2025,Volume 2 , Issue 6 , PSIJK (10-16)

PURE SCIENCES International Journal of Kerbala

Pure Sciences International Journal of Kerbala

A Study of The Ability to Remove Textile Dye (Eosin Y) Using a Novel Nano Co-Polymer

Dhiea M. Alnessrioy [a], Furqan Mohammed Hussein[b], Ahmed Essam Sultan[c], Ali R. Khudhair [d*]

[a,b,c,d] *Department of Chemistry, College of Education for Pure Sciences, University of Kerbala , Karbala, Iraq.*

P A P E R I N F O

Received: 10 November 2024
Accepted: 14 February 2025
Published: 30 June 2025

Keywords:
nano co-polymer, eosin yellwoish, adsorption, remove of textile dye

Abstract

In this paper, a nanoparticle co-polymer was made through condensation polymerization, which releases water as a byproduct when one mole of glycerol and one mole of phthalic anhydride react at various temperatures and periods. DSC and FT-IR were used to analyze the nano co-polymer produced. Adsorbed textile dye Eosin yellowish from aqueous solutions was disclosed in this paper, along with measurements of the nano co-polymer's particle size by AFM and XRD. The nano co-polymer had a particle size of 69.42 nm according to the results of the AFM and 69.04 nm according to the results of the XRD. Three distinct concentrations of nano co-polymer (1 ppm, 3 ppm and 5 ppm) as well as three different temperatures (298 K, 308 K and 318 K) were examined for their effects on the adsorption process. It is clear that these variables are crucial to the process. The findings of the experiment revealed that the exothermic nature of the reaction was demonstrated by the fact that the amount of eosin yellow dye that could be adsorbed on the surface of this nano co-polymer decreased as temperature increased. The obtained findings confirmed the great efficacy of nano co-polymer in the removal of yellowish eosin textile dye.

1. INTRODUCTION

An important class of materials known as polymer nanocomposites exhibits unique physicochemical features that are not possible with the individual components functioning alone. As a result of their promising potential for a wide range of applications in environmental remediation and the solution to diverse environmental challenges, these nanocomposites have lately gained intense scientific interest. [1]

The contaminants (dyes, heavy metals, phenols, medicines, etc.) are prevalent and constitute a serious hazard to humans and other living things even in low quantities. [2] Industrial colors are often used in modern technology. Paper, skin, hair, food, cosmetics, and textiles may all be colored using dyes. [3] They are water-soluble. The treatment of industrial wastewater, which present environmental dangers, is the issue that is posing the greatest challenge to the sustainable growth of human civilization. [4-5] This is due to the fact that domestic industry's toxicity has made removing color from effluent or industry very popular. Sewage reclamation and recycling are the two key goals for preserving the world ecological and improving environmental quality. Some of the often used procedures include oxidation, adsorption, membrane filtration, coagulation and focculation, chemical precipitation, ion exchange, electrochemical removal, biosorption, and reverse osmosis. [6-8].

*Corresponding Author Institutional Email: ali.razzaq@uokerbala.edu.iq (Ali R. Khudhair)

2. LITERATURE SURVEY

Previous research focused on the use of a hybrid adsorption membrane technique (HAMT) to remove dye from both synthetic and natural wastewater. Three unique configurations were used to remove the dye methyl green (MG) from synthetic wastewater. By using the best circumstances, this technology demonstrated that it is quite effective in the real treatment of wastewater. [9]

In a different study, the Adsorption Kinetic and Isotherm Study focuses on the adsorption of the organic dye (methylene blue, MB) from aqueous media using natural Iraqi bentonite clay (NIBC) and examines the characteristics and applicability of the NIBC for toxic cationic dye removal. This study shows that the NIBC may be used to effectively remove MB from aquatic environments. [10]

