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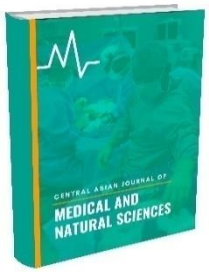

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SYNTHESIS, CHARACTERIZATION, AND STUDY OF BIOLOGICAL ACTIVITY OF OXAZEPINE COMPOUNDS DERIVED FROM 1,3,4-OXADIAZOLE

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Abstract: This study involves the synthesis of pentagonal rings of oxazepine derivatives through the reaction of one mole of hydrazide base derivatives with two moles of malic anhydride. The validity of the compound structures was confirmed using physical and spectroscopic methods such as UV-Vis. spectroscopy, infrared spectroscopy, proton nuclear magnetic resonance spectroscopy. Additionally, melting points and purity were determined, and reaction progress was monitored by Thin-Layer Chromatography (TLC). The impact of some prepared compounds on the growth of two bacterial isolates, one Gram-negative (Escherichia coli) and the other Gram-positive (Staphylococcus aureus), was studied. Antibiotics amoxicillin, ampicillin, and ciprofloxacin were used as controls, and some of the prepared compounds showed good inhibitory effectiveness against the tested bacteria.

Key words: Oxazepine, Schiff base, Hydrazide, Biological activity, Escherichia coli, Staphylococcus aureus.

1. Introduction

Oxazepine compounds have been captivating the attention of researchers and chemists alike, as these chemical entities bring a unique blend of structure and functionality to the realm of organic chemistry [1]. This topic delves into the fascinating world of oxazepine compounds, shedding light on their intricate molecular structure, synthesis methods, and the diverse range of applications that make them stand out in the scientific landscape [2]. At the heart of the discussion lies the distinctive molecular structure of oxazepine compounds, characterized by a seven-membered ring containing one oxygen and two nitrogen atoms [3]. This unique arrangement sets them apart from other heterocyclic compounds, paving the way for an exploration of their electronic and steric properties [4]. Understanding the methods of synthesizing oxazepine compounds is crucial to unveiling their potential applications [5]. Researchers have developed diverse synthetic routes, ranging from traditional methods to cutting-edge techniques, each presenting its own set of advantages and challenges [6]. Exploring these synthesis pathways provides valuable insights into the feasibility and efficiency of producing oxazepine compounds on a laboratory scale [7]. The functional diversity of oxazepine

compounds is a key aspect of their allure. These compounds exhibit a wide range of biological activities, making them of interest in medicinal chemistry [8, 9]. From potential pharmaceutical agents to innovative materials, oxazepine compounds offer a versatile palette for researchers to explore and exploit [10]. This topic explores the biological and medicinal significance of oxazepine compounds, highlighting their interactions with biological systems and potential therapeutic applications [11, 12]. From anticonvulsant properties to anti-inflammatory effects, the pharmacological potential of oxazepine compounds is a promising avenue for further research and development in the field of medicine [13, 14]. In conclusion, oxazepine compounds stand as a captivating subject within the realm of organic chemistry, with their unique molecular structure, diverse synthesis methods, and potential applications across various domains [15, 16]. As researchers continue to unravel the mysteries surrounding these compounds, the possibilities for advancements in medicine, materials science, and beyond appear boundless, making oxazepines a topic ripe for exploration and discovery [17].

2. Experimental:

2.1. Material: All chemicals used in this work were purchased from Fluka, Aldrich, and BDH and used without further purification.

2.2. Devices used: The melting points were measured using Electrothermal Melting Apparatus 9300. Shimadzu FT-IR 8400S spectrophotometer with a scale of (400-4000) cm^{-1} by KBr disc. ^{1}H-NMR and ^{13}C-NMR spectra on Bruker instruments running at 400 MHz. Shimadzu UV-1800 spectrophotometer with quartz cells and in the range of 200-800 nanometers, Tikrit University. Thin Layer Chromatography (TLC) was performed using Fluka silica gel plates with 0.2 mm thickness, activated with fluorescent silica gel G, and visualization was achieved using UV light.

