as 30% on a dry basis.

For the adsorption process, the material was dried in a circulating air oven for 24 hours at 25 C until the final moisture content of 0.8 % on a dry basis was reached [19].

Saturated salt solutions were used to generate the desired relative humidity. They were prepared at ambient temperature by dissolving pure salt in boiling water, stirred continuously for two hours using a magnetic stirrer with the addition of excess salt to ensure the saturation, then left to cool. The solutions were placed in desiccators at the desired temperature for seven days before the sorption experiment [5]. The proportions are shown in Table 2 [25]. It has been noted that temperature affects the relative humidity [27, 28]. The relative humidity values at the three temperatures for the different kinds of salt solutions are shown in Table 3 [25].

Table 2. Proportions for saturated salt solutions preparation

Salt kind	Salt (g.)	Distilled Water (ml)
NaOH	36	100
LiCl	42.5	75
MgCl ₂	12.5	100
K ₂ CO ₃	45.0	100
Mg(NO ₃) ₂	15.0	100
NaBr	40.0	100
KI	25.0	100
NaCl	30.0	100
KCl	40	100

Table 3. Relative humidity at different temperatures

Salt Solution	Temperature °C		
	25	35	45
	% Relative Humidity		
NaOH	8.24	6.92	5.6
LiCl	11.3	11.25	11.16
CH ₃ COOK	0.225	0.209	0.193
MgCl ₂	32.78	32.05	31.10
K ₂ CO ₃	44.30	43.60	43.2
Mg(NO ₃) ₂	52.89	49.91	46.93
KI	68.86	66.96	65.26
NaCl	75.29	74.87	74.52
KCl	84.34	82.95	81.74

2.2. Method

The sample weight had a considerable effect on the time required to reach equilibrium because of the time needed for molecular diffusion through the sample interior structure, so samples of 3g each were weighted using a balance of ± 0.0001 g sensitivity model (Startuos) and placed in crucibles over the support inside desiccators [4].

Desiccators were placed in an oven at the controlled and desired temperature, allowed to reach equilibrium. The samples were weighted periodically every 24 hours until the change between three successive readings was less than 0.001 g.

The EMC of samples was determined by loss on drying method (LOD) at 105 °C for 24hr [1]. This procedure was repeated for adsorption-desorption processes for the nine kinds of salts and the three temperatures. [5, 24, 26] .

3- Results and Discussion

3.1. Experimental equilibrium moisture content results, EMC, (on dry basis) were plotted against water activity for desorption-adsorption processes at 25, 35, and 45 °C and presented in Fig. 1- Fig. 5.

