**Annexure –VI**

**UNIVERSITY GRANTS COMMISSION**

**BAHADUR SHAH ZAFAR MARG**

**NEW DELHI – 110 002.**

# EXECUTIVE SUMMERY OF THE MRP

1. Project report No. 1st /Final.**Final**
2. UGC Reference No. **FileNo.47-264/12(WRO) Dt. 25/02/2013**
3. Period of report: from.**25/03/2013** to **24/03/2015**
4. Title of research project. **Synthesis and Biological Studies of 1,3,4-OxadiazoleDerivatives**
5. (a) Name of the Principal Investigator. **Dr. MODI V. B.**
   (b) Deptt.**Chemistry**
   **(c)** College where work has progressed**SHRI U P ARTS SMT. M G PANCHAL SCIENCE & SHRI V L SHAH CMMERCE COLLEGE, AT & POST PO PILVAI, VIJAPUR, MEHSANA-382850**
6. Effective date of starting of the project. **25/03/2013**
7. Grant approved and expenditure incurred during the period of the report:
   a. Total amount approved **Rs.1,00,000/-**
   b. Total expenditure **Rs.103425/-**
   c. Report of the work done: (attach a separate sheet)

**i.** Brief objective of the project

## EXECUTIVE SUMMARY OF THE RESEARCH WORK

All the Schiff bases from4-(5-furan-2-yl)-1,3,4-oxadiazol-2-yl)aniline are in amorphous form and soluble in polar organic solvents. The C, H, N contents of all the Schiff bases are consistent with the predicted structures. The infrared spectral data are given in details of each compound. All the spectra comprises the important IR spectral features of aromatic, furan ring and –C=N- group.

The $^{1}H$ NMR spectra of all Schiff bases shows the signal for aromatic protons in the range of 6.6 to 7.9 ppm. The spectrum of all compounds shows the signal for -N=CH group.

Schiff bases (2a-h) on cyclo-condensation reaction with thioglycolic acid (mercapto acetic acid) in the presence of anhydrous $ZnCl_2$ yields 4-thiazolidinones (3a-h). Their structures were confirmed by analytical and spectral data. The C, H, N and S contents of the prepared compounds were consistent with their predicted structures as shown in Scheme. The analytical and spectral data of the compounds (3a-h) . The infrared spectra show the band in the region ~1690 $cm^{-1}$ for carbonyl group of 4-thiazolidinone ring.

The NMR spectra show a signal at ~5.9 ppm for $CH_2$ protons at position-5 in the 4-thiazolidinone ring and a signal at ~3.8 ppm for CH protons at position-2 of the 4-thiazolidinone ring. All other signals are at their respective positions for the respective protons in the NMR spectra.

The Schiff bases (3a-h) on cyclocondensation reaction with chloroacetyl chloride in the presence of triethylamine (TEA) affords the biologically active 2-azetidinone (β-lactam) derivatives (4a-h).

Their structures were confirmed by analytical and spectral data. The C, H, and N contents of the prepared compounds were consistent with their predicted structures as shown in Scheme-1. The infrared spectra show the band in the region ~1750$cm^{-1}$ for carbonyl (>C=O) group, which is the characteristic band for the cyclic β-lactam ring.

The proton magnetic resonance spectra of the prepared compounds (4a-h) showband at ~5.7 ppm for $C_3H$ of β-lactam in the 2-azetidinone ring and other at ~5.3ppm for CH proton at position-2 in the ring. All other signals are at their respective positions in the PMR spectrum.

Ampicilli, Tetracycline andGentamycin were used as standard drugs and a solvent control was also run to know the activity of solvent.

Activity of standards and inhibition due to DMF (solvent) are given in . The results shown by compounds and standards are corrected for DMF. Comparison of antimicrobial activity of produced compounds with that of standard antimicrobial drugs reveals that the produce compounds (Schiff Bases, 2-Azetidinones, 4-Thiazolidinones) shows moderate to good activity against all four bacterial strains.

Among*N*-(benzylidene)-4-(5-(furan-2-yl)-1,3,4-oxidiazol-2-yl)aniline(2a-h)compounds 2f, 2g and 2h shows good antimicrobial activity.

Among3-(4-(5-(furan-2-yl)-1,3,4-oxidiazol-2-yl)phenyl)-2-phenylthiazolidin-4-one(3a-h) compound 4c,4dand 4g show good antimicrobial activity.

Among3-chloro-1-(4-(5-(furan-2-yl)-1,3,4-oxidiazol-2-yl)phenyl)-2-phenylazetidin-2-one(4a-h)compounds, 5b, 5g and 5h show good antimicrobial activity.

Screening results of the title compounds of the project shows very good antimicrobial activity against gram positive, gram negative bacteria and fungi species also. These results lead on the focusing of further better research on these molecules and to studies are undergoing to explore the scope of the various biological activities.

Title compounds of the projects possess very good antimicrobial activity and least toxic and more potent. Hence, synthesized compound have better future in various field of medicinal chemistry.

The research work useful to society, nation and new avenue of research for the better future.