2.3. Preparation of oxazepine derivatives (M32-M37) [18, 19]

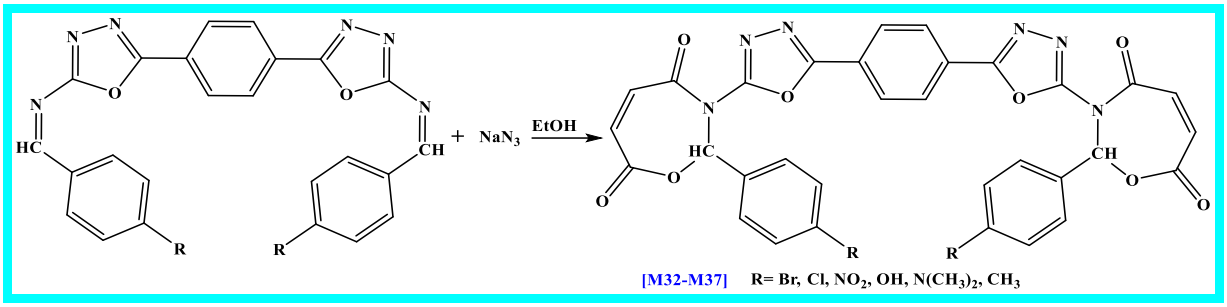
A mixture of 0.2 grams (0.0005 moles) of pre-dissolved hydrazide bases in 25 mL of dry benzene was combined with (0.098 grams, 0.001 moles) of malic anhydride dissolved in 15 mL of the same solvent. The mixture was refluxed for a period of (6-10) hours, and the completion of the reaction was verified using Thin-Layer Chromatography (TLC) technique. After cooling, the mixture was filtered, washed with cold water, and the resulting crystals were recrystallized using methanol [30, 31]. Table (1) illustrates the physical properties of the oxazepine derivatives.

2.4. Biological activity study [20, 21]

Two types of pathogenic bacteria were used in this study, one of which is Gram-positive, which is Staphylococcus aureus, and one of which is Gram-negative, which is Escherichia coli. These bacteria were taken from the laboratories of the College of Education for Pure Sciences, Department of Life Sciences, and the culture medium was used, a type of Multer Hinton Agar [39]. It is used to measure and determine the minimum inhibitory concentration (MIC), and chemical solutions of (M32, M34, M37) were prepared in concentrations (25, 50, 75) mg/ml and using a solvent Dimethyl sulfoxide (DMSO). The sensitivity test for the bacteria isolates used in the study was carried out by diffusion method in the nutrient medium Mueller-Hinton agar. The medium was prepared and sterilized by autoclave, then distributed in dishes and left to harden, then small pits were made at a rate of four holes in each plate. Then it was incubated at (37 ^{0}C) for a period of (24 hours). The results were read on the next day to show the derivatives sensitivity derivatives used, which depends on the diameter of the inhibition evident in the dishes around the holes used, as the increase in diameter Inhibition means the increase in the biological activity of the prepared compounds and compare that with the diameter of inhibition for antibiotics [22, 23].

3. Results and discussion

In this study, pentagonal rings of oxazepine derivatives were synthesized by reacting one mole of Schiff bases derivatives with two moles of malic anhydride, as depicted in Scheme 1.



Scheme (1): Route of prepared compounds (M32-M37)

3.1. Characterization of oxazepine derivatives (M32-M37)

In this study, the Ultraviolet-Visible (UV-Vis) spectra of tetrazole derivative compounds were examined using ethanol (95%) as a solvent, with concentrations ranging from (10^{-4}-10^{-5}) molar for the prepared compounds. Short wavelength absorptions (λ_{1max}) were observed at (210-257) nanometers, attributed to ($\pi\rightarrow\pi^*$) transitions. Additionally, long wavelength absorptions (λ_{2max}) in the range of (299-386) nanometers were noted, associated with ($\pi\rightarrow n^*$) electronic transitions. The absorption bands closely matched literature values [24, 25], as shown in Table (2), which provides absorption values for the prepared tetrazole derivatives.

