Solvent -Free One -Pot Multicomponent, Synthesis, Characterization and Anti-bacterial activity, of some 2-substituted-3-cyano-Pyridine Derivatives

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Abstract

Solvent- free thermal heating, one-pot condensation of acetophenone, ethyl cyanoacetate or malononitrle and substituted Aromatic aldehyde, ammonium acetate give, 2-oxo-3-cyano-4-substituted Aryl-6-phenyl pyridine $[I]_{a-h}$, or 2-amino-3-cyano-4-substituted Aryl-6-phenyl pyridine derivatives$[II]_{a-f}$, respectively.

Treatment of compounds 2-oxo-3-cyano-4-substituted Aryl-6-phenyl pyridine with phosphorous penta sulphide (P_2S_5), give 2-thioxo-3-cyano-4-substituted Aryl-6-phenyl pyridine derivatives$[III]_{a-c}$.

All prepared compounds are characterized by, C.H.N.S-elmental analysis, melting points, FTIR-and^{1}H-NMR-spectral analysis .

Antibacterial examination of synthesized compounds $[I]_{a-c}$, $[II]_{a-c}$ and $[III]_{a-c}$ against five types of, (G-) and (G+) bacterial . in comparison with common antibiotic like Ampicillin, Amoxicilin and Lincomycin the result shows 2-thioxo-3-cyano-4-substituted Aryl-6-phenyl pyridine derivatives are more reactive than 2-oxo-3-cyano pyridine derivatives or 2-amino-3-cyano pyridine derivatives .

Key words: Solvent-free, one-pot, pyridine derivatives .

