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The Effect of Changing the Weights of Zinc Oxide Nanoparticles and Weights of Sodium Chloride on Some Physical Properties of Carboxymethylcellulose thin Films.

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Abstract

The objective of this work is to improve certain physical properties of the polymer Carboxymethylcellulose (CMCHV). The samples were prepared by adding sodium chloride and Zinc oxide nanoparticles to CMCHV solutions at different weights (0.00, 0.75, 1.50, 2.25, 3.00 g). When samples are exposed to heat, they do not become liquid or evaporate, but instead ignite and burn. The elasticity of the samples increased with increasing weights of the materials added to them, but the elasticity increased more with increasing weights of sodium chloride than with increasing weights of zinc oxide nanoparticles. The decrease in the transmission spectrum of the samples with increasing weights of sodium chloride and zinc oxide nanoparticles indicates that the opacity of the samples increases with increasing weights (As in the sample containing 3 grams of sodium chloride or Zinc oxide nanoparticles).

1. Introduction:

The purpose of the study is to improve certain physical properties of the polymer CMCHV by adding materials that modify them to obtain samples that can be used in specific fields. Aqueous solutions of carboxymethyl cellulose (CMC) can have different rheological properties depending on the synthesis conditions, of substitution total degree, concentration, degree of polymerization and temperature [1]. CMC obtained from cellulose and monochloroacetic acid or by adding alkaline cellulose to sodium monochloroacetate.

The polymer chains of CMC monomers are formed by joining them through 1, 4-glycosidic bonds. Each unit of the chain has free hydroxyl groups that can undergo substitution with carboxymethyl groups, with a maximum of three such substitutions being possible [2]. Nanoparticles (NPs) encompass a wide range of particles of matter defined as having a diameter of less than 100 nm. These particles can exist in the form of nanocapsules or nanospheres. They exhibit size-related properties that are very different from those of bulk materials [3].

Zinc oxide is an inorganic compound with the molecular formula ZnO. It comes in the form of a white powder and is almost insoluble in water. ZnO powder is widely used as an additive in many materials, including ceramics, products, glass, cement, paints, rubber lubricants, ointments, plastics, adhesives, etc. [4]. Sodium chloride (NaCl), also known as salt, is an ionic compound. Pure NaCl is an optical compound and is used in studies of the infrared spectrum, also it has been used to clean household surfaces, and in shampoos and toothpastes [5].

Ultraviolet-visible spectroscopy is based on the absorption of light by a sample. Depending on the amount of light and its wavelength absorbed by the sample, valuable information can be obtained. Furthermore, the amount of light absorbed is related to the amount of sample and, therefore, it is possible to perform quantitative analyzes using optical spectroscopy [6]. In UV/VIS spectroscopy, light absorption is measured as a function of wavelength. The spectrum provides information about the electronic transitions that occur in the material [7]. In the transmission configuration, the user places the sample of interest, here called a working sample, in the path of a collimated light beam. Samples should have at least a small degree of transparency. Light passes through the working sample and is partially absorbed at characteristic wavelengths corresponding to electronic transitions in the sample [7].

Stress test is probably the most basic type of mechanical test that can be performed on a material. Tensile tests are simple, relatively inexpensive and fully standardized tensile tests. Material properties are used as the primary method of material acceptance, quality control, and design limits. The main parameters that describe the stress-strain curve obtained during the tensile test are tensile strength, elastic limit, elastic modulus, percentage of elongation and area reduction. [8]. The stress-strain state of composite structures in the connection zones of the elements under the action of forced deformations breaking along the contact line of the elements is characterized by an exponential characteristic. The stress-strain state in the irregular point zone of the surface boundary under the action of forced deformations, especially those of temperature, is determined by solving the homogeneous limit value problem of the theory of elasticity. [9]. Stress that a material can withstand can be described by its ultimate strength, while the elastic limit describes the maximum amount of stress necessary to elastically deform the part [10]. The objective of this work is to improve certain physical properties of the polymer Carboxymethylcellulose (CMCHV). The samples were prepared by adding sodium chloride and Zinc oxide nanoparticles to CMCHV solutions at different weights (0.00, 0.75, 1.50, 2.25, 3.00 g).