When studying the infrared spectrum of 1,3-oxazpine 7,4-dione derivatives, it was noted that the azomethine band disappeared and an absorption band appeared in the range (3054-3092) cm-1, which belongs to the stretching of the aromatic (CH) bond. Also, an absorption band appeared in the range (2911-2991) cm-1 is due to the stretching of the aliphatic (CH) bond, and an absorption band appeared in the range (1718-1727) cm-1 is due to the stretching of the carbonyl (C=O) lactone bond, and an absorption band appeared in the range (1658-1674) cm- 1 It is due to the stretching of the carbonyl chain (C=O) of the lactam, and an absorption band appeared in the range (1622-1635) cm-1 It is due to the stretching of the carbonyl chain (C=N) in the oxadiazole ring. It was also observed that two absorption bands appeared in the range (1575-1599 & 1475-1497) cm-1 is due to the stretching of the aromatic (C=C) axis, and the appearance of an absorption band in the range (1308-1380) cm-1 is due to the stretching of the (C-O) axis, and the appearance of an absorption band in the range (1245-1284) cm-1 is due to Stretching the joint (C-N) [26, 27], as shown in Table (2) and Figures (1, 2).

When studying the 1H-NMR spectrum of the compound [M33] using a solvent (DMSO-d6), it was observed that a single signal appeared at the chemical shift (8.85) ppm attributed to the protonation of the two groups (CH) in the oxazan ring (c). A multiple signal in the range (7.99-8.62) ppm is attributed to the protons of the aromatic rings (a, b, f), and a double signal appears at the chemical shift (7.67 and 7.64) ppm due to the proton of two groups (=CH) in the ring. The oxazan adjacent to the lactam group (e), and the appearance of a double signal upon chemical displacement (7.09 and 7.08) ppm due to the protonation of two groups (=CH) in the oxazan ring adjacent to the lactam group (d), and the appearance of a single signal upon chemical displacement (3.33) Parts per million is attributed to the protons of water (HDO), and a signal appears at the chemical shift (2.48). Parts per million is attributed to the protons of the solvent (DMSO-d^6) [28, 29], and as in Figure (3).

3.2. Evaluation of the Biological Activity of Prepared Compounds

Compounds with non-homogeneous rings exhibit varied biological activities against Gram-positive and Gram-negative bacteria. In this dissertation, the biological activity of the prepared compounds was

evaluated against two types of bacteria[30].: Escherichia coli and Staphylococcus aureus, selected due to their medical significance as they cause various diseases. Additionally, these bacteria differ in their antibiotic resistance profiles [31, 32]. The biological activity of prepared compounds was assessed using the agar well diffusion method, measuring the inhibition zone diameter [33, 34]. The results indicate that the prepared compounds possess the ability to inhibit the growth of both Gram-positive and Gram-negative bacteria to varying degrees. The compounds exhibited significant inhibitory activity against Escherichia coli and showed excellent inhibitory effects against Staphylococcus aureus [35,36]. The relationship between concentration and inhibition was dose-dependent, with higher inhibition percentages observed at a concentration of 75 milligrams per milliliter, as presented in Table (3)

Table (1): Some physical properties of tetrazole derivatives.

Comp.	R	Molecular Formula/ M.Wt g/mol	Color	Time (h)	M.P (^{0}C)	Rf	Y. %
M32	Br	$C_{32}H_{18}N_6O_8Br_2$ / 774.34	Light brown	6	151-153	0.92	81
M33	Cl	$C_{32}H_{18}N_6O_8Cl_2$ / 685.43	Yellow	8	307-309	0.25	84
M34	NO_2	$C_{32}H_{18}N_8O_{12}$ / 706.54	Yellow	10	288-289	0.48	76
M35	OH	$C_{32}H_{20}N_6O_{10}$ / 648.54	Dark brown	7	239-240	0.38	62
M36	$N(CH_3)_2$	$C_{36}H_{30}N_8O_8$ / 702.68	Dark yellow	9	216-218	0.81	80
M37	CH_3	$C_{34}H_{24}N_6O_8$ / 644.60	Orange	9	202-203	0.86	77

Table (2): Uv-Viv and FT-IR absorption results for oxazepine derivatives (M32-M37)