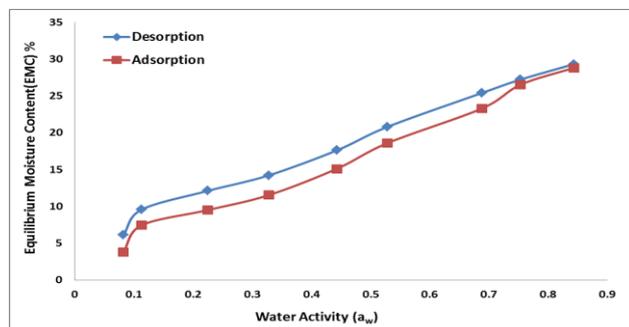


Fig. 1. Sorption isotherms of Mefenamic acid at 25°C

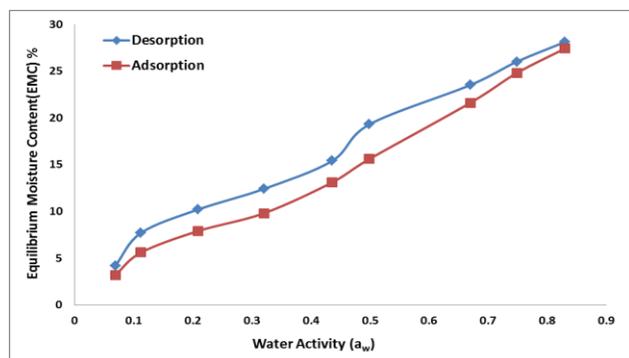


Fig. 2. Sorption isotherms of Mefenamic acid at 35°C

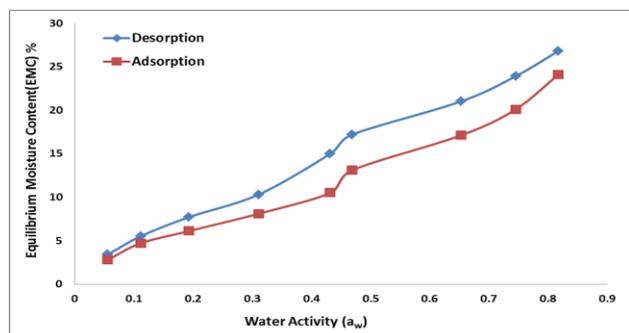


Fig. 3. Sorption isotherms of Mefenamic acid at 45°C

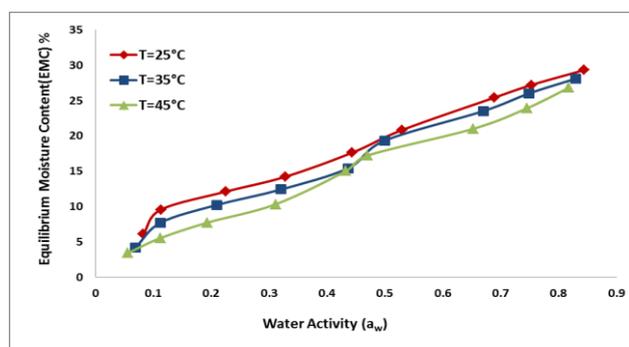


Fig. 4. Desorption Isotherm of Mefenamic acid at different temperatures

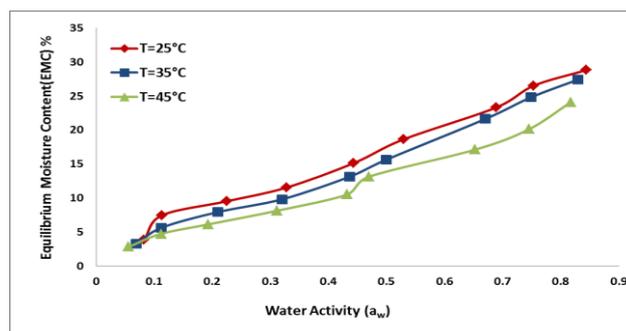


Fig. 5. Adsorption isotherm of Mefenamic acid at different temperatures

Fig. 1, Fig. 2 & Fig. 3 showed that the EMC increased with the increase of water activity at a constant temperature for both sorption processes that agreed with [4, 5, 17, and 24].

Fig. 4 & Fig. 5, showed that the increase in temperature at constant a_w caused to decrease the EMC, which means the sorption capacity decreased and the material became less hygroscopic because when temperature raised, the degree of disorder of water molecules present at the adsorbent surface increased, they became more active leading to instability and breakage of intermolecular connections between sorption sites and water molecules, that increased the intermolecular distances, decreased the attractive forces, the water easily break away from binding sites allowing water vaporization consequently decreasing EMC and the degree of water sorption at a given water activity. This behavior is typical for pharmaceuticals and agreed with [6, 15, 20, 22, and 24].

At constant M, the increase in temperature caused to lower the isotherm curves, for a higher temperature the product had a higher value of relative humidity thereby making it more susceptible to degradation and that agreed with [30]. [33] concluded that For each product, there is an optimum range of water activity values for the best storage conditions.

The values of EMC for desorption were higher than those for adsorption at constant water activity, this behavior was an indication of the appearance of hysteresis phenomenon and it was noticed for other pharmaceuticals [13, 16, 18, 28].