2. The theory:

2.1 stress-strain:

By known (A) which is the cross-sectional area, and the force applied by the tensile testing machine (F), then the tensile stress σ_s is [11, 12]

$$\sigma_s = \frac{F}{A} \tag{1}$$

The strain resulting from the tensile stress on the sample is calculated by equation (1). [11, 12]:

$$\varepsilon = \frac{L - L_0}{L_0} \tag{2}$$

Where (L_0) is the original length of the samples, and (L) is the length of the samples after applying a tensile force. The constant in the following relationship between stress and strain (E) is called elastic modulus or Young's modulus. [11, 12, 13]:

$$\sigma_s = E\ \varepsilon \tag{3}$$

2.2 UV/VIS spectroscopy:

The absorption coefficient (α) was calculated using equation (4), where (T) is the transmittance value and d is the thickness of the samples [14]. While the extinction coefficient (K) was calculated using the equation (5), where λ is the wavelength of the spectrum [15]

$$\alpha = -\frac{1}{d}\ ln\ (T) \tag{4}$$

$$K = \frac{\alpha\ \lambda}{4\ \Pi} \tag{5}$$

3. Experiment and Materials:

3.1 Materials:

Zinc oxide nanoparticles were provided by Sigma-Aldrich GMBH and carboxymethyl cellulose was provided by National Corporation Jowfe Oil Technology. Sodium chloride is a dietary salt.

3.2 Samples preparation:

The samples studied in this manuscript consist of two parts, the first part contains sodium chloride and the second part contains zinc oxide nanoparticles. Samples were prepared by dissolving 6 g of CMCHV in 40 ml of distilled water, then adding sodium chloride and zinc oxide nanoparticles by weights (0.00, 0.75, 1.50, 2.25, 3.00 g) and stirring for three hours, then pour it onto a plate and leave it until thin films with thickness(0.05 nm) form.

3.3 Measurements:

3.3.1 Heat effect:

The effect of heat on the pieces of samples was tested. They were placed in a water bath and heated to more than 1000 C, then the other pieces of samples were tested by placing them directly over a flame. Finally, the samples were placed on top of a heater.

3.3.2 stress-strain:

Loads were applied to the samples and the increase in their lengths was measured. The loads were gradually increased until the sample were cut off, where the stress and strain were calculated using equations (1) and (2), then the elastic modulus was calculated using equation (3).

3.3.3 UV/VIS spectroscopy:

Transmission and absorption measurements were studied using a DU 800 spectrophotometer, serial number 8000770, software version ”2.0, Build 67”, firmware version 2.0.012, method name ”Default method” located at the laboratory of the Faculty of Sciences. Omar Al-Mukhtar University, Al-Bayda, Libya.

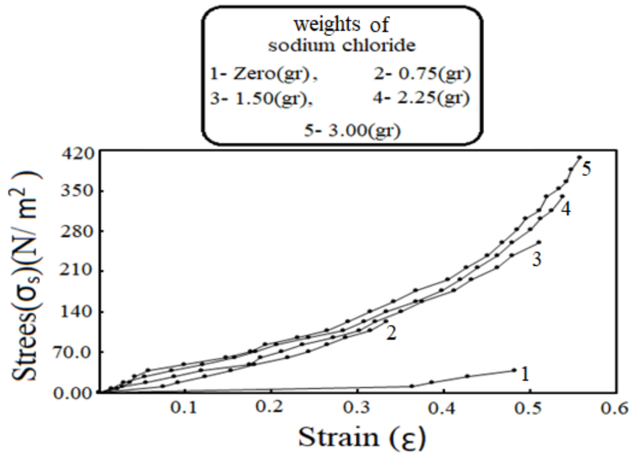

Figure 1. The effect of weights of NaCl on stress-strain curves for CMCHV thin films.

4. Results and Discussion:

4.1 Heat effect:

4.1.1 Water bath:

When the samples were placed in a water bath, they shrank and dried at the boiling temperature of water (100 °C).

4.1.2 Direct flame:

A flame was placed under the samples, they burned and turned into ashes.

4.1.3 The Electric heater:

The samples were placed in an electric heater. The Table 1 shows the evolution of the state of the samples with the change in temperature.

These results show that samples containing sodium chloride resist higher temperatures than those containing ZnO NPs.