Comp. No.	R	λ_1,λ_2 max (nm)	IR (KBr) cm^{-1}					
			νC-H	νC=O Lactone, Lactam	νC=N	νC=C	νC-O, νC-N	Others
M8	Br	235, 370	3054, 2913	1718, 1670	1631	1599, 1475	1308, 1246	ν (C-Br) 592
M9	Cl	210, 386	3091, 2943	1724, 1664	1622	1575, 1479	1371, 1284	ν (C-Cl) 729
M10	NO_2	228, 302	3092, 2911	1727, 1671	1624	1599, 1496	1376, 1280	ν(NO_2) 1536, 1321
M11	OH	256, 337	3087, 2965	1719, 1658	1626	1598, 1477	1345, 1243	ν (OH) 3400
M12	$N(CH_3)_2$	257, 299	3068, 2948	1724, 1674	1635	1593, 1492	1344, 1282	ν(CH_3) 2948, 2844
M13	CH_3	233, 321	3066, 2991	1725, 1666	1630	1589, 1497	1380, 1249	ν(CH_3) 2991, 2875

Table (7): Biological effectiveness of prepared compounds and control treatments (inhibition in mm).

Comp. No.	Escherichia coil			Staphylococcus aureus		
Conc. mg/ml	**25**	**50**	**75**	**25**	**50**	**75**
M32	16	19	20	14	17	19
M34	15	16	21	15	19	22
M37	14	17	22	18	19	20
Amoxicillin	14	17	24	10	14	22
Ampicillin	10	16	22	14	20	24
Ciprofloxacin	12	17	21	15	18	21
Blank disk	0	0	0	0	0	0

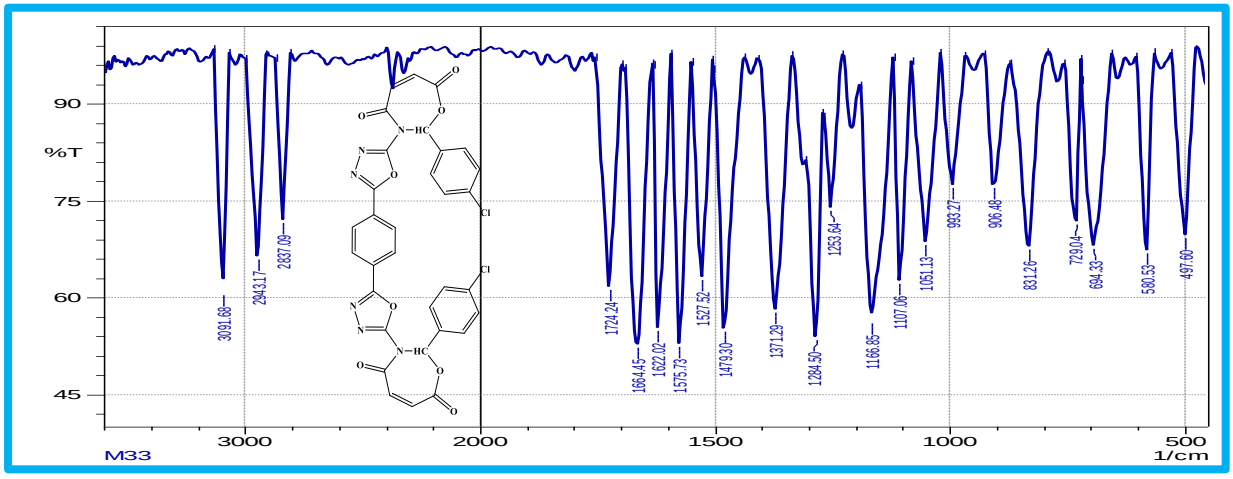


Figure (1): FT-IR spectrum of the compound (M33).