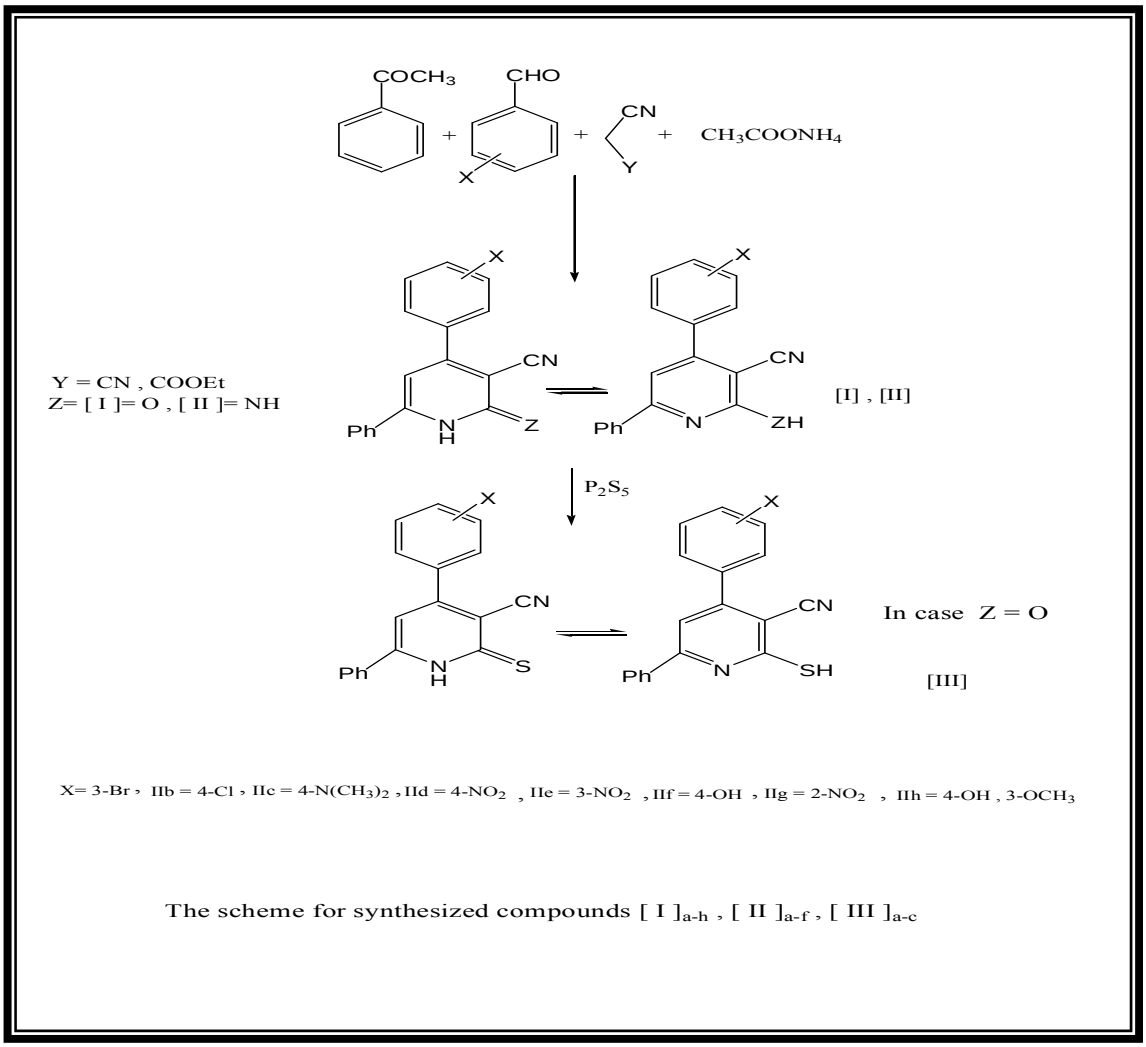
Introduction

One-pot multi-component reactions, is an important synthetic methodology for a broad spectrum of biological and pharmaceutical organic compounds, in which the simultaneous interaction of three or more components in a sequence of steps to afford the final product [1-4].

3-Cyano-2-pyridone derivatives draw a special attention for their wide spectrum biological activities along with their importance and utility as intermediates in preparing variety of heterocyclic compounds [5-7].

In recent years much attention has been developed of 3-cyanopyridine derivatives because of interesting pharmaceutical and biological activities, such as antimicrobial [8-13] , analgesic anti-inflammatory [14]; and antitumor agents [15].

In view of the above mentioned facts, and giving attention to the antimicrobial effects of 3-cyanopyridines derivatives, we use the thermal heating solvent-free one-pot multicomponent reaction as a synthetic methodology for synthesis of three different types of 3-cyano pyridine with different substituted in position-2, like 2-oxo-3-cyanopyridine, 2-amino-3-cyanopyridine and 2-thioxo-3-cyanopyridine derivatives, and antibacterial activities examination against five different types of (G-) and (G+) bacteria species .



The scheme for synthesized compounds [I]$_{a-h}$, [II]$_{a-f}$, [III]$_{a-c}$

Experimental

Materials and instruments

All chemicals were supplied from Merck , Fluka and Aldrich Chemicals Co. and used as received .

FTIR spectra were recorded using potassium bromide discs on a Shimadzo (IR prestige-21) FTIR spectrophotometer . ^{1}HNMR spectra were carried out by company : Bruker , model: ultra shield 400 MHz , origin : Switzerland and are reported in ppm(δ) duterated, DMSO was used as a solvent with TMS as an internal standard . Elemental analysis (C.H.N.S) were carried out using an EuroEA Elemental Analyzer at (The Central Service Laboratory-College of Education For Pure Science Ibn Al- Haitham). Uncorrected melting points were determined by using Hot-Stage, Gallen Kamp melting point apparatus . The biological activity was performed in Center for Market Research and Consumer Protection , University of Baghdad .

Synthesis Methods

Synthesis 2-oxo -3 - cyano - 4 -substituted Aryl - 6 - phenyl pyridine [I] $_{a-h}$.

A- Solvent-free one-pot multicomponent condensation at 140 ^{0}C

A stirred mixture of acetophenone (0.01 mol, 1.17 ml), ethyl cyanoacetate (0.01 mol ,1.1 ml) , substituted benzldehyde (0.01 mol) and ammonium acetate (0.01 , 0.77 g) was heated at (140 C°) in oil bath for 15- minute , progress of reaction was monitored by TLC (petroleum ether : ethyl acetate eluent) . Dough was formed , solidified upon cooling , Then Ethanol was added , a precipitate began to form , left in ice-chest for an hour , then filtered , washed with water and ethanol , dried to give a very good yield (80-90 %) . Recrystallized from ethanol .