Fig. 1-Fig. 3 showed that the hysteresis magnitudes increased as temperature increased, the hysteresis effect was noticed during the entire water activity range for the three temperatures, at T=25C it decreased nearly at $a_w=0.7529$, at T=35 C, it was in increasing form for the whole range of water activity then decreased at $a_w=0.7452$ and at T=45 C it was in increasing form.

According to [12] the large hysteresis is associated with tightly bound water and the large magnitude of hysteresis loops is due to the difference in the distribution of pore size. [15] explained this phenomenon occurrence by capillary condensation theory: the material porous is formed by narrow capillaries of small diameters, they control capillary emptying during desorption process, causing the relative humidity reduction, while during

adsorption process, moisture gained, capillaries were not filled as before desorption, lead to a lower value of moisture content as before.

The isotherm curves were of type II according to Brunauer's classification, they had the S-shape, sigmoidal, this shape is common for hygroscopic products, and indicated the formation of a well-defined monolayer [13, 14]. It is caused by synergistic effects of the capillarity, Raoult's law, and moisture interactions at the surface of the material [15]. There was a slight increase in EMC at a low and intermediate range of a_w . Two bending regions can be noticed that agreed with [5, 6], the first at a_w equals to (0.113, 0.1125, 0.1116) for the three temperatures, where water sorption was in the monolayer region, the second at a_w of (0.5289, 0.4991, 0.4693) where the isotherm curve had up-ward slope which represented the sorption of bound water, this EMC is called the critical equilibrium moisture content, it can be chosen to guarantee well product preservation because water activity value is suitable to prevent degradation, the values were: for desorption (20.8, 19.3, 17.2 %), for adsorption (18.6, 15.6, 13.1 %). As a_w increased, the EMC increased more sharply due to capillarity and physicochemical changes, such as multilayers creation and the filling of pores then followed by filling of larger pores and solutes dissolution. This behavior was the identification of type II isotherm according to Brunauer's classification [15, 23]. [31] Concluded that the shape of sorption isotherms curves is characterized by the states of system constituents.

3.2. Fitting of Experimental Sorption Isotherms to the Models

The experimental results of sorption isotherms of Mefenamic acid at 25, 35 and 45 °C have been fitted to three models (Oswin, Smith, and GAB) using Microsoft Excel 2010, to select the best model that describes the processes. The results are shown in Table 4 and Fig. 6- Fig. 14

a. Oswin Model

Fitting results were obtained by linear regression of $\ln M$ versus $\ln [a_w/1-a_w]$. The results are shown in Figs.6, 7 & 8.