3. CONTENTS AND METHODS

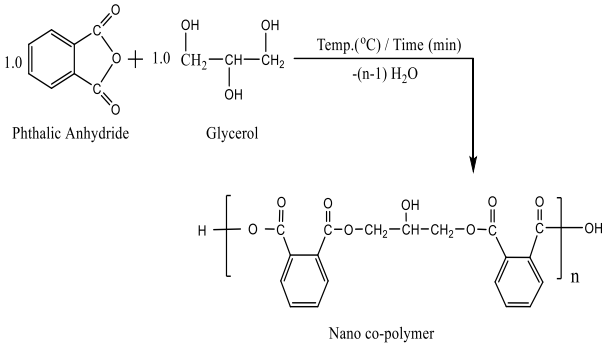
Previous research focused on the use of a hybrid adsorption membrane technique (HAMT) to remove dye from both synthetic and natural wastewater. Three unique configurations were used to remove the dye methyl green (MG) from synthetic wastewater. By using the best circumstances, this technology demonstrated that it is quite effective in the real treatment of wastewater. [9]

TABLE 1. Chemical material, purity and companies supply

Materials	Purities	Company
Glycerol	99.5%	BHD
Phthalic Anhydride	99%	ALPHA
Di methyl sulfoxide (DMSO)	99.5%	CDH
Ortho xylene	99%	MERCK
Eosin Yellowish	98%	MERCK

3.1. Preparation of Nano Co-polymer

In a 200 mL beaker, 30 mL of DMSO and (1.0 mole, 148 g) of phthalic anhydride were mixed. There was a thermometer with this beaker. Glycerol (1.0 mole, 92 g) was slowly added to the solution after it had been carefully warmed to 70 ºC and clear liquor had formed. After the mixture had been properly warmed to 100 ºC, 10 mL of o-xylene was dropped in stages of three drops into the reaction beaker to remove the water produced during esterification. The reaction beaker was then gradually heated. Heating was halted at 110 ºC after 45 minutes when the remaining water was evaporating to produce the nano co-polymer. The icy distilled water is then added, producing the suspension solution. The equation below shows how to filter the suspension solution, soak it in distilled water, and let it dry freely after allowing it to precipitate overnight.



3.2. Establishing the Calibration Curve

Various concentrations of eosin yellowish fluid (1, 3, and 5 ppm) were used to generate the titration curve, which showed the connection between absorbance and concentration. The maximum wavelength of the eosin yellowish dye (λ max = 516 nm) [11] was used to determine the absorbance of these concentrations, and the standard curve between absorption and concentration was then created, as seen in Figure 1.

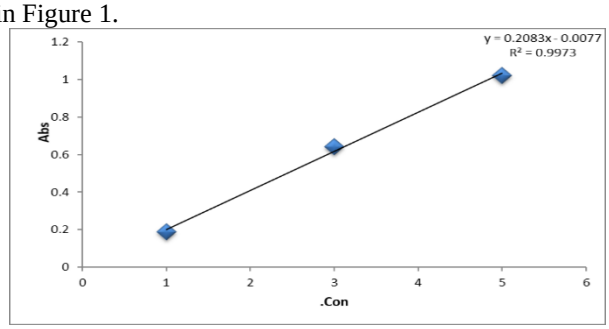


Figure 1. Standard curve between Eosin yellow dye concentration and adsorption.

3.3. Nano Co-polymer Adsorption Measurement

Eosin Y stock remedy By initially combining 0.5 g of the dye with a certain amount of distilled water, then adding another 1000 mL, you may create a concentration of 500 ppm. In volumetric flasks, 30 ml of each concentration of the dye (eosin Y) was placed in contact with the predetermined weight (0.2 g) of the adsorbent outer layer (nano co-polymer) after being appropriately diluted with 100 mL of distilled water. To create the diluted solutions with concentrations of (1, 3, and 5 ppm), this concentrated solution was employed. After the predetermined equilibrium time of 20 minutes, these flasks were placed in a shaking device with a temperature of 298 K. The amount of each solution at equilibrium Ce (mg/L) and the quantities of the adsorbate material Qe (mg/g) of the calibration curves were calculated using UV-Vis spectroscopy after the solutions had been filtered: [12]

$$Qe = (Co-Ce) .V_{sol} / Wt \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

4. DESCRIPTION AND RESULTS

4.1. Assessment of Nano Co-Polymer

Utilizing FT-IR, DSC, AFM and XRD techniques, the nano co-polymer was investigated. Figure 2. displays extending band at (1668 cm^{-1}) assigned to the bond (C=O) ester, and a prominent sharp peak at (1069 cm^{-1}) of the ester bond (C-O). The FT-IR spectrum has a fragile broad band at (2500-3300 cm^{-1}) assigned to the bond (O-H) alcoholic, as well as an extended band at (3001 cm^{-1}) attributed to the bond (C-H) aromatic.