II **Research Papers Publication :-**

(1)DPC-2015-1525,DerPharma Cemica,Vol.7,issue 7:182-188

To synthesis, characterization and microbicidal activity of novel heterocyclic compounds having 2-Azetidinone

(2) Accepted ,Manuscript No.SLR-2015-DPL-1934,DerPharmaletter ,Vol.7,issue 7

To synthesis, characterization and microbicidal activity of novel heterocyclic compounds having 4-Thiazolidinones moiety

# FINAL REPORT OF
# MINOR RESEARCH PROJECT

**On**

## Synthesis and Biological Studies of 1,3,4-Oxadiazole Derivatives

**Submmited**
**To**

**UGC Reference No.47-264/12(WRO)**
**Date:25/02 2013**
**(XII plan)**

**Submmited**
**By**


**Dr. Modi V.B.**

**Assistant Professor in Chemistry**
**Shri U.P. Arts, Smt. M.G .Panchal Science,**
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## i-1Introduction

The compounds containing 1,3,4-oxadiazole ring have been known for about a hundred years. Their synthesis was extensively studied at the beginning of the 20$^{th}$ century by stoll et al [1-5]. Since that time a vast amount of work devoted to these compounds has been done [6-14]. An increase in number of publications devoted to their biological activities observed recently is worth noting and their brief review is given here.

Antimicrobial activities like, antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and antifungal activity against *Candida albicans* were studied by Mohan and Kataria [15] for two imidazol[1,2-d]-s-triazolo[3,4-b][1,3,4]oxadiazoles and by Rollas et al [16] for four 3-acetyl-5-(4-flourophenyl)-2-substituted-2,3-dihydro-1,3,4-oxadiazoles.2-amino-5-(1/2-naphthyloxymethyl)-1,3,4-oxadiazole have been screened for their activity against the above microbes and for other two fungi(*C.krusei* and *C.parapsilosis*) by Sachin et al [17]., the compounds studied showed moderate activities.

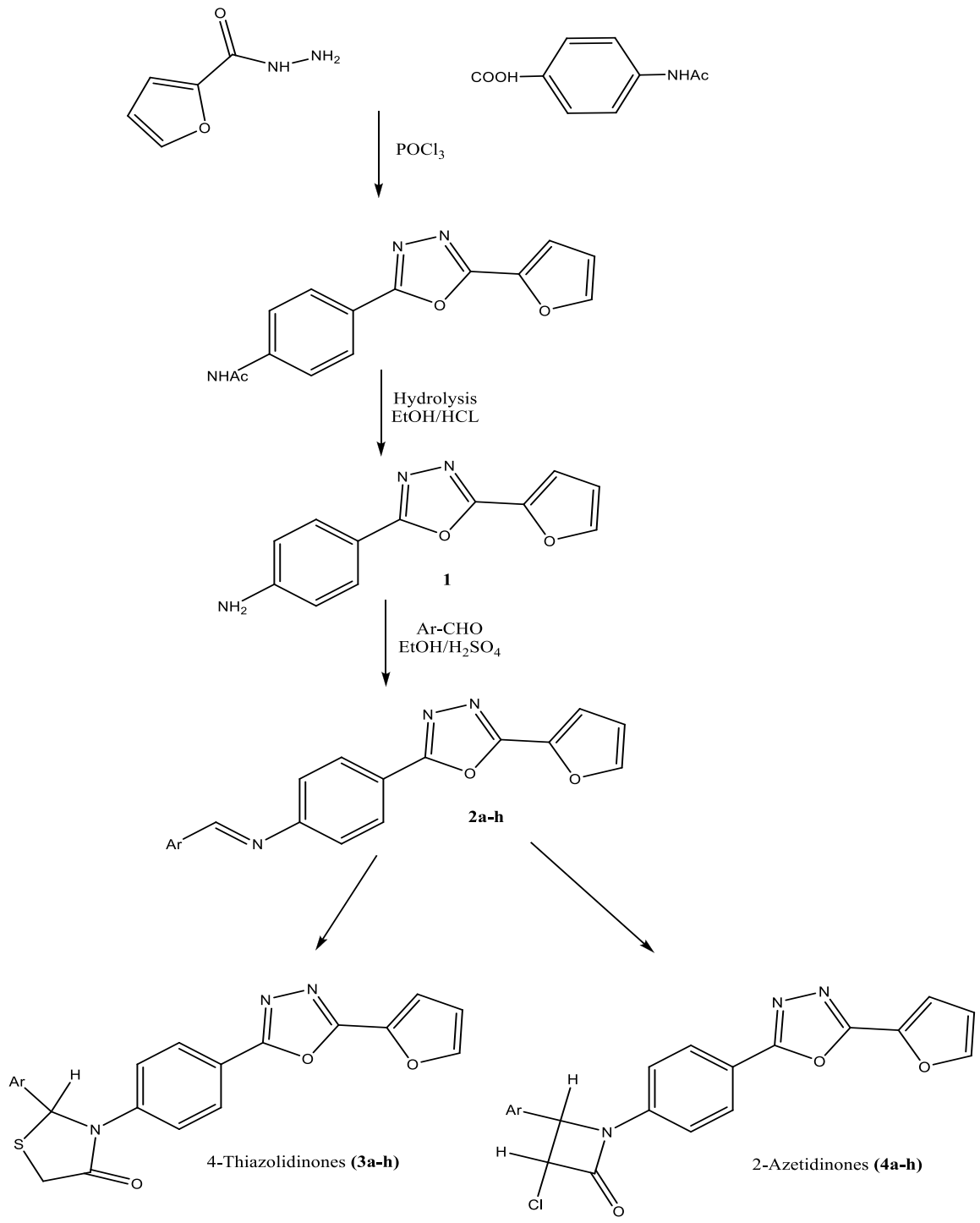
A series of 5-aryl-2-[(N,N-disubstitutedthiocarbamoylthio)-acylamino]-1,3,4-oxadiazoles were tested against various microorganisms by Ates et al [18]. But only 5-phenyl-2-[(N,N-dimethylthiocarbamoylthio)propionylamino]-1,3,4-oxadiazole showed a reasonable activity against S.aureus and S.epidermidis. the same group [19] performed analogous study for a series of 2-[[α-(4-substituted benzyloxy)- α-phenylacetyl/ methylacetyl]amino]-5-(4-methoxy phenyl)-1,3,4-oxadiazoles and some of them also showed activity against S.aureus and S.epidermidis. Shah et al [20] have studied antibacterial activities (against E.coli, S.aureus and S.typhi) of 2-(N-substituted carboxamidomethylthio)-5-(4-acetylaminophenyl)-1,3,4-oxadiazoles. The N-3-methoxyphenyl derivative, showed higher activity than that of chloromycetin. A number of 2-aryl-5-(α-methyl-4-isobutylbenzyl)-1,3,4-oxadiazoles, 2-arylsulfonamido-5-( α-methyl-4-isobutylbenzyl)-1,3,4-oxadiazoles, and 2-substituted benzamido-5-(α-methyl-4-isobutylbenzyl)-1,3,4-oxadiazoles showed antimicrobial activities (against *B.Subtilis*, *S.pyogens*, *K.pneumoniae*, *A.niger* and *S.cerevisiae*) comparable to those of chloramphenical, norfloxacin and griseofulvin [21]. Palaska and co-workers [22,23] have tested 2-(2-naphthyloxymethyl)-5-substituted amino-1,3,4-oxadiazoles for their anti-inflammatory activity. Among the compounds studies, 2-(2-naphthyoxymethyl)-5-methylamino-1,3,4-oxadiazole showed the best inhibition of prostaglandin production and none of the compounds showed significant side effects. Omar et al [24] have