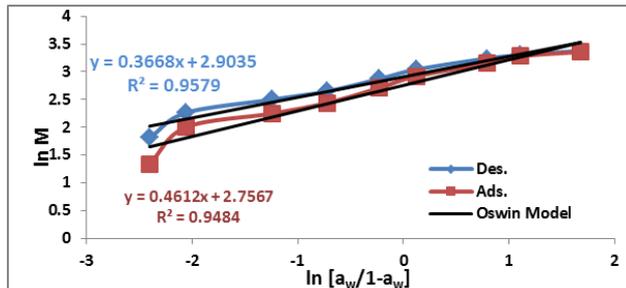


Fig. 6. Fitting of Oswin model to Sorption isotherms at 25°C

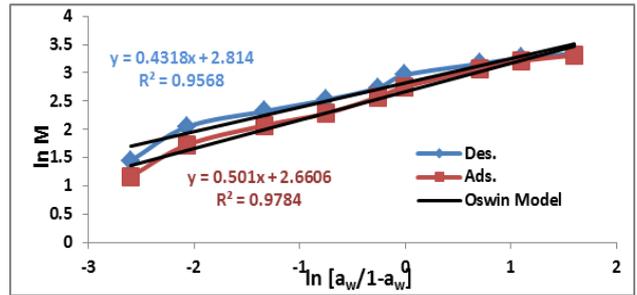


Fig. 7. Fitting of Oswin model to Sorption isotherms at 35°C

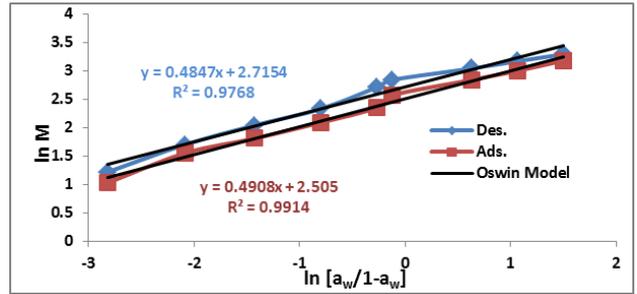


Fig. 8. Fitting of Oswin model to Sorption isotherms at 45°C

b. Smith Model

Fitting results were obtained by linear regression of $\ln M$ versus $\ln (1-a_w)$. The results are shown in Figs.9,10 & 11.

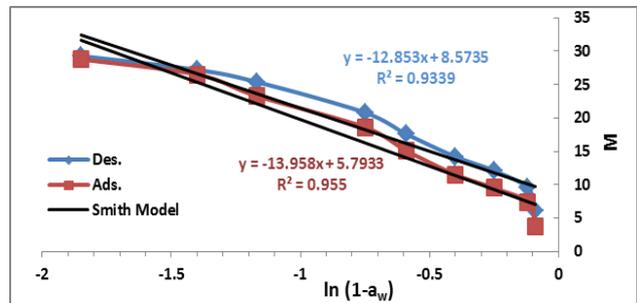


Fig. 9. Fitting of the Smith model to Sorption isotherms at 25°C

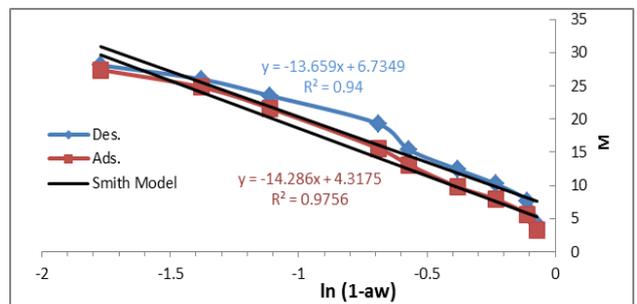


Fig. 10. Fitting of the Smith model to Sorption isotherms at 35°C

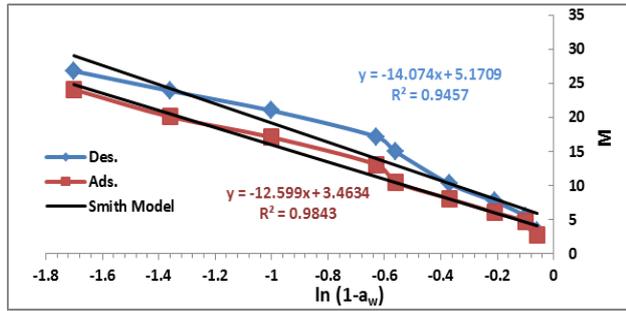


Fig. 11. Fitting of the Smith model to Sorption isotherms at 45°C

c. Guggenheim , Anderson and De -Boer model (GAB)

The GAB model was transformed to quadratic form, Eq. (5) the constants α, β and γ , and the regression coefficients were obtained by non-linear regression of the second degree polynomial from the plot of $(\frac{a_w}{M_w}$ vs a_w).

The model constants were calculated using Eq. 6, Eq. 7, Eq. 8, and Eq.9 [5, 7, 28, 30]. The results are shown in Table 4 and Fig. 13, Fig. 14.