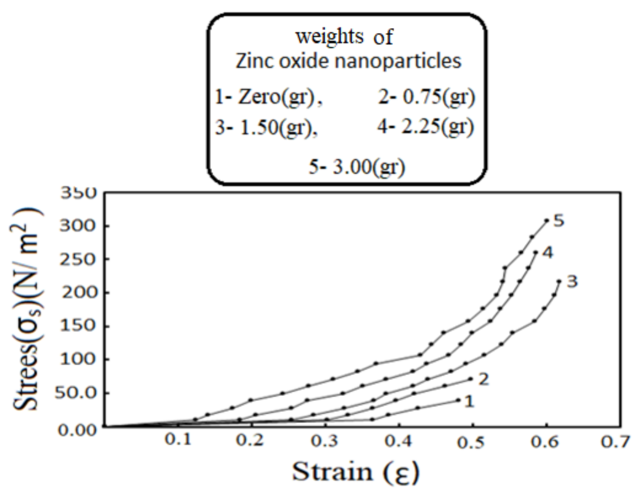

Figure 2. The effect of weights of ZnO NPs on stress-strain curves for CMCHV thin films.

4.2 The stress-strain effects:

Figure 1 represents the relationship between stress and strain for (CMCHV/ NaCl) samples. It is clear that the increase the weights of (NaCl), the greater the ability of the samples to withstand stress despite the increase in strain, furthermore, Figure 2, shows that the increase the weights of (ZnO NPs), the greater the ability of the samples to withstand stress applied to them as the strain increases.

The relationship between the elastic modulus and the changing of the weights of (NaCl) in (CMC/ NaCl) thin films

Table 1. The evolution of the state of the samples with the change in temperature.

Weight of additives in the sample	Dryness and shrinkage at (^{o}C)	Burning at (^{o}C)	Carbonizing at (^{o}C)
0.0g	37.5	91.0	115
0.75 gr of ZnO NPs	38.9	6.28	102.3
1.50 gr of ZnO NPs	40.8	74.6	95.4
2.25 gr of ZnO NPs	43.6	68.2	87.3
3.00 gr of ZnO NPs	47.3	57.5	76.8
0.75 gr of NaCl	40.0	124.0	139.0
1.50 gr of NaCl	43.5	150.0	168.9
2.25 gr of NaCl	48.3	174.8	185.2
3.00 gr of NaCl	53.6	182.4	195.6

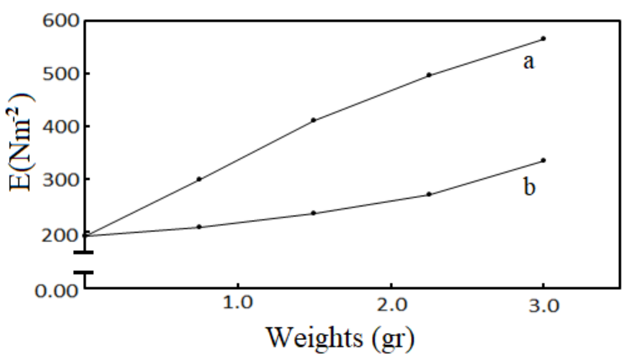

Figure 3. (a) Elastic modulus curve of CMCHV/ NaCl thin films, and (b) Elastic modulus curve of CMCHV/ ZnO NPs thin films.

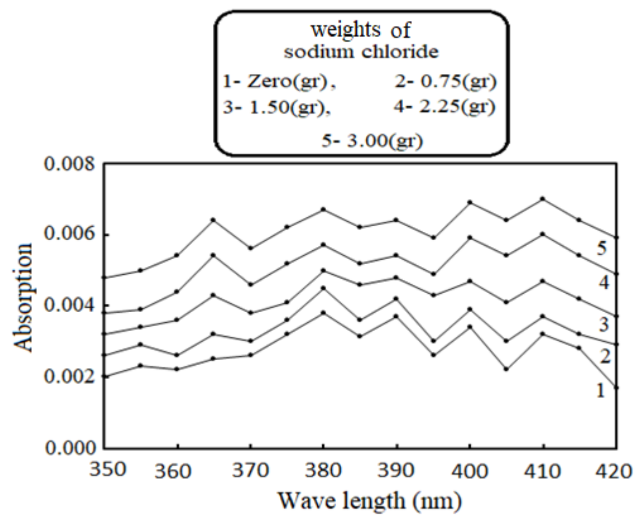

Figure 4. The wave length of UV/VIS spectroscopy vs the absorption of UV/VIS spectrum by CMCHV/ NaCl thin films. [16, 17, 18].

appears in Figure 3(a) and shows the increase in the elastic modulus with increasing weights of (NaCl).From Figures 1 and 3(a), it is clear that the flexibility of polymer thin films (CMCHV) increases with increasing weights of (NaCl).