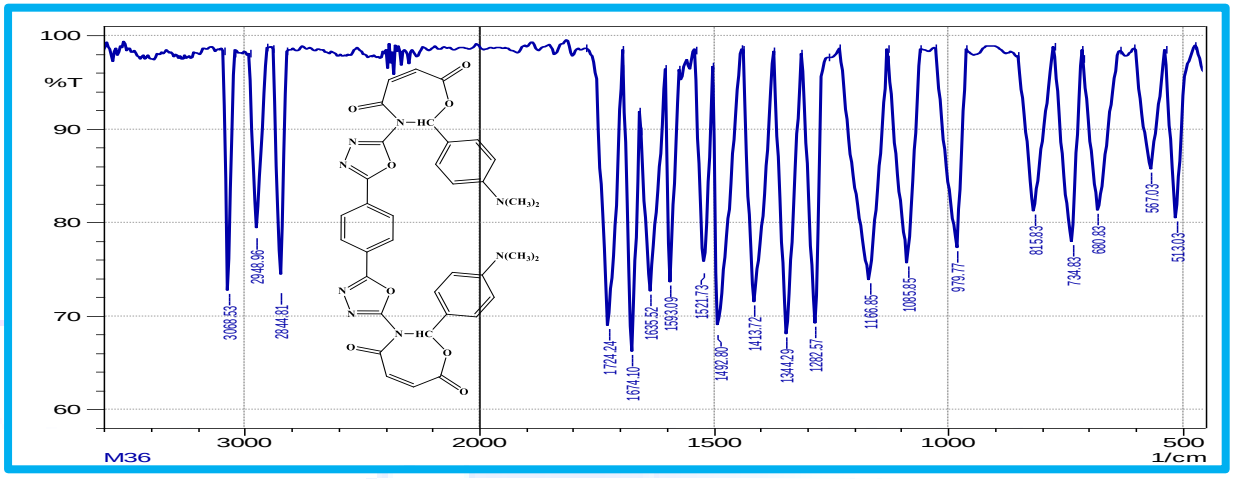


Figure (2): FT-IR spectrum of the compound (M36).

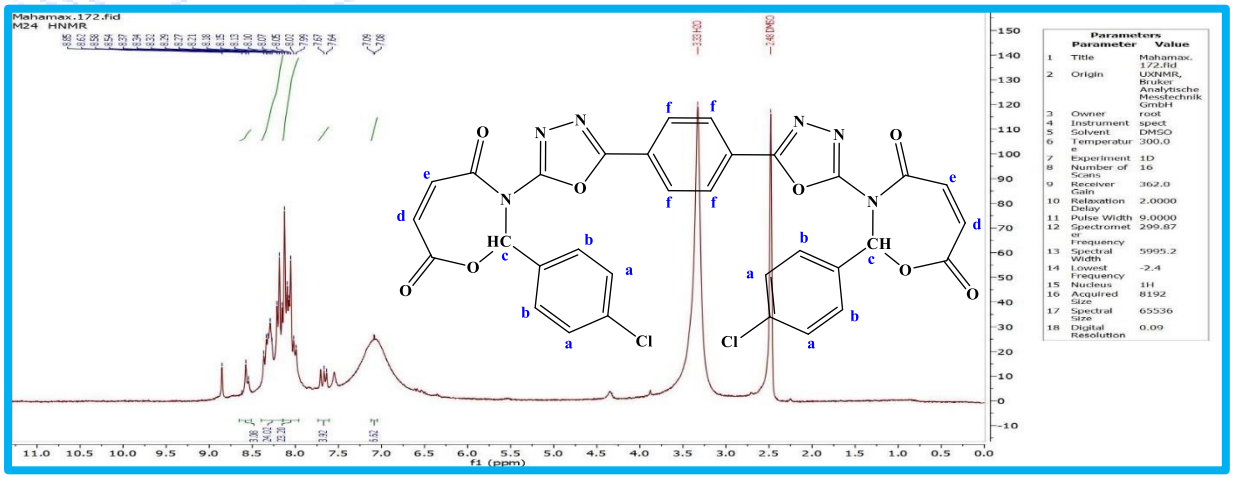


Figure (3): ^{1}H-NMR spectrum of the compound (M33).

4. Conclusions

The reaction of hydrazide derivatives with compounds containing appropriate functional groups often yields heterogeneous Heptagonal rings. Bioassay results indicate that most of the prepared compounds exhibit antibacterial activity and have the ability to inhibit bacterial growth. Some of these compounds even displayed higher biological efficacy than the antibiotics used as control samples. Physical

and spectroscopic measurements validated the accuracy of the prepared nano compound structures.