$$\frac{a_w}{M_w} = \alpha a_w^2 + \beta a_w + \gamma \quad (5)$$

$$\alpha = \frac{K}{M_w} \left(\frac{1}{C} - 1 \right) \quad (6)$$

$$\beta = \frac{1}{M_w} \left[1 - \frac{2}{C} \right] \quad (7)$$

$$\gamma = \frac{1}{M_w \cdot C \cdot K} \quad (8)$$

$$M_m = \sqrt{\frac{1}{\beta^2 - 4\alpha\gamma}} \quad (9)$$

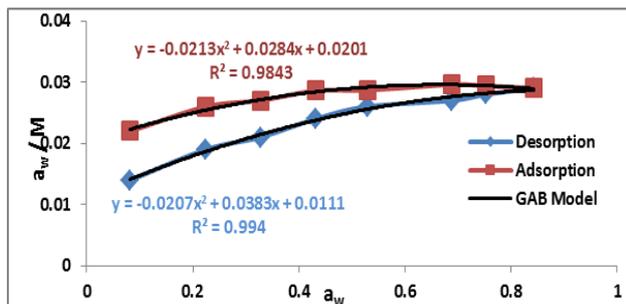


Fig. 12. Fitting of GAB model to sorption isotherms at 25°C

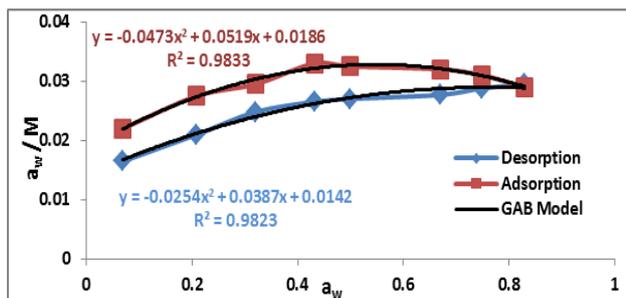


Fig. 13. Fitting of GAB model to sorption isotherms at 35°C

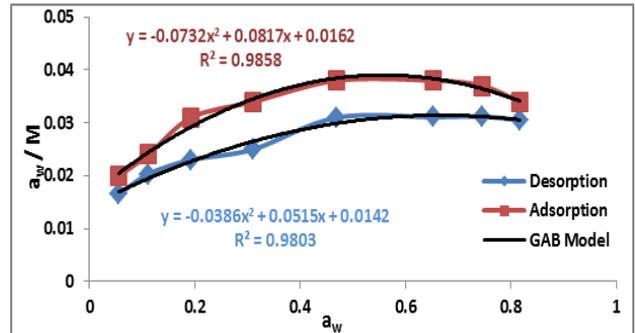


Fig. 14. Fitting of GAB model to sorption isotherms at 45°C

Table 4. Fitting results and statistical parameters

Model	Temperature	25 °C	35 °C	45 °C
Oswin	Desorption			
	n	0.3668	0.4318	0.4847
	m	2.9035	2.814	2.7154
	R ²	0.9579	0.9568	0.9768
	%E	0.59	0.76	0.23
	SEE	1.7	2.2	2.2
	Adsorption			
	n	0.4612	0.501	0.4908
	m	2.7567	2.6606	2.505
	R ²	0.9484	0.9784	0.9914
	%E	3.8	0.08	0.35
	SEE	1.8	1.8	1.7
Smith	Desorption			
	K ₁	-12.853	-13.659	-14.074
	K ₂	8.5735	6.7349	5.1709
	R ²	0.9339	0.94	0.9457
	%E	4.3	7.4	8.8
	SEE	2.1	1.4	1.9
	Adsorption			
	K ₁	-13.958	-14.286	-12.599
	K ₂	5.7933	4.3175	3.4634
	R ²	0.955	0.9756	0.9843
	%E	6.4	0.40	5.0
	SEE	1.9	2.1	0.85
GAB	Desorption			
	M _m	20.46	18.43	14.37
	C	9.24	6.97	7.69
	K	0.48	0.55	0.63
	R ²	0.994	0.9833	0.9858
	%E	0.7	0.69	1.9
	SEE	0.52	0.65	0.44
	Adsorption			
	M _m	20.73	12.69	14.52
	C	4.12	5.86	7.93
	K	0.58	0.72	0.54
	R ²	0.9843	0.9823	0.9803
%E	4.06	2.1	3.6	
SEE	0.69	0.44	0.57	

From the results shown in Table 4, it can be noted that the fitting results of Oswin and GAB models were better than that of Smith. The regression coefficients for GAB and Oswin models ranges (0.9803- 0.994) and (0.9484-0.9914) for both sorption processes, for GAB they were higher than 0.98 and better than Oswin. The mean relative percent deviation values for both of them were less than 5% and that was an indication of the well-fitting of the two models. For the Smith model, the regression coefficients were less than 0.98, and %E was less than 10 indicate a reasonable adjustment.