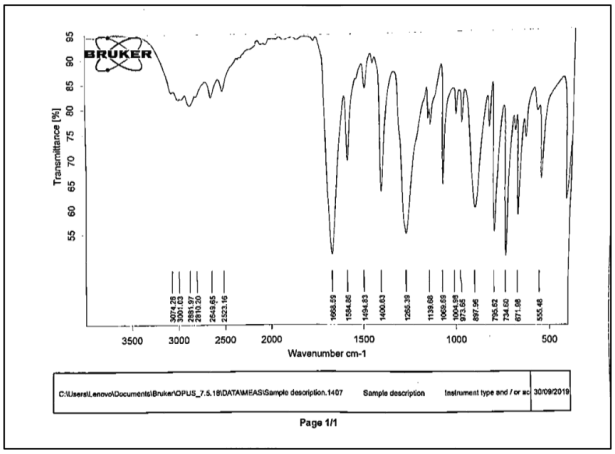
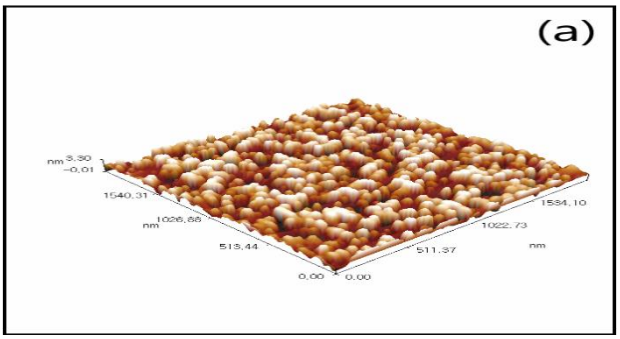


Figure 2. FT-IR of nano co-polymer

After esterification, the dimensions of the nano co-polymer's particles were measured using an atomic force microscope (AFM). The surface of the nano co-polymer had a roughness coefficient of 0.827 nm, and its square root was 0.955 nm. Additionally, 3.30 nm was the average particle height. The findings show that, as illustrated in Figure 3. the co-polymer nanoparticle's particle size was 69.42 nm.



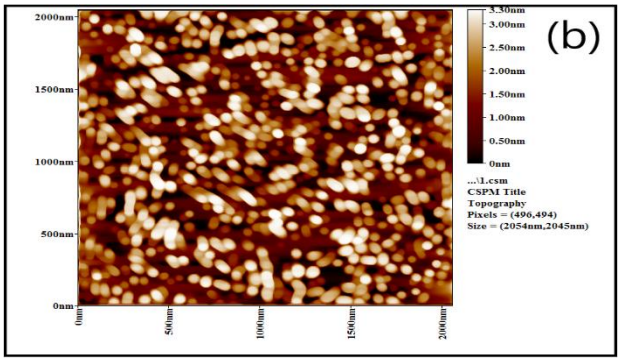


Figure 3. a) AFM image in 3D for nano co-polymer, b) AFM image in 2D of a nano co-polymer.

In Figure 4. the nanoparticle co-polymer exhibits peaks at 2θ values of 15.4°, 18.6°, 22.3°, 27.0°, 30.5°, and 37.0° in the x-ray diffraction (XRD) analysis. The creation of the novel co-polymer as a crystalline material with decreased amorphous carbon atoms was shown by these peaks. According to Bragg's Law [13], the average interplaner distance (d hkl) between atoms was 0.385 nm using Origin software:

$$n\lambda = 2d\sin\theta \ldots\ldots\ldots\ldots..(2)$$

The total average crystallite size was 69.04 nm relative to Scherrer's equation:

$$D = k\lambda / \beta\cos\theta \ldots\ldots\ldots.. (3)$$

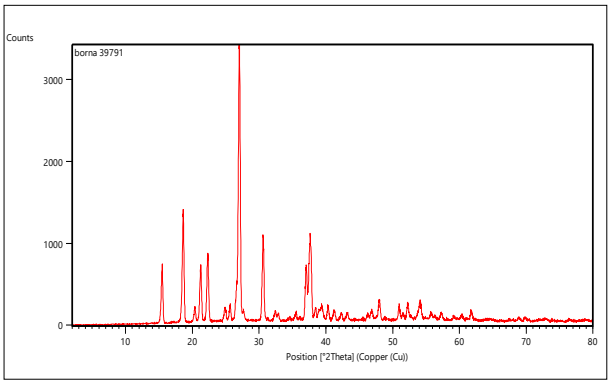


Figure 4. The nanoparticles co-polymer's x-ray diffraction.

Figure 5. displays the DSC thermal imagery for the nano co-polymer. The glass transition temperature (T_g) is represented by the first thermal transition at the peak (71.77 ^oC), the crystallization temperature (T_c) is denoted by the second transition at the peak (230.13 ^oC), and the melting temperature (T_{m1} and T_{m2}, respectively) is characterized by the third and fourth thermal transitions at the peaks (279.37 and 296.27 ^oC). [14]

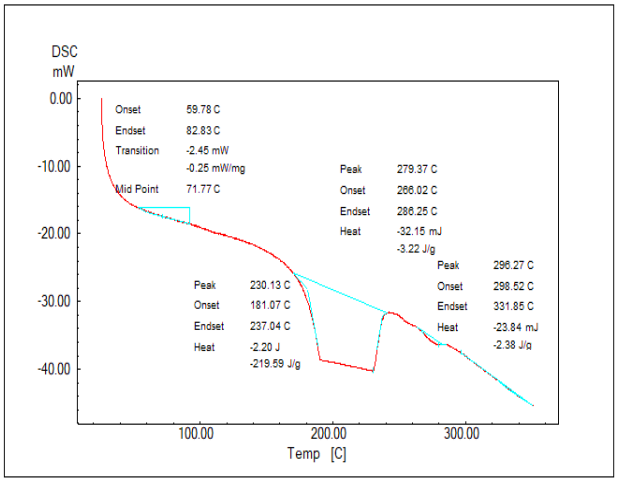


Figure 5. Nano co-polymer DSC thermo grams.

4.2. Eosin Y Dye Removal via Adsorption

As Table 2 reveals, it has been investigated how temperature within the thermal limits (298, 308, and 318 K) impacts the adsorption of eosin Y dye on the outer layer of nano co-polymer. According to the experimental findings, the reaction's exothermic character is demonstrated by the fact that the amount of eosin yellow adsorption on these nano co-polymers' outer layer decreased as the temperature increased. This might be an indication of a desorption process, which is described as the dissociation of the adsorbate granules on the outermost layer of the adsorbent and their return to the solution, lowering the speed of the diffusion process with raising the temperature. [15] as in Figure 6. a, b, and c.

TABLE 2. Effect of temperature on eosin yellow dye adsorption

Conc. (ppm)	Temp.	Nano Co-Polymer	
		Ce	*Qe*
1 ppm	298K	0.045	477.52
	308K	0.047	476.52
	318K	0.057	471.52
3 ppm	298K	0.057	1471.5
	308K	0.062	1469
	318K	0.068	1466
5 ppm	298K	0.066	2467
	308K	0.068	2466
	318K	0.071	2464.5