studied anti-inflammatory activity of a number of 2,5-disubstituted-1,3,4-oxadiaziles in relation to the standard reference drug, namely ibuprofen. Five compounds were found to have higher inflammatory activity than ibuprofen and the highest activity was revealed by 2-(3-pyridyl)-5-ethylamino-1,3,4-oxadiazole.

Antiinflamatory activities of the series of 2-substituted-5-[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]-1,3,4-oxadiazoles have been studied by Mullican et all [25]. Jakubkiene et all [26] have studied the anti-inflammatory activity of 5-(6-methyl-2-substituted-4-pyrimidinyloxymethyl)-2,3-dihydro-1,3,4-oxadiazole-2-thiones relative to that of acetylsalicylic acid. The highest activity compounds appeared to be 5-(6-methyl-2-morpholino-4-pyrimidinyloxymethyl)-2,3-dihydro-1,3,4-oxadiazole-2-thione and 5-(6-methyl-2-methylthio-4-pyrimidinyloxymethyl)-3-morpholinomethyl-2,3-dihydro-1,3,4-oxadiazole-2-thione.

The literature review pertaining to the Amino-aryl functionalized 1,3,4-oxadiazole derivatives reveals that there are no reports have been found. While few reports about Aryl-amino derivatives have been reported [27,28].

Hence, it was worthwhile to undertake the post reaction of Amino-aryl 1,3,4-oxadiazole derivatives into heterocyclic ring like, 2-Azetidinone and 4-Thiazolidinone. The work carried is described in **(Scheme 1).**


POCl3
Hydrolysis
EtOH/HCL
1
Ar-CHO
EtOH/H2SO4
2a-h
4-Thiazolidinones (3a-h)
2-Azetidinones (4a-h)

**Scheme-1**

**ii-2Experimental**

**(a) Materials**

Furan-2-carbohydrazine and4-Acetamidobenzoicacid were purchased from local market. N-(4-(5-(furan-2-yl)-1,3,4-oxadiazol-2-yl)phenyl)acetamide**(1)**was prepared by reported method[27,28]. The various benzaldehyde derivatives were used to prepare Schiff bases. They were obtained from local market. All the other chemicals used were of analytical grade.

**(b) Synthesized compounds**

- **Synthesis of 4-(5-furan-2-yl)-1,3,4-oxadiazol-2-yl)aniline (1):**

4-(5-furan-2-yl)-1,3,4-oxadiazol-2-yl)anilinewas prepared by reportedmethod[27,28]. The resultant Schiff bases are designated as **1** and their details are shown as follows.