Figure 3(b) represents the relationship between the elastic modulus and the changing of the weights of (ZnO NPs) in (CMC/ ZnO NPs) thin films, this relationship shows the increase in the elastic modulus with increasing weights of (ZnO NPs). From Figures 2 and 3(b), it is clear that the flexibility of polymer thin films (CMCHV) increases with increasing weights of (ZnO NPs), Still, the modulus of elasticity of the sample at zero weight is equal to (193.11 Nm^{-2}), but by adding sodium chloride in different weights, the highest value of the modulus of elasticity of the samples reaches (565.75 Nm^{-2}), while by adding different concentrations of zinc oxide nanoparticles, the highest value of the elastic modulus reached (565.75 Nm^{-2}), from this result, it is clear that increasing the weight of sodium chloride increases the elastic modulus of the (CMCHV) thin films more than the increase caused by increasing the weights of zinc oxide nanoparticles.

4.3 UV-VIS spectroscopy:

Figure 4 shows a relationship between the wavelength and absorption spectrum of UV-VIS light waves, The added weight increased the absorbance of the samples for wavelengths in the spectral range 350 -420.

The relationship between the wavelength and transmission ratio of ultraviolet waves and visible light is shown in Figure 5, it shows that by increase in the weight of sodium chloride decreases the transmission of the spectrum from 350 to 420 through the samples

Figure 6 shows a relationship between the wavelength and absorption spectrum of UV-VIS light waves, it is observed that the absorption of wavelengths with values (355, 365, 380, and 390 nm) of near ultraviolet waves increases with increasing

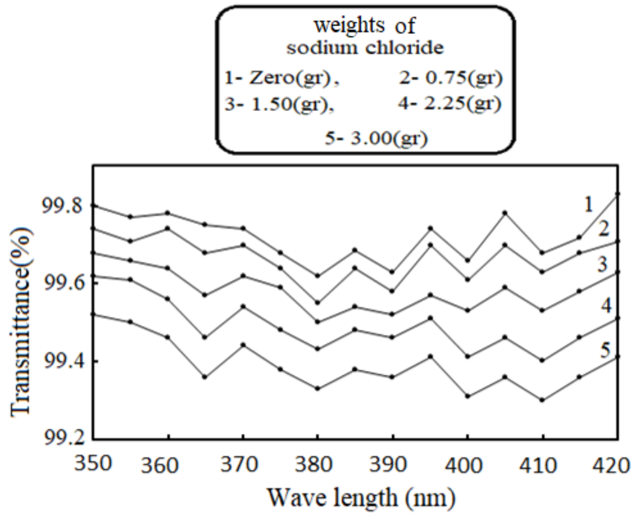

Figure 5. The wave length of UV/VIS spectroscopy vs the transmittance ratio of UV/VIS spectrum from CMCHV/ NaCl thin films. [19].

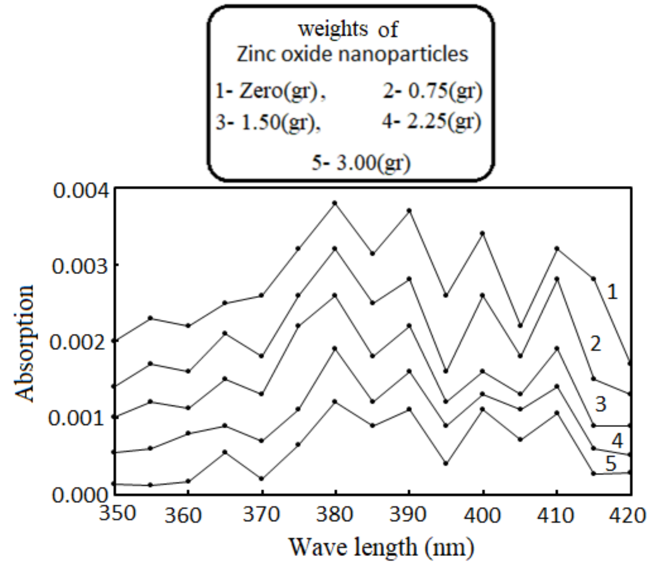

Figure 6. The wave length of UV/VIS spectroscopy vs the absorption of UV/VIS spectrum by CMCHV/ ZnO NPs thin films. [16, 17, 18]

weights of ZnO NPs in the samples, also the absorption of wavelengths (400 and 410 nm) of visible light also increases with increasing ZnO NPs weights in the samples.