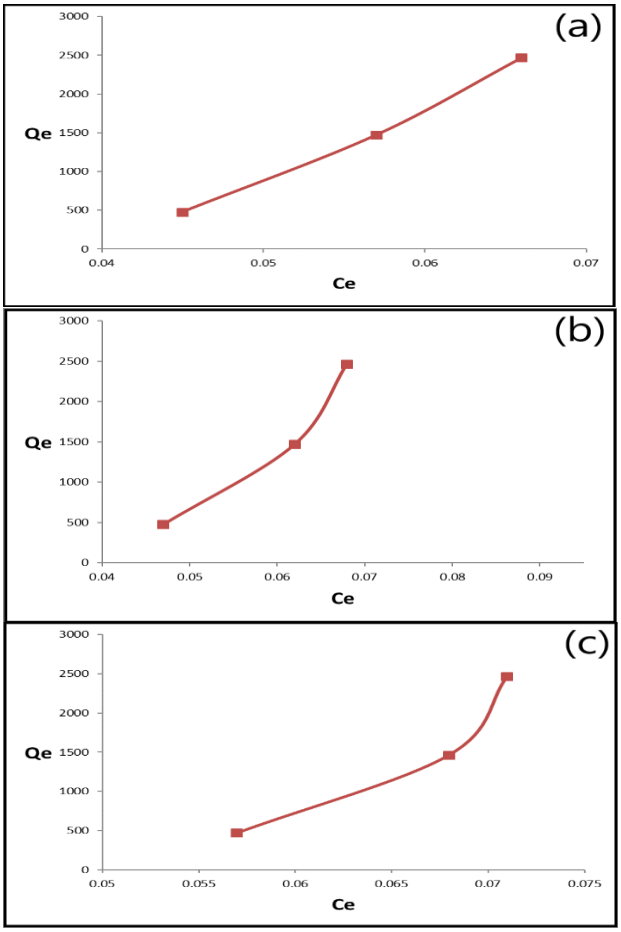


Figure 6. Impact of temperature on the adsorption of a nano co-polymer with (1, 3, and 5 ppm) of the eosin Y dye at: a) 298K, b) 308K, c) 318K

4.3. Isotherms of Adsorption

Adsorption isotherms were discovered when analyzing the eosin Y dye's adsorption on the outer layer of the nano co-polymer at 298 K and pH = 6.6. Given that the adsorbate particles can be positioned either vertically or obliquely on a surface, Figure 7. The demonstration of the nano co-polymer adsorption isotherms being of type (S1) which results from Freundlich's principles, shows that the material has a heterogeneous surface. [16]

TABLE 3. Eosin Y dye adsorpiton on nano co-polymer surface at 298 k

Conc. (ppm)	Temp.	Nano Co-Polymer	
		Ce	*Qe*
1 ppm	298K	0.045	477.52
3 ppm	298K	0.057	1471.5
5 ppm	298K	0.066	2467

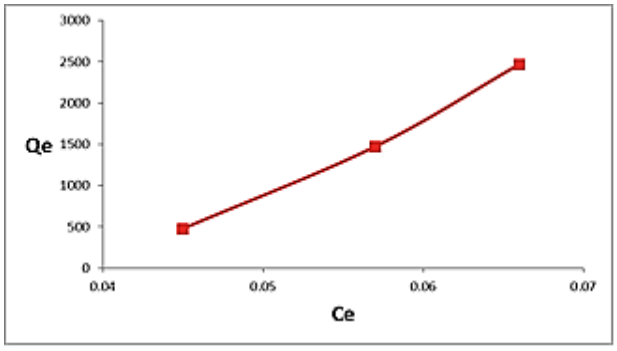


Figure 7. Eosin yellowish dye adsorption Freundlich isotherm on nano co-polymer surface

4.4. Freundlich equation for adsorption

The Freundlich equation is among the most significant isothermal equations for the explanation of the adsorption of solutions on substance surfaces[17] :

$$Qe = K_f \cdot Ce^{1/n} \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

where Ce is the equilibrium adsorbate substance concentration in the fluid (in mg/L). Qe stands for the equilibrium adsorbate concentration (mg/g). Kf, n: The adsorption amplitude and intensity are each represented by a Freundlich constant. The following results from calculating the logarithmic formula of equation:(4)

$$\text{Log } Qe = \text{Log } K_f + (1/n) \text{ Log } Ce \ldots\ldots.(5)$$

When we plot the connection throughout Log Qe and Log Ce, as seen in Figure 8. we get a straight line. The findings of the Freundlich test for the eosin yellowish adsorption on nano co-polymer at 298 k are shown in Tables 3 and 4. The values of Freundlich constants :

$K_f = 8.523$, $n = 4.329$, $R^2 = 0.994$.