**(1): 4-(5-furan-2-yl)-1,3,4-oxadiazol-2-yl)aniline**

**Yield**: 78%
**M.p**.: 140°C
**Mol**.**Wt.:** 227
**Anal.Calcd.for $C_{12}H_9N_3O_2$(%)**: C, 63.43; H, 3.99; N, 18.49. **Found**: C, 63.3; H, 3.9; N, 18.4.
**$^1$H NMR (DMSO-$d_6$ 400 MHz):**6.60–7.58 (7H, m, aromatic protons), 6.30 (2H, s,aromatic C-NH protons).
**$^{13}$C NMR (DMSO-$d_6$ 100 MHz)**: 114-152(Ar-10C,), 158.5, 165.4 (N=CH).
**IR (KBr. cm$^{-1}$)**:1655 cm$^{-1}$(C=N), 3030 cm$^{-1}$ (C-H, of Ar.), 1095 (C-O-C).

- **Synthesis of Schiff bases of 4-(5-furan-2-yl)-1,3,4-oxadiazol-2-yl)aniline (1): formationof (2a-h).**

The Schiff bases of 4-(5-furan-2-yl)-1,3,4-oxadiazol-2-yl)aniline**(1)**were prepared by reportedmethod [29].

Benzaldehyde derivative (a-h) (0.01mole), oxadiazol (1) (0.01mole) and ethanol (20ml) were taken in a beaker [100ml]. The mixture was heated until a clear solution was obtained. The clear solution was kept overnight when respective Schiff base fall out which was filtered, washed by petroleum ether and air dried. The resultant Schiff bases are designated as 2a-h and their details are shown as follows.

**Table:-1 Analytical Data and Elemental Analysis of Compounds (2a-h)**

| Compd. | Mol. formula (Mol.wt.) | Yield | M.P.* $^0$C | Elemental Analysis | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | % C | | % H | | % N | |
| | | | | Found | Calcd. | Found | Calcd. | Found | Calcd. |
| **2 a** | $C_{19}H_{13}N_3O_2$ (315) | 72 | 205-207 | 72.3 | 72.37 | 4.1 | 4.16 | 13.2 | 13.33 |
| **2 b** | $C_{20}H_{15}N_3O_3$ (345) | 75 | 211-212 | 69.5 | 69.56 | 4.3 | 4.38 | 12.1 | 12.17 |
| **2 c** | $C_{19}H_{13}N_3O_3$ (331) | 78 | 216-217 | 68.8 | 68.88 | 3.9 | 3.95 | 12.6 | 12.68 |
| **2 d** | $C_{19}H_{13}N_3O_3$ (331) | 74 | 204-206 | 68.8 | 68.88 | 3.9 | 3.95 | 12.6 | 12.68 |
| **2 e** | $C_{20}H_{15}N_3O_2$ (329) | 73 | 218-220 | 72.9 | 72.94 | 4.5 | 4.59 | 12.7 | 12.76 |
| **2 f** | $C_{20}H_{13}N_3O_4$ (359) | 72 | 221-222 | 66.8 | 66.85 | 3.6 | 3.65 | 11.6 | 11.69 |
| **2 g** | $C_{20}H_{15}N_3O_4$ (361) | 75 | 218-219 | 66.4 | 66.48 | 4.1 | 4.18 | 11.5 | 11.63 |
| **2 h** | $C_{23}H_{21}N_3O_4$ (403) | 71 | 222-225 | 68.4 | 68.47 | 5.2 | 5.25 | 10.3 | 10.42 |

***** Uncorrected

**Table:-2Spectral Data of Compounds (2a-h)**

| Compd. | IR cm$^{-1}$ | NMR ppm |
|---|---|---|
| **2 a** | 3040 (Ar-H), 1655 (C=N), 1110 (C-O-C) | 6.6–7.9 (12H, m, Ar-H), 8.4 (1H, s, -N=CH) |
| **2 b** | 3045 (Ar-H), 1650 (C=N), 1095,1200 (C-O-C) | 6.6–7.9 (11H, m, Ar-H), 8.4 (1H, s, -N=CH) 3.7 (3H, s, -$OCH_3$) |
| **2 c** | 3450 (OH), 3030 (Ar-H), 1652 (C=N), 1112 (C-O-C) | 6.6–7.9 (11H, m, Ar-H), 8.4 (1H, s, -N=CH) 4.3 (1H, s, -OH) |
| **2 d** | 3430 (OH), 3030 (Ar-H), 1652 (C=N), 1114 (C-O-C) | 6.6–7.9 (11H, m, Ar-H), 8.4 (1H, s, -N=CH) 4.2 (1H, s, -OH) |
| **2 e** | 3032 (Ar-H), 1655 (C=N), 1110 (C-O-C) | 6.6–7.9 (11H, m, Ar-H), 8.4 (1H, s, -N=CH) 2.3 (3H, s, -$CH_3$) |
| **2 f** | 3035 (Ar-H), 1655 (C=N), 1098 (C-O-C) | 6.3–7.9 (10H, m, Ar-H), 8.4 (1H, s, -N=CH) |

| | | |
|---|---|---|
| | | 5.5 (2H, s, O-$CH_2$-O) |
| **2 g** | 3444 (OH), 3030 (Ar-H), 1650 (C=N), 1095, 1205 (C-O-C) | 6.6–7.9 (10H, m, Ar-H), 8.4 (1H, s, -N=CH) 3.7 (3H, s, -$OCH_3$) 4.3 (1H, s, -OH) |
| **2 h** | 3036 (Ar-H), 1655 (C=N), 1098,1202 (C-O-C) | 6.6–7.9 (10H, m, Ar-H), 8.4 (1H, s, -N=CH) 2.1 (6H, s, -2$CH_3$) 3.7 (4H, s, -2$CH_2$) |