The physical data of these compounds are listed in Table 1. Anal. Calcd. for compound [I]$_a$ $C_{18}H_{11}N_2OBr$: C, 61.53; H, 3.13; N, 7.97 Found: C, 61.88; H, 3.20; N,8.21 , for Calcd. compound [II]$_h$ $C_{19}H_{14}N_2O_3$: C, 71.69 ; H, 4.40; N, 8.80 Found: C, 71.82; H, 4.48 ; N, 8.86 .

B-ethanol reflux one-pot multicomponent condensation of acetophenone, ethyl cyanoacetate, substituted aromatic aldehyde and ammonium acetate for 8 h give poor yield (20-45)% of product .

Synthesis 2-amino -3 - cyano -4 -substituted Aryl -6 - phenyl pyridine[II]$_{a-f}$.

A-Solvent-free one-pot multicomponent condensation at 140 ^{o}C

A stirred mixture of acetophenone (0.01mol , 1.17 ml), malononitrle (0.01mol, 0.66 g) , substituted benzldehyde (0.01mol), and ammonium acetate (0.01mol, 0.77 g) was heated (140 C°) in oil bath for 20 minute , progress of reaction was monitored by TLC (petroleum ether: ethyl acetate eluent). Dough was formed , solidified upon cooling , Then ethanol was added a precipitate began to form , then left in ice-chest for an hour , then filtered , washed with water then ethanol , dried to give a very good yield (75-87 %) . Recrystallized from ethanol and acetic acid.

B-ethanol reflux one-pot multicomponat condensation of acetophenone, malononitrle, substituted aromatic aldehyde and ammonium acetate for 8 h give poor yield .

The physical data of these compounds are listed in Table 1. Anal. Calcd. For compound $[II]_a$ $C_{18}H_{12}N_3Br$: C, 61.71; H, 3.42; N, 12.00; Found: C, 61.85 ; H, 3.49; N, 12.28 and Calcd. for compound $[II]_b$ $C_{18}H_{12}N_3Cl$: C, 70.70 ; H, 3.92; N, 13.74; Found: C,71.11; H,4.01; N, 13.86 .

Synthesis 2- thioxo -3 - cyano -4 -substituted Aryl -6 - phenyl pyridine $[III]_{a-c}$.

A mixture of 2-oxo3-cyano-4-(x′-substituted phenyl)-6- phenyl -2(*1H*)-pyridinones [II]a-c (0.01 mol) and Phosphorous pentasulphide (P_2S_5) (0.01 mol) in pyridine (10 mL) was refluxed for 5 h . Then reaction mixture was poured into ice-cold water. The separated solid was filtered off and washed with dilute HCl to afford the corresponding thione derivative , which was crystallized from ethanol .

The physical data of these compoundes are listed in Table 1. Anal. Calcd. For compound $[III]_a$ $C_{18}H_{11}N_2SBr$: C,58.85; H, 2.99; N, 7.62; S, 8.71; Found: C, 59.12 ; H, 3.17; N, 7.88; S,8.98 and Calcd. for compound $[III]_c$ $C_{20}H_{17}N_3S$: C,72.50; H, 5.13; N, 12.68; S, 9.66; Found: C, 72.72 ; H, 5.29; N, 12.92; S,9.90.

Evaluation of Antibacterial Activity

Antibacterial activity of synthesized compounds was determined using a disc diffusion method 30 µl of each Gram negative Pseudomonas aeruginosa, Escherichia coli, Proteus mirabilis and gram positive Bacillus subtilis, Staphylo coccus aureus bacterial suspension of approximately 10^8 colony cell/ml was incubated at 37 ºC for 24 h, were spread on Muller-Hintone agar using sterile collon. Swaks . 30 mg/ml solution of synthesized compounds in DMSO, were prepared and placed into occulted plates . The plates were incubated aerobically at 37ºC for 24 h then inhibition zone diameter (mm) were measured.