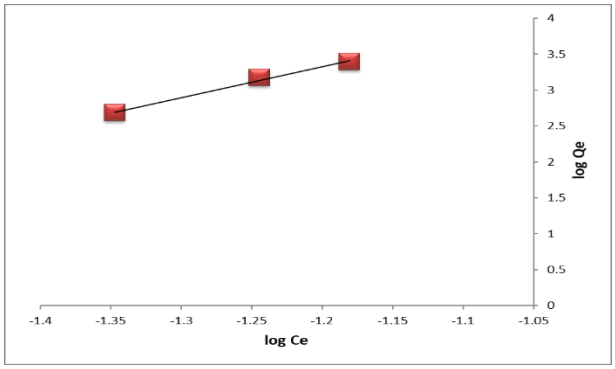


Figure 8. Eosin yellowish dye adsorption Freundlich isotherm on nano co-polymer surface at 298K

TABLE 4. Friendlich isotherm results

Conc. (ppm)	Temp.	Nano Co-polymer	
		log Ce	***log Qe***
1 ppm	298K	-1.347	2.679
3 ppm	298K	-1.244	3.1678
5 ppm	298K	-1.181	3.3922

5. CONCLUSION AND FUTURE

5.1. Conclusion

Under conditions with temperatures below 250 °C, the nano copolymer was created by phthalic anhydride and glycerol. AFM photos validated the polymer's nano structure, while FT-IR revealed the functional groups of the ester co-polymer, and XRD data suggested a crystalline structure. In batch mode, the nano co-polymer's adsorption of the yellowish eosin dye was investigated for the constant solution pH at room temperature and the starting dye concentration. The outcomes demonstrated that the ability of the novel nano co-polymer to remove eosin yellowish dye by adsorption increased with initial concentration and temperature.

5.2. Future

Apply different polymers and techniques. Figure out how many pigments will be absorbed to clean up the land, water, and air. Apply more hydroxyl compound removal techniques to provide the carboxylic compounds with more connections to other hydroxyl compounds

6. REFERENCES

1. Khudhair, A.R., Al-Baiati, M.N., Sherazi, S.T.H.; (2023); Eosin Yellowish Dye Removal By Using Novel Nano Polymer As Adsorbents Surface From West Water; AIP Conference Proceedings, 2414; https://doi.org/10.1063/5.0114722
2. Khudhair, A.R., Al-Baiati, M.N., Sherazi, S.T.H.; (2020); Adsorption of methylene blue from aqueous solutions by using a novel nano co-polymer; AIP Conference Proceedings, 2290, https:// doi.org/10.1063/5.0027741
3. Ali Mohammed, B. ., Alattar, R. ., M Al – Alnessrioy, D. ., & R. Khudhair, A. . (2024). Separation Heavy Metals from Waste Water. *Pure Sciences International Journal of Kerbala*, *1*(2). Retrieved from https://journals.uokerbala.edu.iq/index.php/psijk/article/view/1782
4. Al–alnessrioy, D. M., Al–Da'amy, M. A.; (2020); FI-Spectrophotometric determination of Cu (II) ions in analytical sample Via reaction with a new reagent HPEDN; IOP Conference Series: Materials Science and Engineering, 928, doi:10.1088/1757-899X/928/5/052013
5. Hussein, F. M., Salman, H. I., Balakit, A. A.; (2023); Adsorption isotherms studies of methyl orange on cross-linked chitosan Schiff base/TiO2 nano composite; AIP Conference Proceedings, 2414; https://doi.org/10.1063/5.0114891
6. Husseina, F. M., Salmana, H. E., Balakitb, A. A. (2021). A cross-linked chitosan-Schiff base: new material for the removal of methyl orange from aqueous solution. DESALINATION AND WATER TREATMENT, 234, 288-298.
7. AL-Baiati, M.N., Shaker, Z.M., Salman, H.I.; (2023); Removal of Pollutants from Wastewater Using a Nano Co-Polymer Surface; AIP Conference Proceedings, 2414; https://doi.org/10.1063/5.0114706
8. Al-Baiati, M.N., Guzar, S.H., Al-Mayali, A.S.; (2023); Removal of Pollution with Dye Malachite Green from