- **Synthesis of 4-Thiazolidinones derivatives(3a-h).**

The Schiff bases of 4-(5-furan-2-yl)-1,3,4-oxadiazol-2-yl)aniline **(1)**were prepared by reportedmethod [30-32].

A mixture of Schiff bases (2a-h) (0.01 mole) in THF (30ml) and mercapto acetic acid (thioglycolic acid) (0.01 mole) with a pinch of anhydrous $ZnCl_2$ was refluxed for 12 hours. The solvent was then removed to get a residue, which was dissolved in benzene and passed through column of silica gel using benzene: chloroform (8:2; v/v) mixture as eluent. The eluate was concentrated and the product crystallized from alcohol to give 4-thiazolidinones (5a-h).The analytical and spectra data of compounds (5a-h) are described in **Table-3**.

**Table:-3 Analytical Data and Elemental Analysis of Compounds (3a-h)**

| C. | Mol. formula (Mol.wt.) | Yield | M.P.* $^0$C | Elemental Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | % C | | % H | | % N | | % S | |
| | | | | Found | Cal. | Found | Cal. | Found | Cal. | Found | Cal. |
| **3a** | $C_{21}H_{15}N_3O_3S$ (389) | 70 | 221-223 | 64.7 | 64.77 | 3.8 | 3.88 | 10.7 | 10.79 | 8.1 | 8.23 |
| **3b** | $C_{22}H_{17}N_3O_4S$ (419) | 72 | 228-230 | 62.9 | 63.00 | 4.0 | 4.09 | 9.9 | 10.02 | 7.6 | 7.64 |
| **3c** | $C_{21}H_{15}N_3O_4S$ (405) | 74 | 226-227 | 62.1 | 62.21 | 3.7 | 3.73 | 10.3 | 10.36 | 7.8 | 7.91 |
| **3d** | $C_{21}H_{15}N_3O_4S$ (405) | 75 | 222-224 | 62.1 | 62.21 | 3.7 | 3.73 | 10.3 | 10.36 | 7.8 | 7.91 |
| **3e** | $C_{22}H_{17}N_3O_3S$ (403) | 72 | 232-233 | 65.4 | 65.49 | 4.2 | 4.25 | 10.3 | 10.42 | 7.9 | 7.95 |
| **3f** | $C_{22}H_{15}N_3O_5S$ (433) | 68 | 235-237 | 60.9 | 60.96 | 3.4 | 3.49 | 9.6 | 9.69 | 7.3 | 7.40 |
| **3g** | $C_{22}H_{17}N_3O_5S$ (435) | 70 | 230-231 | 60.6 | 60.68 | 3.9 | 3.93 | 9.6 | 9.65 | 7.3 | 7.36 |
| **3h** | $C_{25}H_{23}N_3O_5S$ (477) | 68 | 237-238 | 62.8 | 62.88 | 4.8 | 4.85 | 8.7 | 8.80 | 6.6 | 6.71 |