The relationship between the wavelength and transmission ratio of ultraviolet waves and visible light is shown in Figure 7. In this figure we see that by increasing the weights of ZnO NPs, the wavelengths of the ultraviolet fiber values (360,370, 385 and 395 nm) decrease their transmission ratio, while the transmission ratio of the wavelength (405 and 415 nm) of visible light decreases.

Figures 4, 5, 6 and 7, shows that the increase in absorption and decrease in transmission with increasing weights of sodium chloride and zinc oxide nanoparticles occur at approximately the same wavelengths.

Table 2 Shows the change in the values of the absorption coefficient of the ultraviolet spectrum appears with the change in the weights of sodium chloride at the peak wavelengths, since it is clear that the absorption coefficient increases with increasing the weight of sodium chloride.

Table 2. The absorption coefficient values for the peak wavelengths of CMCHV/NaCl thin films.

λ(nm)	$\alpha(0)$	$\alpha(0.75)$	$\alpha(1.5)$	$\alpha(2.25)$	$\alpha(3)$
365	0.050063	0.064103	0.086185	0.108293	0.128411
380	0.076145	0.090203	0.100251	0.114326	0.134451
390	0.074137	0.084177	0.096231	0.108293	0.128411
400	0.068116	0.078152	0.094222	0.118349	0.138478
410	0.064103	0.074137	0.094222	0.120361	0.140492

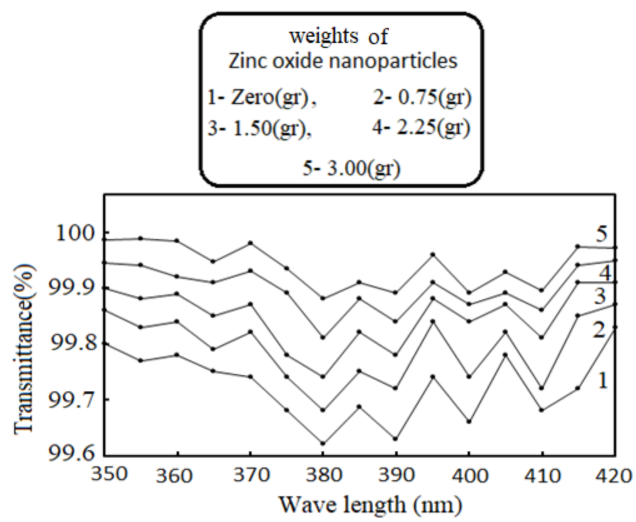

Figure 7. The wave length of UV/VIS spectroscopy vs the transmittance of UV/VIS spectrum from CMCHV/ ZnO NPs thin films. [19]

Table 3 Represents the change in the values of the extinction coefficient of the ultraviolet spectrum appears with the change in the weights of sodium chloride at the peak wavelengths, since it is clear that the absorption coefficient increases with increasing the weight of sodium chloride.

Table 3. The extinction coefficient values for the peak wavelengths of CMCHV/NaCl thin films.

λ(nm)	K(0)	K(0.75)	K(1.5)	K(2.25)	K(3)
365	1.454845	1.862855	2.504593	3.14704	3.731699
380	2.303743	2.729075	3.033067	3.458912	4.067782
390	2.302032	2.613773	2.988069	3.36259	3.987295
400	2.169295	2.488933	3.000688	3.769092	4.410137
410	2.092522	2.420085	3.075705	3.928996	4.586134

Table 4 Shows the change in the values of the absorption coefficient of the ultraviolet spectrum appears with the change in the weights of ZnO NPs at the peak wavelengths, since it is clear that the absorption coefficient increases with increasing the weight of ZnO NPs.

Table 4. The absorption coefficient values for the peak wavelengths of CMCHV/ ZnO NPs thin films.