Results and Discussion

Thermal-heating one-pot multicomponent condensation of equimolecular amounts of substituted benzaldehyde and acetophenon with ethylcyanoacetate and anhydrous ammonium acetate at 140 ºC for less than 15 min ; afforded an excellent yield of 2-oxo- cyanopyridin derivatives $[I]_{a-h}$ (80-90)%. FTIR-spectral analysis of compounds$[I]_{a-h}$, showed disappearance of carbonyl stretching bands of acetophenone, substituted benzaldehyde, ethyl cyanoacetate ester and ammonium acetate, and appearance of secondary amide carbonyl stretching band (C=O) at 1643-1699cm^{-1}, besides the secondary amide (N-H) stretching bands at 3130-3150cm^{-1} and cyano stretching bands at 2214-2225cm^{-1}, as well as the appearance of (NO_2) a symmetrical and symmetrical stretching bands of compounds $[I]_d$ 1516 and 1350cm^{-1} , $[I]_e$ at 1531,1350cm^{-1} and $[I]_g$ at 1527,1353 cm^{-1}, respectively , while compound $[I]_f$, $[I]_h$ showed (O-H) stretching band at 3338 and 3429cm^{-1}, respectively. The other data of functional groups which are characteristics of these compounds are given in Table 2.

The ^{1}HNMR spectrum (in DMSO), of compound $[I]_b$ showed pyridine ring proton at C5 as a singlet signal at 6.82 ppm , aromatic proton (9H) of phenyl groups at C4 and C6 of pyridine ring as a multiplet signal at 7.5-7.9 ppm : equivalent to 9-protons , and secondary amide (N-H) proton as a singlet signal at 12.89 ppm, While ^{1}HNMR-spectrum of compound $[I]_g$, showed pyridine ring proton at C5 as a singlet signal at 6.9 ppm , aromatic proton (9H) of phenyl groups at C4 and C6 of pyridine ring as a multiplet signal at 7.5-8.3 ppm : equivelant to 9-protons , and secondary amide (N-H) proton as a singlet signal at 13.0 ppm .

Thermal heating one-pot multicomponent reaction of equimolar amounts of acetophenone, substituted benzaldehyde, malononitrle, ammonium acetate at 140 °C for less than 20 minute give a very good yield (75-87%), with high purity of 2_amino - 3 -cyano-4(x′_substituted phenyl) - 6 - phenyl pyridine[II]$_{a-f}$, which were characterized , (C.H.N.S) elemental analysis , FTIR-spectral analysis and ^{1}H.NMR-spectral analysis .

The FTIR absorption spectra of compound [II]$_a$, showed the disappearance of absorption bands of the starting materials together with appearance of (C=N) of pyridine ring at1610-1643cm-1and a symmetrical and symmetrical stretching bands of amino group (NH_2) at 3460-3487cm^{-1} and 3305-3375cm-^{1} , respectively, and cyano group (C≡N) stretching band 2206-2214 cm^{-1}.

Moreover, the ^{1}HNMR spectrum (in DMSO), of compound [II] $_a$ showed pyridine ring proton at C 5 as a singlet signal at 6.8 ppm , (NH2) proton as a singlet signal at 6.9 ppm (equivalent to 2-proton) and Aromatic proton (9H) of phenyl groups at C4 and C6 of pyridine ring as a multiplet signal at 7.5-7.7 ppm (equivalent to 9-proton) .

Treatment of compounds 2- oxo-3 –cyano-4(x′ -substituted phenyl) -6 - phenyl (*2H*) pyridine[I] $_{a-c}$ with phosphorous penta sulfide (P_2S_5) in pyridine under reflux give correspounding 2- thioxo-3 –cyano- 4(x′ -substituted phenyl) -6 - phenyl (*2H*) pyridine[III]$_{a-c}$.

Structure of compounds [III]$_{a-c}$ has been characterized by its melting points ,(C.H.N.S) elemental analysis , FTIR and ^{1}H.NMR-spectral analysis.

FTIR-spectral of compounds [III]$_{a-c}$, showed disappearance of carbonyl stretching bands of 2-oxo pyridine starting material and appearance of 2-thioxo pyridine (C=S) stretching bands at 1199 , 1188, 1184 cm^{-1} , respectively, besides the appearance of secondary thioxo amide (N-H) stretching bends at 3433, 3398, 3394 cm^{-1}, respectively and cyano (C≡N) 2218 , 2218 , 2210 cm^{-1} , respectively .