***** Uncorrected

**Table:-4Spectral Data of Compounds (3a-h)**

| Compd. | IR cm$^{-1}$ | NMR ppm |
|---|---|---|
| **3 a** | 3080 ($CH_2$ of thiazolidinone), 3032 (Ar-H), 1690 (C=O), 1654 (C=N), 1112 (C-O-C), 718 (C-S-C) | 6.5–8.2 (12H, m, Ar-H), 3.8 (2H, s, -$CH_2$), 5.8 (1H, s, $C_2H$) |
| **3 b** | 3085 ($CH_2$ of thiazolidinone), 3040 (Ar-H), 1695 (C=O), 1650 (C=N), 1105,1205 (C-O-C), 720 (C-S-C) | 6.5–8.2 (11H, m, Ar-H), 3.8 (2H, s, -$CH_2$), 5.8 (1H, s, $C_2H$) 3.9 (3H, s, -$OCH_3$) |
| **3 c** | 3080 ($CH_2$ of thiazolidinone), 3439 (OH), 3036 (Ar-H), 1692 (C=O), 1648 (C=N), 1111 (C-O-C), 718 (C-S-C) | 6.5–8.2 (11H, m, Ar-H), 3.8 (2H, s, -$CH_2$), 5.9 (1H, s, $C_2H$) 4.4 (1H, s, -OH) |
| **3 d** | 3080 ($CH_2$ of thiazolidinone), 3428 (OH), 3035 (Ar-H), 1694 (sC=O), 1652 (C=N), 1113 (C-O-C), 718 (C-S-C) | 6.5–8.2 (11H, m, Ar-H), 3.8 (2H, s, -$CH_2$), 5.9 (1H, s, $C_2H$) 4.2 (1H, s, -OH) |
| **3 e** | 3090 ($CH_2$ of thiazolidinone), 3040 (Ar-H), 1690 (C=O), 1651 (C=N), 1115 (C-O-C), 718 (C-S-C) | 6.5–8.2 (11H, m, Ar-H), 3.9 (2H, s, -$CH_2$), 5.8 (1H, s, $C_2H$) 2.1 (3H, s, -$CH_3$) |
| **3 f** | 3080 ($CH_2$ of thiazolidinone), 3035 (Ar-H), 1688 (C=O), 1654 (C=N), 1110 (C-O-C), 720 (C-S-C) | 6.5–8.2 (10H, m, Ar-H), 3.8 (2H, s, -$CH_2$), 5.9 (1H, s, $C_2H$), 5.4 (2H, s, O-$CH_2$-O) |
| **3 g** | 3085 ($CH_2$ of thiazolidinone), 3450 (OH), 3040 (Ar-H), 1680 (C=O), 1650 (C=N), 1107,1212 (C-O-C), 718 (C-S-C) | 6.5–8.2 (10H, m, Ar-H), 3.8 (2H, s, -$CH_2$), 5.9 (1H, s, $C_2H$) 3.9(3H, s, -$OCH_3$) 4.3 (1H, s, -OH) |
| **3 h** | 3085 ($CH_2$ of thiazolidinone), 3038 (Ar-H), 1690 (C=O),1655 (C=N), 1106,1207 (C-O-C), 720 (C-S-C) | 6.5–8.2 (10H, m, Ar-H), 3.8 (2H, s, -$CH_2$), 5.8 (1H, s, $C_2H$) 2.2 (6H, s, -$2CH_3$) 3.4 (4H, s, -$2CH_2$) |

- **Synthesis of 2-Azetidinones derivatives(4a-h).**

The Schiff bases of 4-(5-furan-2-yl)-1,3,4-oxadiazol-2-yl)aniline **(1)**were prepared by reportedmethod [30-32].

A mixture of Schiff base (2a-h) (0.002 mole) and triethyl amine (TEA) (0.004 mole) was dissolved in 1,4-dioxane (50 ml), cooled, and stirred. To this well-stirred cooled solution

chloroacetyl chloride (0.004 mole) was added drop wise within a period of 30 minutes. The reaction mixture was then stirred for an additional 3 hours and left at room temperature for 48 hours. The resultant mixture was concentrated, cooled, poured into ice-cold water, and then air-dried. The product thus obtained was purified by column chromatography over silica gel using 30% ethyl acetate: 70% benzene as eluent. Recrystallization from ether/n-hexane gave 2-azetidinone (4a-h). The analytical and spectral data of compounds (4a-h) are described in **Table-5**.

**Table:-5 Analytical Data and Elemental Analysis of Compounds (3a-h)**

| Compd. | Mol. formula (Mol.wt.) | Yield | M.P.* $^0$C | Elemental Analysis | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | % C | | % H | | % N | |
| | | | | Found | Calcd. | Found | Calcd. | Found | Calcd. |
| **4 a** | $C_{21}H_{14}ClN_3O_3$ (391) | 75 | 232-233 | 64.3 | 64.37 | 3.5 | 3.60 | 10.7 | 10.72 |
| **4 b** | $C_{22}H_{16}ClN_3O_4$ (421) | 70 | 238-239 | 62.6 | 62.64 | 3.8 | 3.82 | 9.9 | 9.96 |
| **4 c** | $C_{21}H_{14}ClN_3O_4$ (407) | 72 | 246-248 | 61.8 | 61.85 | 3.4 | 3.46 | 10.2 | 10.30 |
| **4 d** | $C_{21}H_{14}ClN_3O_4$ (407) | 74 | 240-241 | 61.8 | 61.85 | 3.4 | 3.46 | 10.2 | 10.30 |
| **4 e** | $C_{22}H_{16}ClN_3O_3$ (405) | 78 | 252-255 | 65.0 | 65.11 | 3.9 | 3.97 | 10.3 | 10.35 |
| **4 f** | $C_{22}H_{14}ClN_3O_5$ (435) | 69 | 248-250 | 60.6 | 60.63 | 3.2 | 3.24 | 9.6 | 9.64 |
| **4 g** | $C_{22}H_{16}ClN_3O_5$ (437) | 70 | 242-243 | 60.3 | 60.35 | 3.6 | 3.68 | 9.5 | 9.60 |
| **4 h** | $C_{25}H_{22}ClN_3O_5$ (479) | 68 | 250-251 | 62.5 | 62.57 | 4.5 | 4.62 | 8.7 | 8.76 |