Waste Water by Using Novel Nano Co- Polymer; AIP Conference Proceedings, 2414; https://doi.org/10.1063/5.0114728
9. Al-Baiati, M.N., Obaid, M.M.; (2023); Studying the Effectiveness of Using a Novel Nano Polymer as a Protein Delivery System; AIP Conference Proceedings, 2414; https://doi.org/10.1063/5.0114723
10. AL-Baiati, M.N., Jawad, S.F., Maged, M.N.A., ...Abd Al-Aama, Z.M., Abd Nusaif, K.I.; (2023); Synthesis of a New Nano Covalent Polymer and Test its Capacity on Drug Delivery; AIP Conference Proceedings, 2414; https://doi.org/10.1063/5.0114717
11. Al-Baiati, M.N., Al-Mayali, A.S., Guzar, S.H.; (2023); Remove Pollutants from Wastewater Using Novel Nano Material; AIP Conference Proceedings, 2414; https://doi.org/10.1063/5.0114716
12. Al-Baiati, M.N., Shakir, Z.M., Kareem, M.M.; (2023); Inhibition of Spread of the Breast Cancer by using of Some Nano Co-Polymer-Drugs; AIP Conference Proceedings, 2414; https:// doi.org/10.1063/5.0114719
13. Al-Baiati, M.N., Obaid, M.M.; (2023); Study the Possibility of Using a Novel Nano Co-Polymer as Drug Delivery System; AIP Conference Proceedings, 2414; https://doi.org/10.1063/5.0114731
14. AL-Baiati, M.N., Abd Al-Aama, Z.M., AL-Masoudi, H.Q., ...Abdulridha, A.A., Abd Nusaif, K.I.; (2023); Synthesis of a Smart Nano Graft Co-Polymer as a Drug Delivery; AIP Conference Proceedings, 2414; https://doi.org/10.1063/5.0114726
15. Al-Baiati, M.N., Abbas, A.H.; (2023); Using of Nano-poly Chitosan Cephalexin Drug to Inhibit Spread Cancer Cells; International Journal of Drug Delivery Technology, 13(1), pp. 29-32
16. Al-Baiati, M.N., Abd Nusaif, K. I.. Abbas, A.H., ...Abed, A.S., Abood, E.S.; (2022); Nano-Poly Chitosan-Ampicillin Drug: Synthesis, Characterization and Cytotoxicity; Egyptian Journal of Chemistry, 65(131), pp. 1313-1318
17. Al-Baiati, M.N., Shakir, Z.M., Kareem, M.M.; (2023); Study the Effects of Some Nano Graft Co-Polymer-Drugs on the Spread of Breast Cancer; AIP Conference Proceedings, 2414; https:// doi.org/10.1063/5.0114710

Arabic Abstract

في هذا البحث، تم تصنيع مركب نانوي متعدد البلمرة عن طريق البلمرة التكثيفية، والتي تحرر الماء كناتج ثانوي عند تفاعل مول واحد من الجلسرين مع مول واحد من أنهيدريد الفثاليك عند درجات حرارة وأزمنة مختلفة. تم استخدام تقنيتي المسح الحراري التفاضلي (DSC) ومطيافية الأشعة تحت الحمراء لتحليل المركب النانوي المتعدد البلمرة الناتج. وتم الكشف عن امتزاز صبغة الأيوسين الصفراء من المحاليل المائية على هذا المركب النانوي، بالإضافة إلى قياس حجم جسيمات المركب النانوي باستخدام مجهر القوة الذرية(AFM) وحيود الأشعة السينية (XRD). وقد أظهرت نتائج كل من AFM و XRD أن حجم جسيمات المركب النانوي هو 69.42 نانومتر و 69.04 نانومتر على التوالي. تم دراسة تأثير ثلاثة تركيزات مختلفة للمركب النانوي (1 جزء في المليون، 3 جزء في المليون، و 5 جزء في المليون) وثلاثة درجات حرارة مختلفة (298 كلفن، 308 كلفن، و 318 كلفن) على عملية الامتزاز. ومن الواضح أن هذه المتغيرات ذات أهمية حاسمة في هذه العملية. وأظهرت نتائج التجربة أن الطابع الباعث للحرارة للتفاعل يتضح من انخفاض كمية صبغة الأيوسين الصفراء التي يمكن امتزازها على سطح هذا المركب النانوي مع زيادة درجة الحرارة. وأظهرت النتائج التي تم الحصول عليها كفاءة عالية للمركب النانوي على امتزاز وإزالة صبغة الأيوسين الصفراء.