^{1}H.NMR-spectral analysis of compound [III]$_a$, showed a singlet signal of C5-pyridine ring proton at 7.1 ppm, secondary thioxo amide (N-H) proton at 8.7 ppm, and aromatic proton (9H) of phenyl groups substituted at C4 and C6 of pyridine ring as a multiplet signal at 7.3-8.1 ppm (equivalent to 9-protons) . While the ^{1}H.NMR-spectrum of compound [III]$_b$, showed C5- pyridine ring proton as singlet signal at 7.1 ppm , secondary thioxo amide (N-H) proton as singlet signal at 8.9 ppm , and aromatic proton (9H) of phenyl groups substituted at C4 and C6 of pyridine ring as a multiplet signal at 7.5-8.0 ppm.

All the spectral data of FTIR spectroscopy of synthesized compounds are listed in Table (2).

Biological Activity

Antibacterial activity of synthesized compounds 2–oxo –3 – cyano – 4 –substituted Aryl – 6 – phenyl pyridine [I] $_{a-c}$, 2–amino–3 – cyano – 4 –substituted Aryl – 6 – phenyl pyridine [II]$_{a-c}$, 2–thioxo –3 – cyano – 4 –substituted Aryl – 6 – phenyl pyridine [III] $_{a-c}$ respectively in comparison with common antibiotic, Ampicillin, Amoxicilin and Lincomycin against Gram negative Pseudomonas aeruginosa, Escherichia coli, Proteus mirabilis and gram positive Bacillus subtilis, Staphylo coccus aureus.pathogenic species **.** are given in table (3).

Result showed stronger activity exhibition of compounds [III]$_{a-c}$ against Pseudomonas aeruginosa, Escherichia coli and Staphylo coccus , this may be due to presence of thioxo-group (C=S) at position 2 , of 3-cyanopyridine derivatives .

While all synthesized compounds showed stronger activity against Pseudomonas aeruginosa bactiria .

References:

1- Ming-Yue Yin.; A Mei-Mei Zhang.; B Wei Wang,a Yu-Ling Li,a and Xiang-Shan Wang., (2011), An efficient synthesis of 8-aryl-9H-cyclopenta[a][4,7]phenanthroline derivatives catalyzed by iodine. arkivoc, (xi) 51-59 ,

2- Chebanov V.A.; Sakhno, Y.I.; Desenko, S.M.; Chernenko,V.N; Musatov, V.I.; Shishkina, S.V.; Shishkin O.V. and Kappe C.O., 2007, One-Pot, Multicomponent Route to Pyrazoloquinolizinones, Tetrahedron, 63, 1229.

3- Aggarwal, R., Kumar, V.; Bansal, A. and Sanz,D. Claramunt, R.M., 2012, Multi-component solvent-free versus stepwise solvent mediated reactions: regioespecific formation of 6-trifluoromethyl and 4-trifluoromethyl-1H-pyrazolo[3,4-b]pyridines Journal of Fluorine Chem., 140, 31.

4- El-borai, M.A.; Rizk ,H.F. and Abd-Aal ,M.F., El-Deeb, I.Y., (2012), Synthesis of pyrazolo[3,4-b]pyridines under microwave irradiation in multi-component reactions and their antitumor and antimicrobial activities - Part 1Eur. J. Med. Chem., 48, 92.

5- Swelam, S. A.; El-Said, N. S; Aly, A. and Abdel-Fatth, A. (2009), Facile and Simple Syntheses of Heterocyclic Compounds Based on Pyridine and Pyrazolopyridine Derivatives Int.J. PharmTech Res. 1(3).

6- Kamlesh, K.; Taslimahemad, K. and Praful, P. (2013), One Pot Synthesis of Bioactive Novel Cyanopyridones Journal of the Korean Chemical Society,. 57 (4) .

7- Zahira Kibou1 ; Nawel Cheikh1,2, Didier Villemin2; Noureddine Choukchou-Braham1 ; Bachir Mostefa-Kara1 and Mohamed Benabdallah, (2011), A Simple and Efficient Procedure for a 2-Pyridones Synthesis under Solvent-Free Conditions, International Journal of Organic Chemistry, 1, 242-249 .

8- Hassan, A. El-Sayed, and Nabil, H. Ouf, (2012), An Efficient and Facile Multicomponent Synthesis of 4,6-Diarylpyridine Derivatives under Solvent-Free Conditions, Nature and Science;10(9).