5. Recommendations

Explore alternative synthesis methods such as fusion, microwave, and ultrasound techniques, and compare them with the traditional method. Investigate the synthesis of non-homogeneous ring compounds derived from a single nucleus, expecting potential pharmacological activity. Study the liquid crystalline properties of the prepared compounds. Examine the effects of the prepared compounds on different types of fungi, parasites, and human-associated pathogenic bacteria, such as tuberculosis bacteria that require specific environments for cultivation. Investigate the impact of the prepared compounds on other cancer types and compare the results with breast cancer studies. Prepare new complexes with elements like Pd, Pt, Al, Zn, Ni, and Hg, particularly platinum complexes, to study their effectiveness as anticancer agents against tumors (Anticancer). Study the possibility of attaching these chains to natural polymers and using them as heavy ion removers in industrial wastewater. Utilize the prepared compounds to develop new pesticides for controlling various harmful organisms. Conduct kinetic studies and calculate thermodynamic functions for the prepared derivatives. Explore the relationship between the structure and biological activity by calculating thermodynamic data and the molecular shape, leveraging them in modern software programs.

References

1. Sallal, Z. A., & Ghanem, H. T. (2018). Synthesis and Identification of New Oxazepine Derivatives bearing Azo group in their structures. Iraqi Journal of Science, 1-8.
2. Serrano-Wu, M. H., Laurent, D. R. S., Chen, Y., Huang, S., Lam, K. R., Matson, J. A., ... & Balasubramanian, B. N. (2002). Sordarin oxazepine derivatives as potent antifungal agents. Bioorganic & medicinal chemistry letters, 12(19), 2757-2760.
3. Sunil, D., Ranjitha, C., Rama, M., & KSR, P. (2014). Oxazepine derivative as an antitumor agent and snail1 inhibitor against human colorectal adenocarcinoma. International Journal of Innovative Research in Science, Engineering and Technology, 3(8), 15357-15363.
4. Mohammad, A. T., Yeap, G. Y., & Osman, H. (2015). Synthesis, characterization and theoretical study of a new liquid crystal compound with an oxazepine core. Journal of Molecular Structure, 1087, 88-96.
5. Yang, X., Wei, L., Wu, Y., Zhou, L., Zhang, X., & Chi, Y. R. (2023). Atroposelective Access to 1, 3-Oxazepine-Containing Bridged Biaryls via Carbene-Catalyzed Desymmetrization of Imines. Angewandte Chemie International Edition, 62(1), e202211977.
6. Hamak, K. F., & Eissa, H. H. (2013). Synthesis, characterization, biological evaluation and anti corrosion activity of some heterocyclic compounds oxazepine derivatives from Schiff bases. Organic Chemistry: Current Research, 2(3), 1.
7. Matsuzaki, H., Takeuchi, I., Hamada, Y., & Hatano, K. (2000). Studies on the 1, 4-oxazepine ring formation reaction using the molecular orbital method. CHEMICAL AND PHARMACEUTICAL BULLETIN-TOKYO-, 48(5), 755-756.
8. Al-Juburi, R. M. (2012). Synthesis and characterization of some heterocyclic compounds (oxazepine, tetrazole) derived from Schiff bases. Al-Nahrain Journal of Science, 15(4), 60-67.
9. Zaware, N., & Ohlmeyer, M. (2014). Recent advances in dibenzo [b, f][1, 4] oxazepine synthesis. Heterocyclic Communications, 20(5), 251-256.
10. Nagarajan, K., David, J., & Bhat, G. A. (1985). Synthesis of 10, 11-dihydrodibenz [b, f][l, 4] oxazepine derivatives as potential anticonvulsant & psychotropic agents. Indian Journal of Chemistry-

Section B: Organic and Medicinal Chemistry, 24, 840-844.