λ(nm)	α(0)	α(0.75)	α(1.5)	α(2.25)	α(3)
355	0.0024	0.012004	0.024014	0.034029	0.046053
365	0.010803	0.018008	95.35378	0.042044	0.050063
380	0.024014	0.038036	0.052068	0.064103	0.076145
400	0.022012	0.026017	0.032026	0.052068	0.068116
410	0.021011	0.02802	0.038036	0.056079	0.062297

Table 5 Represents the change in the values of the extinction coefficient of the ultraviolet spectrum appears with the change in the weights of ZnO NPs at the peak wavelengths., since it is clear that the absorption coefficient increases with increasing the weight of ZnO NPs. By studying the previous tables, it is clear that increasing the weight of sodium chloride in CMCHV thin films increases the absorption coefficient and the extinction coefficient has a greater increase than that caused by ZnO NPs for both coefficients.

Table 5. The extinction coefficient values for the peak wavelengths of CMCHV/ ZnO NPs thin films.

λ(nm)	K(0)	K(0.75)	K(1.5)	K(2.25)	K(3)
355	0.067838	0.339274	0.678751	0.961805	1.301657
365	0.313938	0.523325	2771.03	1.221825	1.454845
380	0.726551	1.150775	1.575297	1.93941	2.303743
400	0.701023	0.828564	1.019924	1.658208	2.169295
410	0.68587	0.914653	1.241626	1.83059	2.033578

5. Conclusion:

When all samples are exposed to heat, they do not become liquid or evaporate, but instead ignite and burn. The elasticity of the samples increased with increasing weights of the materials added to them, but the elasticity increased more with increasing weights of sodium chloride as in sample with 3.0 g of NaCl, than with increasing weights of zinc oxide nanoparticles as in sample with 3.0 g of ZnO NPs. The decrease in the transmission spectrum of the samples with increasing weights of sodium chloride and zinc oxide nanoparticles indicates that the opacity of the samples increases with increasing weights. These results can be used in many fields, such as the oil industry, scientific research, or even various medical or industrial fields.

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Declarations:
Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: The manuscript has not been published or submitted to another journal, nor is it under review.

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تأثير تغيير أوزان جزيئات أكسيد الزنك النانوية وأوزان كلوريد الصوديوم على بعض الخواص الفيزيائية للأغشية الرقيقة من كربوكسي ميثيل السليلوز

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الخلاصة

الهدف من هذا العمل هو تحسين بعض الخواص الفيزيائية للبوليمر *Carboxymethylcellulose* (*CMCHV*) . تم تحضير العينات بإضافة جزيئات كلوريد الصوديوم وأكسيد الزنك النانوية إلى محاليل *CMCHV* بأوزان مختلفة (0.00*g* ، 0.75*g* ، 1.50*g* ، 2.25*g* ، 3.00*g*) . عندما تتعرض العينات للحرارة، فإنها تشتعل وتحترق . كما إن مرونة العينات زادت مع زيادة أوزان المواد المضافة إليها، ولكن المرونة زادت أكثر مع زيادة أوزان كلوريد الصوديوم عنها مع زيادة أوزان جزيئات أكسيد الزنك النانوية. إن الإنخفاض في نسبة نفاذ الطيف من العينات مع زيادة أوزان جزيئات كلوريد الصوديوم وأكسيد الزنك النانوية يشير إلى أن عتامة العينات تزداد مع زيادة الأوزان. ويمكن استخدام هذه النتائج في العديد من المجالات مثل الصناعات النفط أو البحث العلمي أو حتى المجالات الطبية أو الصناعية المختلفة.

الكلمات الدالة: الجسيمات النانوية؛ للأشعة المرئيه فوق البنفسجية؛ اجهادانفعال؛ درجة حرارة؛كربوكسي ميثيل السليلوز.

التمويل: لايوجد.

بيان توفر البيانات: جميع البيانات الداعمة لنتائج الدراسة المقدمة يمكن طلبها من المؤلف المسؤول.

اقرارات:

تضارب المصالح: يقر المؤلفون أنه ليس لديهم تضارب في المصالح.

الموافقة الأخلاقية: لم يتم نشر المخطوطة أو تقديمها لمجلة أخرى، كما أنها ليست قيد المراجعة.