9- Smith, A.; Owen, J.; Borgman, K.; Fish, F. and Kannankeril, P., (2011), Relation of milrinone after surgery for congenital heart disease to significant postoperative tachyarrhythmias.Am. J. Card., 108, 1620

10- Sedzani ,A. N. and Teunis ,V. R.,(2014), ‘‘Synthesis and Antimalarial Activities of Some Novel 2-Pyridones’’, Arabian Journal for Science and Engineering,. 39, 9. 6595-6598.

11- Hussein, F.; Zohdi, Nora, M. Rateb and Tamer, A. Khlosy , (2014), Synthesis, reaction and antimicrobial activity of some pyridinethione derivatives containing benzimidazole nucleus, International Journal of Advanced Research 2, 4 ,861-872

12- Mahmoud, M.R.; El-Bordany, E.A.A.; Hassan, N.F. Abu El-Azm(2007), Utility of Nitriles in Synthesis of Pyrido[2,3-d]pyrimidines, Thiazolo[3,2-a]pyridines, Pyrano[2,3-b]benzopyrrole, and Pyrido[2,3-d]benzopyrrolesPhosphorus Sulfur Silicon 182, 2507-2521.

13- Mungra, D.C.; Patel, M.P.;Patel, R.G. (2009), "Microwave-assisted multi-component synthesis of indol-3-yl substituted pyrano[2,3-c]pyrazoles and their antimicrobial activit", Arkivoc XIV: 64-67

14- Bekhit, A.A.; Fahmy, H.T.; Rostom, A.El-Din S.A and Bekhit, A., (2010), Synthesis and biological evaluation of some thiazolylpyrazole derivatives as dual anti-inflammatory antimicrobial agents, Eur J. Med Chem., 45, 6027.

15- Lin, R.; Chiu, G.; Yu Y.; Connolly, P.J.; Li, S.; Lu, Y.; Adams, M.; A.R. Pesquera, Greenberger S.L.E., (2007), synthesis, and evaluation of 3,4-disubstituted pyrazole analogues as anti-tumor CDK inhibitors.Bioorg., Med. Chem. Lett., 17, 4557. Design

Table No. (1) Physical properties of synthesized compounds $[I]_{a-h}$, $[II]_{a-f}$ and $[III]_{a-c}$

comp. No.	Molecular Formula	M.P C^0	Yield% solvent-free At 140 °C	Yield% in ethanol reflux
$[II]_a$	$C_{18}H_{12}N_3Br$	240-242	87	25
$[II]_b$	$C_{18}H_{12}N_3Cl$	252-253	75	18
$[II]_c$	$C_{20}H_{18}N_4$	222-224	80	11
$[II]_d$	$C_{18}H_{12}N_4O_2$	230-231	84	14
$[II]_e$	$C_{18}H_{12}N_4O_2$	218-220	80	14
$[II]_f$	$C_{18}H_{13}N_3O$	233-235	78	16
$[I]_a$	$C_{18}H_{11}N_2OBr$	>300	90	45
$[I]_b$	$C_{18}H_{11}N_2OCl$	>300	88	33
$[I]_c$	$C_{20}H_{17}N_3O$	>300	83	25
$[I]_d$	$C_{18}H_{11}N_3O_3$	>300	86	28
$[I]_e$	$C_{18}H_{11}N_3O_3$	>300	80	36
$[I]_f$	$C_{18}H_{12}N_2O_2$	>300	85	28
$[I]_g$	$C_{18}H_{11}N_3O_3$	>300	82	20
$[I]_h$	$C_{19}H_{14}N_2O_3$	>300	87	22
$[III]_a$	$C_{18}H_{11}N_2SBr$	228-230		
$[III]_b$	$C_{18}H_{11}N_2SCl$	238-239		
$[III]_c$	$C_{20}H_{17}N_3S$	195-197		

Table No.(2):Characteristic FTIR absorption bands of synthesized compounds $[I]_{a-h}$,$[II]_{a-f}$ and $[III]_{a-c}$