11. Dalaf, A. H. (2018). Synthesis and Characterization of Some Quartet and Quinary Hetero cyclic Rings Compounds by Traditional Method and Microwave Routes Method and Evaluation of Their Biological Activity. M.Sc. Thesis, Tikrit University, Tikrit, Iraq: 1-94 pp.
12. Dalaf, A. H., & Jumaa, F. H. (2018). Synthesis, Characterization of some 1,3-Oxazepane -4,7-Dione by Traditional and Microwave routes method and evaluation of their biological activity. Al-utroha for Pure Science. **(8)**: 93-108.
13. Dalaf, A. H., Jumaa, F. H., & Jabbar, S. A. S. (2018). Synthesis and Characterization of some 2, 3-dihydroquinozoline and evaluation of their biological activity. Tikrit Journal of Pure Science, **23(8)**: 66-67. http://dx.doi.org/10.25130/tjps.23.2018.131.
14. Salwa, A. J., Ali, L. H., Adil, H. D., Hossam, S. A. (2020). Synthesis and Characterization of Azetidine and Oxazepine Compounds Using Ethyl-4-((4-Bromo Benzylidene) Amino) Benzoate as Precursor and Evalution of Their Biological Activity. Journal of Education and Scientific Studies, **ISSN**: 24134732. **16(5)**: 39-52.
15. Abd, I. Q., Ibrahim, H. I., Jirjes, H. M., & Dalaf, A. H. (2020). Synthesis and Identification of new compounds have Antioxidant activity Beta-carotene, from Natural Auxin Phenyl Acetic Acid. Research Journal of Pharmacy and Technology, **13(1)**: 40-46. https://doi.org/10.5958/0974-360X.2020.00007.4.
16. Dalaf, A. H., & Jumaa, F. H. (2020). Synthesis, Identification and Assess the Biological and Laser Efficacy of New Compounds of Azetidine Derived from Benzidine. Muthanna Journal of Pure Science (MJPS), **7(2)**:12-25. DOI: 10.18081/2226-3284/14-10/12-25.
17. Saleh, R. H., Rashid, W. M., Dalaf, A. H., Al-Badrany, K. A., & Mohammed, O. A. (2020). Synthesis of Some New Thiazolidinone Compounds Derived from Schiff Bases Compounds and Evaluation of Their Laser and Biological Efficacy. Ann Trop & Public Health, **23(7)**: 1012-1031. http://doi.org/10.36295/ASRO.2020.23728
18. Yass, I. A., Aftan, M. M., Dalaf, A. H., & Jumaa, F. H. (Nov. 2020). Synthesis and Identification of New Derivatives of Bis-1,3-Oxazepene and 1,3-Diazepine and Assess the Biological and Laser Efficacy for Them. The Second International & The Fourth Scientific Conference of College of Science – Tikrit University. **(P4)**: 77-87.
19. Salih, B. D., Dalaf, A. H., Alheety, M. A., Rashed, W. M., & Abdullah, I. Q. (2021). Biological activity and laser efficacy of new Co (II), Ni (II), Cu (II), Mn (II) and Zn (II) complexes with phthalic anhydride. Materials Today: Proceedings, 43, 869-874. https://doi.org/10.1016/j.matpr.2020.07.083.
20. Aftan, M. M., Jabbar, M. Q., Dalaf, A. H., & Salih, H. K. (2021). Application of biological activity of oxazepine and 2-azetidinone compounds and study of their liquid crystalline behavior. Materials Today: Proceedings, 43, 2040-2050. https://doi.org/10.1016/j.matpr.2020.11.838.
21. Aftan, M. M., Talloh, A. A., Dalaf, A. H., & Salih, H. K. (2021). Impact para position on rho value and rate constant and study of liquid crystalline behavior of azo compounds. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2021.02.298.
22. Aftan, M. M., Toma, M. A., Dalaf, A. H., Abdullah, E. Q., & Salih, H. K. (2021). Synthesis and Characterization of New

Azo Dyes Based on Thiazole and Assess the Biological and Laser Efficacy for Them and Study their Dyeing Application. Egyptian Journal of Chemistry, **64(6),** 2903-2911. https://dx.doi.org/10.21608/ejchem.2021.55296.3163.

