Chapter 6
Synthesis of 2-(substituted) benzylidene hydrazino-5-arylamino-1,3,4-thiadiazoles.

Chapter 7
Synthesis of 3-phenylimino-4-[2'-(substituted) alkyl/benzyl-idene amino] phenyl-5-arylimino-1,2,4-dithiazolidines.
Chapter - 6

Synthesis of 2-(substituted) benzylidene hydrazino-5-arylamino-1,3,4-thiadiazoles
Formation of dibromo derivatives

Abstract

2-Substituted benzylidene hydrazino-5-arylamino-1,3,4-thiadiazoles (IV) have been synthesized by the condensation of 1-(N-aryl thioamido)-3-thiocarbohydrazides (II) and different aromatic aldehydes in benzene medium, followed by intramolecular cyclization of compounds (III) in refluxing ethanol medium. The former in turn have been prepared by the reaction of aryl isothiocyanates and thiocarbohydrazide (I). Compounds (IV) on bromination with bromine in glacial acetic acid afforded dibromo derivatives (V). The structures of all these synthesized compounds were confirmed on the basis of chemical transformation, elemental analysis, equivalent weight determination, IR, $^1$H-NMR and Mass spectral studies.

Introduction

Synthesis of various types of 1,3,4-thiadiazoles with sulphur and nitrogen at different positions have been reported in the literature.$^{1-7}$ Some 1,3,4-thiadiazoles and 1,2,4-thiadiazole are found to be possess plant growth promoting and antitumour activity.$^{8,9}$ As well large number of 1,3,4-thiadiazoles and their derivatives are found to show antibacterial,$^{10-12}$ fungicidal,$^{13-14}$ amebicidal$^{15}$ activities. In this chapter we are reporting some new 2-(substituted) benzylidene hydrazino-5-arylamino-1,3,4-thiadiazoles and their dibromo derivatives.
Results and Discussion

The compounds, 1-(N-aryl thioamido)-3-thiocarbohydrazides (IIa-f) were prepared by refluxing the mixture of thiocarbohydrazide (I) (0.01 mole) and aryl isothiocyanates (0.01 mole) in benzene medium for 2.0 hr as described in Chapter - 5.

Preparation of 1-(N-p-tolyl thioamido)-5-(2'-hydroxy) benzylidene thiocarbohydrazide (IIIa):

1-(N-p-tolyl thioamido)-5-(2'-hydroxy) benzylidene thiocarbohydrazide (IIIa) was prepared by refluxing the mixture of 1-(N-p-tolyl thioamido)-3-thiocarbohydrazide (IIa) (0.01 mole) and (2'-hydroxy) benzaldehyde (0.01 mole) in benzene (15.0 ml) medium for 2.0 hr. On completion of reaction and distilling off the solvent, a white solid powder was obtained. It was crystallized from benzene, yield 87%, m.p. 145°C.

Properties of (IIIa):

1. The compound was white coloured solid having melting point 145°C.
2. From analytical data, molecular formula was found to be C_{16}H_{17}N_{5}S_{2}O_{1}.
3. It was insoluble in water but soluble in organic solvents such as benzene, acetone, DMSO etc.

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4. It gave positive test for N and S elements.
5. It was found to be desulphurisable when boiled with alkaline lead acetate solution.
6. **IR Spectrum:**
   
   The IR\textsuperscript{16,17} spectral analysis of compound (IIIa) showed the presence of following absorption bands. (Plate No.- 6.1)

<table>
<thead>
<tr>
<th>Absorption observed (cm\textsuperscript{-1})</th>
<th>Assignment</th>
<th>Literature value (cm\textsuperscript{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3369</td>
<td>O–H stretching</td>
<td>3600 - 3200</td>
</tr>
<tr>
<td>3263</td>
<td>N–H stretching</td>
<td>3500 - 3100</td>
</tr>
<tr>
<td>1620</td>
<td>C=N stretching</td>
<td>1690 - 1470</td>
</tr>
<tr>
<td>1319</td>
<td>C–N stretching</td>
<td>1350 - 1280</td>
</tr>
<tr>
<td>1215</td>
<td>N–N stretching</td>
<td>1225 - 1200</td>
</tr>
<tr>
<td>799</td>
<td>C–S stretching</td>
<td>800 - 600</td>
</tr>
</tbody>
</table>