Comp. No.	υ(N-H)cm^{-1}	υ(C-H)cm^{-1}	υ(C≡N)cm^{-1}	υ(C=N) cm^{-1}	υ(C=O)cm^{-1}	υ(C=S).cm^{-1}	υ(C=C).cm^{-1}
$[I]_a$	3138	3028- 3055	2214	1608	1643	-	1570-1531
$[I]_b$	3140	3066-3028	2214	1608	1643	-	1573-1531
$[I]_c$	3130	3077-3040	2206	1610	1699	-	1564-1517
$[I]_d$	3150	3062-3020	2210	1608	1674	-	1577-1500
$[I]_e$	3140	3082-3028	2214	1604	1651	-	1577-1500
$[I]_f$	3134	3062-3028	2225	1608	1649	-	1575-1519
$[I]_g$	3148	3077 -3040	2218	1603	1643	-	1519-1502
$[I]_h$	3136	3066 -3016	2218	1604	1643	-	1573-1525
$[II]_a$	3358 –3483	3051-3100	2214	1629	-	-	1591-1571
$[II]_b$	3354 -3480	3037-3003	2214	1643	-	-	1573-1544
$[II]_c$	3350 -3464	3116-3080	2206	1612	-	-	1566- 1523
$[II]_d$	3375-3487	3078-3062	2210	1635	-	-	1570 -1554
$[II]_e$	3305 -3475	3100-3080	2206	1639	-	-	1573- 1550
$[II]_f$	3311 -3468	3064 -2988	2210	1629	-	-	1571-1544
$[III]_a$	3433	3080-3055	2218	1608	-	1199	1573-1554
$[III]_b$	3433	3100-3059	2218	1608	-	1188	1573-1539
$[III]_c$	3394	3089-3985	2210	1608	-	1184	1573-1554

Table No.(3): Antibacterial activity of synthesized compounds against five pathogenic Species.

Comp. no.	Mean of Inhibition zone Diameter (mm)				
	S. aureus	P.aerugina	E. coli	P. mirabilis	B.subtilis
$[I]_a$	8	27	2	7	4
$[I]_b$	-	10	-	5	3
$[I]_c$	-	22	-	5	3
$[II]_a$	-	20	-	-	-
$[II]_b$	-	26	22	-	-
$[II]_c$	-	17	-	-	-
$[III]_a$	17	28	30	7	4
$[III]_b$	16	6	22	-	-
$[III]_c$	16	22	17	-	-
Ampicillin	5	-	-	-	-
Amoxicilin	15	3	-	-	-
Lincomycin	9	-	-	-	-
DimethylSulfoxie	0.0	0.0	0.0	0.0	0.0

تخليق (بدون مذيب بوعاء واحد متعدد المكونات) لبعض مشتقات 2-معوض-3-سيانو بريدين ودراسة خواصها البايولوجية وفعاليتها.

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الخلاصة

تكاثف الاسيتوفينون وخلات سيانو اثيل او مالونونايتريل مع الألدهايدات الأروماتية المعوضة وخلات الامونيوم بوعاء واحد وبدون مذيب بالتسخين المباشر عند درجة 140 م^{o} ليعطي المركبات 2-اوكسو-3-سيانو-4-اريل معوض-6-فنيل بريدين $[I]_{a-h}$ ، 2-امينو-3-سيانو-4-اريل معوض-6-فنيل بريدين $[II]_{a-f}$ عند معاملة مركبات 2- اوكسو-3-سيانو-4-اريل معوض-6- فنيل بريدين $[I]_{a-c}$ مع خامس كبريتيد الفسفور(P_2S_5) ليعطي مركبات 2- ثايوكسو-3-سيانو-4- فنيل معوض-6- فنيل بريدين $[III]_{a-c}$.

درست خواص جميع المركبات المحضرة من خلال قياس درجات االنصهارها، تحليل العناصر الدقيق(CHNS) واطياف الاشعة تحت الحمراء والرنين النووي المغناطيسي (FTIR ، ^{1}H NMR).

اظهرت دراسة الفعالية البايلوجية (كمضادات حيوية) للمركبات المحضرة مع خمسة انواع من البكتريا (-G) و (+G) تمت مقارنة الفعالية البايولوجية لهذه المركبات مع المضادات الحيوية الأمبيسلين، الاموكسيلين واللينكوما سين و ان مركبات 2-ثا يوكسو-3-سيانو-4- اريل معوض-6- فنيل بريدين $[III]_{a-c}$ تمتلك فعالية بايلوجية قوية جدا .

الكلمات المفتاحية: بدون مذيب، بوعاء واحد، مشتقات البريدين.