23. Khalaf, S. D., Ahmed, N. A. A. S., & Dalaf, A. H. (2021). Synthesis, characterization and biological evaluation (antifungal and antibacterial) of new derivatives of indole, benzotriazole and thioacetyl chloride. Materials Today: Proceedings. 47(17), 6201-6210. https://doi.org/10.1016/j.matpr.2021.05.160.
24. Dalaf, A. H., Jumaa, F. H., & Salih, H. K. (2021). Preparation, Characterization, Biological Evaluation and Assess Laser Efficacy for New Derivatives of Imidazolidin-4-one. International Research Journal of Multidisciplinary Technovation, 3(4), 41-51. https://doi.org/10.34256/irjmt2145.
25. Dalaf, A. H., Jumaa, F. H., & Salih, H. K. (2021). MULTIDISCIPLINARY TECHNOVATION. Red, 15(A2), C44H36N10O8.
26. Dalaf, A. H., Jumaa, F. H., Aftana, M. M., Salih, H. K., & Abd, I. Q. (2022). Synthesis, Characterization, Biological Evaluation, and Assessment Laser Efficacy for New Derivatives of Tetrazole. In Key Engineering Materials (Vol. 911, pp. 33-39). Trans Tech Publications Ltd. https://doi.org/10.4028/p-6849u0.
27. Alasadi, Y. Kh., Jumaa, F. H., Dalaf, A. H., Shawkat, S. M., & Mukhlif, M. Gh. (2022). Synthesis, Characterization, and Molecular Docking of New Tetrazole Derivatives as Promising Anticancer Agents. Journal of Pharmaceutical Negative Results. 13(3): 513-522. https://doi.10.47750/pnr.2022.13.03.079.
28. Dalaf, A. H., Jumaa, F. H., & Yass, I. A. (2022, November). Synthesis, characterization, biological evaluation, molecular docking, assess laser efficacy, thermal performance and optical stability study for new derivatives of bis-1, 3-oxazepene and 1, 3-diazepine. In AIP Conference Proceedings (Vol. 2394, No. 1, p. 040037). AIP Publishing LLC. https://doi.org/10.1063/5.0121213.
29. Alasadi, Y. K., Jumaa, F. H., & Dalaf, A. H. (2022, November). Synthesis, identification, antibacterial activity and laser effect of new derivatives of bis-1, 3-oxazepene-4, 7-dione and 1, 3-diazepine-4, 7-dione. In AIP Conference Proceedings (Vol. 2394, No. 1, p. 040019). AIP Publishing LLC. https://doi.org/10.1063/5.0121358.
30. Toma, M. A., Ibrahim, D. A., Dalaf, A. H., Abdullah, S. Q., Aftan, M. M., & Abdullah, E. Q. (2022, November). Study the adsorption of cyclopentanone on to natural polymers. In AIP Conference Proceedings (Vol. 2394, No. 1, p. 040007). AIP Publishing LLC. https://doi.org/10.1063/5.0121209.
31. Saleh, J. N., & Khalid, A. (2023). Synthesis, Characterization and Biological Activity Evaluation of Some New Pyrimidine Derivatives by Solid Base Catalyst AL2O3-OBa. *Central Asian Journal of Medical and Natural Science*, *4*(4), 231-239.
32. Hamad, A. M., Atiyea, Q. M., Hameed, D. N. A., & Dalaf, A. H. (2023). Green synthesis of copper nanoparticles using strawberry leaves and study of properties, anti-cancer action, and activity against bacteria isolated from Covid-19 patients. Karbala International Journal of Modern Science, 9(1), 12.
33. Jassim, A. S., Dalaf, A. H., and Abdullah, T. F. (2022). Studying the Biological Activity and Properties of Copper Nanoparticles Prepared by Pulsed Laser Ablation in Liquid. The Third International and The Fifth Scientific Conference for

College of Science –Tikrit University. 1(25): 213-221.

34. Mohammed, L. J., Hamad, A. M., Atiyea, Q. M., Jwair, W. A., Dalaf, A. H., Jasim, A. S., Elsaigher, S. M., Ragab, A., and Hassan, Z. H. S. (2022). In vitro Comparison of the Effect of Zinc Oxide Nanoparticles and Hibiscus sabdariffa Extract on Streptococcus mutans Isolated from Human Dental Caries. The Third International and The Fifth Scientific Conference for College of Science –Tikrit University. 2(2): 5-14.
35. Najm, R. S., Shannak, Q. A. and Dalaf, A. H., (2023). Synthesis and Decoration of Aromatic Derivatives Nano Platelets by the Electric Method. Azerbaijan Pharmaceutical and Pharmacotherapy Journal. 22(2): 92-97. DOI https://doi.org/10.61336/appj/22-2-22.
36. Saleh, M. J., & Al-Badrany, K. A. (2023). Preparation, Characterization of New 2-Oxo Pyran Derivatives by AL2O3-OK Solid Base Catalyst and Biological Activity Evaluation. *Central Asian Journal of Medical and Natural Science*, *4*(4), 222-230.