7. **\textsuperscript{1}H-NMR Spectrum:**
   
   The \textsuperscript{1}H-NMR spectral analysis of compound (IIIa) showed the presence of following peaks (Plate No.- 6.2). The chemical shift can be correlated as below.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Signal position (δ ppm)</th>
<th>Relative No. of H-atoms</th>
<th>Multiplicity</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.34</td>
<td>3H</td>
<td>Singlet</td>
<td>Ar–CH\textsubscript{3}</td>
</tr>
<tr>
<td>2</td>
<td>6.99-7.47</td>
<td>4H</td>
<td>Multiplet</td>
<td>Ar–H</td>
</tr>
<tr>
<td>3</td>
<td>8.38</td>
<td>1H</td>
<td>Singlet</td>
<td>CH=\textsuperscript{N}</td>
</tr>
<tr>
<td>4</td>
<td>9.44</td>
<td>2H</td>
<td>Singlet</td>
<td>NH,NH</td>
</tr>
<tr>
<td>5</td>
<td>9.87</td>
<td>2H</td>
<td>Singlet</td>
<td>NH,NH</td>
</tr>
<tr>
<td>6</td>
<td>10.66</td>
<td>1H</td>
<td>Singlet</td>
<td>Ar–OH</td>
</tr>
</tbody>
</table>
Table - 6.1

Synthesis of 1-(N-aryl thioamido)-5-(substituted) benzylidene thiocarbohydrazides (III)
Reactants : - 1-(N-arylamido)-3-thiocarbohydrazides (II) (0.01 mole) and different aromatic aldehydes (II) (0.02 mole)

<table>
<thead>
<tr>
<th>1-(N-aryl thioamido)-5-(substituted) benzylidene thiocarbohydrazides (III)</th>
<th>Yield (%)</th>
<th>M.P. (°C)</th>
<th>Elemental analysis Found (Calcd.) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-(N-p-tolyl thioamido)-5-(2'-hydroxy) benzylidene thiocarbohydrazide</td>
<td>(IIIa)</td>
<td>87</td>
<td>145</td>
</tr>
<tr>
<td>1-(N-p-tolyl thioamido)-5-benzylidene thiocarbohydrazide</td>
<td>(IIIb)</td>
<td>79</td>
<td>139</td>
</tr>
<tr>
<td>....... (N-m-tolyl thioamido)-5-benzylidene .............</td>
<td>(IIIc)</td>
<td>77</td>
<td>130</td>
</tr>
<tr>
<td>....... (N-o-tolyl thioamido)-5-benzylidene .............</td>
<td>(IIId)</td>
<td>74</td>
<td>130</td>
</tr>
<tr>
<td>....... (N-m-chlorophenyl thioamido)-5-benzylidene ......</td>
<td>(IIIg)</td>
<td>84</td>
<td>135</td>
</tr>
<tr>
<td>....... (N-p-chlorophenyl thioamido)-5-benzylidene ......</td>
<td></td>
<td>87</td>
<td>138</td>
</tr>
<tr>
<td>1-(N-aryl thioamido)-5-(substituted) benzylidene thiocarbohydrazides (III)</td>
<td>Yield (%)</td>
<td>M.P. (°C)</td>
<td>Elemental analysis Found (Calcd.) (%)</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>------------</td>
<td>-----------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>1-(N-p-tolyl thioamido)-5-(4-hydroxy) benzylidene thiocarbohydrazide</td>
<td>(IIIh)</td>
<td>77</td>
<td>18.65 (18.76) 17.04 (17.15)</td>
</tr>
<tr>
<td>.............................................................................</td>
<td>(IIIi)</td>
<td>80</td>
<td>18.55 (18.76) 16.97 (11.15)</td>
</tr>
<tr>
<td>.............................................................................</td>
<td>(IIIj)</td>
<td>72</td>
<td>18.70 (18.76) 17.01 (11.15)</td>
</tr>
<tr>
<td>.............................................................................</td>
<td>(IIIk)</td>
<td>83</td>
<td>19.40 (19.49) 17.75 (17.82)</td>
</tr>
<tr>
<td>.............................................................................</td>
<td>(IIIm)</td>
<td>85</td>
<td>17.75 (17.81) 16.55 (16.68)</td>
</tr>
<tr>
<td>.............................................................................</td>
<td>(IIIm)</td>
<td>89</td>
<td>17.78 (17.81) 16.62 (16.68)</td>
</tr>
</tbody>
</table>
3. It was insoluble in water but soluble in organic solvents such as benzene, acetone, DMSO etc.

4. It gave positive test for N and S elements.

5. **IR Spectrum**:

   The IR spectral analysis of compound (IVa) showed the presence of following absorption bands. (Plate No.-6.3)

<table>
<thead>
<tr>
<th>Absorption observed (cm⁻¹)</th>
<th>Assignment</th>
<th>Literature value (cm⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3410</td>
<td>O–H stretching</td>
<td>3600 - 3200</td>
</tr>
<tr>
<td>3325</td>
<td>N–H stretching</td>
<td>3500 - 3100</td>
</tr>
<tr>
<td>1618</td>
<td>C=N stretching</td>
<td>1690 - 1470</td>
</tr>
<tr>
<td>1278</td>
<td>C–N stretching</td>
<td>1350 - 1280</td>
</tr>
<tr>
<td>1199</td>
<td>N–N stretching</td>
<td>1225 - 1200</td>
</tr>
<tr>
<td>744</td>
<td>C–S stretching</td>
<td>800 - 600</td>
</tr>
</tbody>
</table>