The SEE values for GAB were lower than the other two models and ranges (0.85-2.2). So the GAB is better for describing sorption isotherms of Mefenamic acid tablets. The GAB model can be used over a wide range of water activity up to 0.9; its application is more advantageous than other models since its parameters have physical meanings allowing a detailed study of mass and heat transfer that occur during desorption-adsorption processes [4, 5, 16 and 25]. From the results shown in Table 4, the GAB constants were temperature dependent that agreed with [22, 28].

The first constant of the GAB model is the monolayer moisture content (M_m), it is a critical point of the sorption isotherm curve that represents the water content when the entire surface is covered with moisture, bears significant consequences for storage conditions of products. It is the moisture content for the maximum shelf stability used to control the quality and to extend the self-life of products by storing at or slightly above M_m value [3, 4, 5, 29]. At M_m , the physical changes, oxidation, and degradation are slow down. Changes occur when the moisture content value of a product is lower than M_w [1, 22]. It is generally decreased with temperature and that agreed with [7, 23, 27]. The estimated values of % M_m on a dry basis using the GAB model are presented in Table 5.

Table 5. Monolayer moisture content (% d. b.) at different temperatures

Temperature (°C)	Desorption	Adsorption
25	20.46	20.73
35	18.43	12.69
45	14.37	14.52

From Table 5, As the temperature increased from 25 to 45°C, M_w values decreased from (20.46 to 14.37 % d.b.) for desorption and (20.73 to 14.52 % d.b.) for adsorption and that explained due to the gained kinetic energy by the molecules which caused to loosen the attractive forces, allowing some molecules of the water to break away from their sorption sites, also a reduction in the number of active sites and decrease in the available specific surface area that caused to decrease the M_m that agreed with [4, 5, 22, 23].

The tablets should be stored at moisture content slightly higher than (0.2046, 0.1843, and 0.1437 %) for desorption and (0.2073, 0.1269, and 0.1452 %) for adsorption for the three temperatures. It can be noted that the monolayer moisture content values were close to the concluded values of critical EMC from Figs 1-5 that discussed previously in section 3.1. [32] Confirmed this conclusion that the M_m and critical EMC are important for maintaining shelf stability.

The second constant, the Guggenheim constant (C), represents the enthalpy change, it is related to the different chemical potentials between the monolayer and the upper layers and should be higher than zero. When $C \geq 2$, the sorption curves had a sigmoid shape, type II of Brunauer's classification.

As shown in Table 4, the C values were greater than 2 and that ensures the sorption curves were of type II [5,13, 21, 23]. There was an increase in C values with increasing temperature, for adsorption from (4.12 - 7.93), and for desorption (6.97 to7.69) that ensures the constant is temperature dependent [28]. The increase was a result of the strong binding of water monolayer with the primary sorption sites; the temperature increase caused a gain in kinetic energy which increase enthalpy and more moisture loss at a higher temperature. The values of C for desorption were higher than that for adsorption, which means the water monolayer removal from the structure of the material required more heat [22, 27].

The third constant, K is the degree of freedom of water molecules, it is related to multilayer properties, between the upper layers and free water, k values are always less than 1.0, values greater than one indicate infinite sorption which is physically unsuitable. As shown in Table 4.the range of K values was less than unity and that in agreement with the assumption of the GAB model that the multilayer properties were between the monolayer and bulk liquid[28]. K values increased with temperature from (0.48 to 0.63) for desorption and (0.58 to 0.72) for adsorption, this increase was an indication that the molecules in the multilayer became more entropic which agreed with its physical meaning [9, 21 23, 24, 27].