***** Uncorrected

**Table:-6Spectral Data of Compounds (4a-h)**

| Compd. | IR cm$^{-1}$ | NMR ppm |
|---|---|---|
| **4 a** | 3037 (Ar-H), 1742 (C=O), 1652 (C=N), 1108 (C-O-C) | 6.8–8.1 (12H, m, Ar-H), 5.7 (1H, s, $C_3H$ ofβ-lactam) 5.3 (1H, s, $C_2H$) |
| **4 b** | 3045 (Ar-H), 1750 (C=O), 1650 (C=N), 1101, 1210 (C-O-C) | 6.8–8.1(11H, m, Ar-H), 5.7(1H, s, $C_3H$ ofβ-lactam) 5.3 (1H, s, $C_2H$) 3.6 (3H, s, -$OCH_3$) |
| **4 c** | 3439 (OH), 3042 (Ar-H), 1745 (C=O), 1654 (C=N), 1115 (C-O-C) | 6.8–8.1(11H, m, Ar-H), 5.6 (1H, s, $C_3H$ ofβ-lactam) 5.3 (1H, s, $C_2H$) 4.4 (1H, s, -OH) |
| **4 d** | 3428 (OH), 3045 (Ar-H), 1743 (C=O), 1658 (C=N), 1112 (C-O-C) | 6.8–8.1(11H, m, Ar-H), 5.7 (1H, s, $C_3H$ ofβ-lactam) |

| | | |
|---|---|---|
| | | 5.3 (1H, s, $C_2H$)<br>4.2 (1H, s, -OH) |
| **4 e** | 3035 (Ar-H), 1748 (C=O), 1656 (C=N), 1111 (C-O-C) | 6.8–8.1(11H, m, Ar-H),<br>5.7 (1H, s, $C_3H$ ofβ-lactam)<br>5.3 (1H, s, $C_2H$)<br>2.3 (3H, s, -$CH_3$) |
| **4 f** | 3048 (Ar-H), 1740 (C=O), 1655 (C=N), 1115 (C-O-C) | 6.8–8.1 (10H, m, Ar-H),<br>5.7 (1H, s, $C_3H$ ofβ-lactam)<br>5.2 (1H, s, $C_2H$)<br>5.4 (2H, s, O-$CH_2$-O) |
| **4 g** | 3450 (OH), 3040 (Ar-H), 1738 (C=O), 1652 (C=N), 1110, 1208 (C-O-C) | 6.8–8.1(10H, m, Ar-H),<br>5.6 (1H, s, $C_3H$ ofβ-lactam)<br>5.3 (1H, s, $C_2H$)<br>3.6 (3H, s, -$OCH_3$)<br>4.3 (1H, s, -OH) |
| **4 h** | 3032 (Ar-H), 1742 (C=O), 1658 (C=N), 1112, 1204 (C-O-C) | 6.8–8.1(10H, m, Ar-H),<br>5.7 (1H, s, $C_3H$ ofβ-lactam)<br>5.2 (1H, s, $C_2H$)<br>2.1 (6H, s, -$2CH_3$)<br>3.6 (4H, s, -$2CH_2$) |

**ii-3Biological evaluation**

- **The culture medium preparation**

Nutrient agar medium was used. Chemical composition of the medium was,

| | |
|---|---|
| Peptone | 1.0 gm |
| NaCl | 0.5 gm |
| Meat extract | 0.3 gm |
| Distilled water | 100 ml |
| pH | 7.6 |
| Agar | 2.0 gm |

The ingredient were weighed and dissolved in distilled water, pH was adjusted to 7.6 and then agar power was added to it. The medium was dispensed in 25 ml quantity in different test-tubes. The test-tubes were plugged by cotton-wool and sterilized at 121.5$^{O}$C and 15 pounds per square inch (psi) pressure for 15 minutes.

- **Antibacterial susceptibility testing**

The study has been conducted according to the method adopted by Cruickshank et al [33]. Nutrient agar broth was melted in a water bath and cooked to 45$^{O}$C with gentle shaking to bring about uniform cooling. It was inoculated with 0.5-0.6 ml of 24 hour old culture especially

and mixed well by gentle shaking before pouring on the sterilized Petri dish (25 ml each). The poured material was allowed to set (1.5 hour) and there after the "cups" were made by punching into the agar surface with a sterile cork borer and sooping out the punched part of agar. Into this "cups" 0.1 ml of test solution (prepared by dissolving 10gm of sample in 10ml DMF) was added by sterile micropipette. The plates were noted.

**Table:-7Biological evaluation of Compounds**

| **Comps.** | **Zone of inhibition (in mm)** | | | |
|---|---|---|---|---|
| | **Gram positive** | | **Gram negative** | |
| | **B.Subtillis** | **S.Aureus** | **E.Coli** | **Ps.Aeruginosa** |
| DMF | 5 | 5 | 5 | 5 |
| Ampicillin | 19 | 15 | 20 | 21 |
| Tetracyclin | 21 | 19 | 15 | 24 |
| Gentamycin | 20 | 18 | 19 | 22 |
| **2a** | 15 | 14 | 13 | 14 |
| **2b** | 15 | 16 | 14 | 12 |
| **2c** | 14 | 14 | 15 | 13 |
| **2d** | 12 | 13 | 13 | 12 |
| **2e** | 14 | 11 | 10 | 10 |
| **2f** | 21 | 20 | 18 | 22 |
| **2g** | 20 | 21 | 17 | 19 |
| **2h** | 18 | 15 | 19 | 18 |
| 3a | 10 | 13 | 09 | 08 |
| 3b | 19 | 17 | 17 | 20 |
| 3c | 12 | 11 | 08 | 07 |
| 3d | 11 | 13 | 15 | 10 |
| 3e | 10 | 12 | 11 | 14 |
| 3f | 10 | 12 | 11 | 13 |
| 3g | 18 | 15 | 16 | 15 |
| 3h | 18 | 17 | 19 | 21 |
| **4a** | 07 | 09 | 12 | 10 |
| **4b** | 11 | 10 | 11 | 12 |
| **4c** | 18 | 17 | 19 | 16 |
| **4d** | 16 | 19 | 21 | 20 |
| **4e** | 10 | 07 | 11 | 08 |
| **4f** | 14 | 11 | 10 | 11 |
| **4g** | 20 | 21 | 17 | 19 |
| **4h** | 13 | 12 | 10 | 10 |