6. **¹H-NMR Spectrum**:

   The ¹H-NMR spectral analysis of compound (IVa) showed the presence of following peaks (Plate No.-6.4). The chemical shift can be correlated as below.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Signal position (δ ppm)</th>
<th>Relative No. of H-atoms</th>
<th>Multiplicity</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.37</td>
<td>3H</td>
<td>Singlet</td>
<td>Ar–CH₃</td>
</tr>
<tr>
<td>2</td>
<td>6.97-7.68</td>
<td>8H</td>
<td>Multiplet</td>
<td>Ar–H</td>
</tr>
<tr>
<td>3</td>
<td>8.57</td>
<td>1H</td>
<td>Singlet</td>
<td>CH=N</td>
</tr>
<tr>
<td>4</td>
<td>9.2-9.4</td>
<td>2H</td>
<td>Singlet</td>
<td>NH,NH</td>
</tr>
<tr>
<td>5</td>
<td>11.36</td>
<td>1H</td>
<td>Singlet</td>
<td>Ar–OH</td>
</tr>
</tbody>
</table>
7. **Mass Spectrum:**

The Mass spectral analysis of compound (IVa) showed the presence of following molecular ion peaks. (Plate No.-6.5)

<table>
<thead>
<tr>
<th>Molecular ions (m/e)</th>
<th>Fragment ions</th>
<th>Relative intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/Z = 325</td>
<td>M⁺⁻</td>
<td>35</td>
</tr>
<tr>
<td>m/e = 326</td>
<td>(M+1)</td>
<td>40</td>
</tr>
<tr>
<td>m/e = 310</td>
<td>M⁺⁻ – CH₃</td>
<td>36</td>
</tr>
<tr>
<td>m/e = 232</td>
<td>M⁺⁻ – Ph–OH</td>
<td>25</td>
</tr>
<tr>
<td>m/e = 164</td>
<td>M⁺⁻ – C₈H₈N₂S</td>
<td>27</td>
</tr>
<tr>
<td>m/e = 150</td>
<td>PhHNCS⁺</td>
<td>30</td>
</tr>
<tr>
<td>m/e = 107</td>
<td>PhCH₂OH⁺</td>
<td>32.5</td>
</tr>
<tr>
<td>m/e = 120</td>
<td>PhNCH₂O⁺</td>
<td>30</td>
</tr>
<tr>
<td>m/e = 91</td>
<td>Ph–CH₃⁺</td>
<td>25</td>
</tr>
</tbody>
</table>

On the basis of above chemical properties and spectral data, the compound (IVa) has been assigned structure, 2'-(2-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole. The other 1,3,4-thiadiazoles (IVb-m) were prepared by extending the above reaction to (IIIb-m) and the related products were isolated in good yield. (Table 6.2)

**Preparation of N-bromo-bromo-2'-(2-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (Va):**

To the solution of 2'-(2-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVa) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid with vigorous shaking. Within half an hour the reaction mixture solidified. On pouring the reaction mixture into little crushed ice, the
Table - 6.2
Synthesis of 2-(substituted) benzyldene hydrazino-5-arylamino-1,3,4-thiadiazoles (IV)

Reactants : 1-(N-aryl thioamido)-5-(substituted) benzyldene thiocarbohydrazides (III) (2.0 gm) and ethanol (10 ml).