4- Conclusions

The sorption isotherms of Mefenamic acid were determined at three temperatures (25, 35, and 45°C) using the standard static method. Equilibrium moisture content was directly proportional to relative humidity (water activity) at a constant temperature.

The sorption capacity decreased with an increase in temperature at constant water activity, the tablets became less hygroscopic and more stable with the rise of sorption temperatures at constant water activity. The sorption isotherms had a sigmoid shape, with type II according to Brunauer's classification. The hysteresis phenomena were significant at the three temperatures for both sorption processes. The monolayer moisture content decreased with the temperature increase of sorption processes.

The tablets should be stored at moisture content slightly higher than (0.2046, 0.1843, and 0.1437 %) for desorption and (0.2073, 0.1269, and 0.1452 %) for adsorption for the three temperatures. The GAB model was the best model to describe the sorption processes, and its constants were temperature dependent.

Acknowledgment

The experimental study was conducted in the laboratories of the chemical engineering department/engineering college/Baghdad University.

Nomenclature

a_w	Water activity		dimensionless
d.b.	On a dry basis		
EMC	Equilibrium moisture content, %	moisture	g H ₂ O /g dry solid
ERH	Equilibrium humidity	relative	-
E	Mean deviation, %	relative	-
K_1, K_2	Smith model constants.		-
LOD	Loss on drying.		
M	Equilibrium moisture content, %	moisture	g H ₂ O /g dry solid
M^{\wedge}	Predicted moisture content, %	moisture	g H ₂ O /g dry solid
M_m	Monolayer moisture content, %	moisture	g H ₂ O /g dry solid
M_m, C, K	GAB model constants		-
m, n	Oswin model constants		-
P	vapor pressure of water in a solid material at T.		N/m ²
P	vapor pressure of pure water at T.		N/m ²
R ²	Coefficient of regression		-
SEE	The standard error of estimate		-
Greek Letters	Constants of GAB model (in quadric form).		-
α, β, γ			

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دراسة عملية لأيزوثيرم امتزاز الرطوبة لأقراص ميفانميك أسيد

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الخلاصة

تعتبر دراسة الايزوثيرم من الطرق التقليدية لوصف العلاقة ما بين محتوى الرطوبة عند الاتزان والرطوبة النسبية بثوت درجة الحرارة والضغط. تم قياس محتوى الرطوبة باستعمال طريقة المحاليل الملحية المشبعة عند ثلاث درجات حرارية 35,25 و 45 درجة مئوية و محتوى رطوبة يتراوح بين (0,065 - 0,8434%). النتائج اوضحت ان محتوى الرطوبة عند الاتزان يزداد مع زيادة الرطوبة النسبية بثوت درجة الحرارة ويقل مع زيادة درجة الحرارة بثوت الرطوبة النسبية اي ان استقرارية المادة ازدادت. من المنحنيات اتضح ان المادة من النوع الثاني حسب تصنيف برونير وان ظاهرة الهسترة واضحة عند الدرجات الحرارية الثلاث. تم مطابقة النتائج العملية مع ثلاث موديلات رياضية هي سميث, اوسون و كوكنهام - اندرسون و دي-بور. وكان الاخير هو الافضل في وصف الايزوثيرم لأقراص ميفانميك اسيد . لتحديد محتوى الرطوبة عند خزن المنتج ,تم حساب محتوى الرطوبة للطبقة الواحدة باستعمال الموديل واتضح انه يجب ان تخزن عند او أعلى قليلا من: للامتزاز (0,1843, 0,143, 0,2046%) انتزاز (0,1452, 2073, 0,1269%).

الكلمات الدالة: ايزوثيرم, الامتزاز, محتوى الرطوبة عند الاتزان, الرطوبة النسبية, نمذجة رياضية, اقراص ميفانميك اسيد.