**ii-4Results and Discussion**

Melting points (°C) of all the compounds were measured by capillary method. All the mp's were uncorrected. The yields of all compounds reported are of crystallized. All solvents used were distilled and dried. The purity of the compounds was checked by TLC. Column chromatography was performed on silica gel (60-120 mesh). C, H, N and S contents of all the compounds were recorded on Thermofinigen 1101 Flash elemental analyzer. IR spectra were recorded in KBr pellets on Nicolet 760D spectrophotometer. PMR spectra were recorded on Bruker NMR spectro-photometer. PMR chemical shifts are recorded using TMS as an internal standard in $CDCl_3/D_6$-DMSO.

All the Schiff bases from4-(5-furan-2-yl)-1,3,4-oxadiazol-2-yl)aniline are in amorphous form and soluble in polar organic solvents. The C, H, N **(Table-1)**contents of all the Schiff bases are consistent with the predicted structures. The infrared spectral **(Table 2)** data are given in details of each compound. All the spectra comprises the important IR spectral features of aromatic, furan ring and –C=N- group.

The $^1H$ NMR spectra **(Table 2)**of all Schiff bases shows the signal for aromatic protons in the range of 6.6 to 7.9 ppm. The spectrum of all compounds shows the signal for -N=CH group.

Schiff bases (2a-h) on cyclo-condensation reaction with thioglycolic acid (mercapto acetic acid) in the presence of anhydrous $ZnCl_2$ yields 4-thiazolidinones (3a-h). Their structures were confirmed by analytical and spectral data. The C, H, N and S contents of the prepared compounds were consistent with their predicted structures as shown in **Scheme-1**. The analytical and spectral data of the compounds (3a-h) are shown in **Table-3**. The infrared spectra show the band in the region ~1690 $cm^{-1}$ for carbonyl group of 4-thiazolidinone ring.

The NMR spectra **(Table-4)**show a signal at ~5.9 ppm for $CH_2$ protons at position-5 in the 4-thiazolidinone ring and a signal at ~3.8 ppm for CH protons at position-2 of the 4-thiazolidinone ring. All other signals are at their respective positions for the respective protons in the NMR spectra.

The Schiff bases (3a-h) on cyclocondensation reaction with chloroacetyl chloride in the presence of triethylamine (TEA) affords the biologically active 2-azetidinone (β-lactam) derivatives (4a-h).

Their structures were confirmed by analytical and spectral data. The C, H, and N contents of the prepared compounds**(Table-5)** were consistent with their predicted structures as shown in **Scheme-1**. The infrared spectra show the band in the region ~1750cm$^{-1}$ for carbonyl (>C=O) group, which is the characteristic band for the cyclic β-lactam ring.

The proton magnetic resonance spectra of the prepared compounds (4a-h) showband at ~5.7 ppm for $C_3H$ of β-lactam in the 2-azetidinone ring and other at ~5.3ppm for CH proton at position-2 in the ring. All other signals are at their respective positions in the PMR spectrum.

Ampicilli, Tetracycline andGentamycin were used as standard drugs and a solvent control was also run to know the activity of solvent.

Activity of standards and inhibition due to DMF (solvent) are given in **Table-7**. The results **(Table-7)**shown by compounds and standards are corrected for DMF.

Comparison of antimicrobial activity of produced compounds with that of standard antimicrobial drugs reveals that the produce compounds (Schiff Bases, 2-Azetidinones, 4-Thiazolidinones) shows moderate to good activity against all four bacterial strains.

Among*N*-(benzylidene)-4-(5-(furan-2-yl)-1,3,4-oxidiazol-2-yl)aniline**(Table-7, 2a-h)**compounds 2f, 2g and 2h shows good antimicrobial activity.

Among3-(4-(5-(furan-2-yl)-1,3,4-oxidiazol-2-yl)phenyl)-2-phenylthiazolidin-4-one**(Table-7, 3a-h)** compound 4c,4dand 4g show good antimicrobial activity.

Among3-chloro-1-(4-(5-(furan-2-yl)-1,3,4-oxidiazol-2-yl)phenyl)-2-phenylazetidin-2-one**(Table-7, 4a-h)**compounds, 5b, 5g and 5h show good antimicrobial activity.**REFERENCES:**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