<table>
<thead>
<tr>
<th>2-(substituted) benzyldene hydrazino-5-arylamino-1,3,4-thiadiazoles (IV)</th>
<th>Yield (%)</th>
<th>M.P. (°C)</th>
<th>Elemental analysis; Found (Calcd.) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-(2-hydroxy) benzyldene hydrazino-5-p-tolylamino-1,3,4-thiadiazole</td>
<td>(IVa) 80</td>
<td>169</td>
<td>C 59.09 (59.07) H 4.60 (4.61) N 21.47 (21.53) S 9.80 (9.84)</td>
</tr>
<tr>
<td>2-benzyldene hydrazino-5-p-tolylamino-1,3,4-thiadiazole</td>
<td>(IVb) 89</td>
<td>170</td>
<td>C 62.09 (62.13) H 4.97 (4.85) N 22.60 (22.65) S 10.30 (10.35)</td>
</tr>
<tr>
<td>.......... -phenyl- ..........</td>
<td>(IVe) 74</td>
<td>169</td>
<td>C 60.85 (61.01) H 4.42 (4.40) N 23.68 (23.72) S 10.80 (10.84)</td>
</tr>
<tr>
<td>.......... -m-chlorophenyl- ..........</td>
<td>(IVf) 72</td>
<td>171</td>
<td>C 54.65 (54.71) H 3.44 (3.64) N 21.18 (21.27) S 9.65 (9.72)</td>
</tr>
<tr>
<td>.......... -p-chlorophenyl- ..........</td>
<td>(IVg) 84</td>
<td>175</td>
<td>C 54.82 (54.71) H 3.55 (3.64) N 21.32 (21.27) S 9.56 (9.72)</td>
</tr>
<tr>
<td>2-(substituted) benzylidene hydrazino-5-arylamino-1,3,4-thiadiazoles (IV)</td>
<td>Yield (%)</td>
<td>M.P. (°C)</td>
<td>Elemental analysis; Found (Calcd.) (%)</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------------</td>
<td>-----------</td>
<td>--------------------------------------</td>
</tr>
</tbody>
</table>
| 2-(4-methoxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVh) | 84 | 176 | C: 60.22 (60.17)  
H: 4.95 (5.01)  
N: 20.66 (20.64)  
S: 9.52 (9.43) |
| .................. m-tolyl- ......................... (IVi) | 74 | 170 | C: 59.97 (60.17)  
H: 5.07 (5.01)  
N: 20.45 (20.64)  
S: 9.28 (9.43) |
| .................. o-tolyl- ......................... (IVj) | 75 | 157 | C: 60.01 (60.17)  
H: 4.87 (5.01)  
N: 20.38 (20.64)  
S: 9.34 (9.43) |
| .................. -phenyl- ......................... (IVk) | 78 | 174 | C: 58.94 (59.07)  
H: 4.53 (4.61)  
N: 21.44 (21.53)  
S: 10.02 (9.84) |
| .................. -m-chlorophenyl- ............... (IVl) | 76 | 169 | C: 53.38 (53.48)  
H: 4.04 (3.89)  
N: 19.32 (19.49)  
S: 9.01 (8.91) |
| .................. -p-chlorophenyl- ............... (IVm) | 87 | 175 | C: 53.52 (53.48)  
H: 3.74 (3.89)  
N: 19.52 (19.49)  
S: 8.82 (8.91) |
granular solid was obtained, it was crystallized from aqueous ethanol (70%) and identified as N-bromo-bromo-2'-(2-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (Va), yield 84%, m.p. 194°C.

![Chemical Structure](image)

Properties of (Va):

1. The compound was off white coloured solid having melting point 194°C.
2. From analytical data, molecular formula was found to be $C_{16}H_{15}N_3S_1O_1Br_2$.
3. It was insoluble in water but soluble in organic solvents such as ethanol, benzene, acetone, DMSO etc.
4. It gave positive test for N, S and Br elements.
5. **IR Spectrum:**

    The IR spectral analysis of compound (Va) showed the presence of following absorption bands. (Plate No.-6.6)
<table>
<thead>
<tr>
<th>Absorption observed (cm⁻¹)</th>
<th>Assignment</th>
<th>Literature value (cm⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3429</td>
<td>O–H stretching</td>
<td>3600 - 3200</td>
</tr>
<tr>
<td>3327</td>
<td>N–H stretching</td>
<td>3500 - 3100</td>
</tr>
<tr>
<td>1619</td>
<td>C=≡N stretching</td>
<td>1690 - 1470</td>
</tr>
<tr>
<td>1278</td>
<td>C–N stretching</td>
<td>1350 - 1280</td>
</tr>
<tr>
<td>1200</td>
<td>N–N stretching</td>
<td>1225 - 1200</td>
</tr>
<tr>
<td>745</td>
<td>C–S stretching</td>
<td>800 - 600</td>
</tr>
</tbody>
</table>

6. **¹H-NMR Spectrum**

The ¹H-NMR spectral analysis of compound (Va) showed the presence of following peaks (Plate No.-6.7). The chemical shift can be correlated as below.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Signal position (δ ppm)</th>
<th>Relative No. of H-atoms</th>
<th>Multiplicity</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.37</td>
<td>3H</td>
<td>Singlet</td>
<td>Ar–CH₃</td>
</tr>
<tr>
<td>2</td>
<td>6.90-7.76</td>
<td>8H</td>
<td>Multiplet</td>
<td>Ar–H</td>
</tr>
<tr>
<td>3</td>
<td>9.25</td>
<td>2H</td>
<td>b-Singlet</td>
<td>NH,NH</td>
</tr>
<tr>
<td>4</td>
<td>10.72</td>
<td>1H</td>
<td>Singlet</td>
<td>Ar–OH</td>
</tr>
</tbody>
</table>

On the basis of above chemical properties and spectral data, the compound (Va) has been assigned structure, N-bromo-bromo-2′-(2-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole. The other compounds (Vb-m) were prepared by extending the above reaction to (IVb-m) and the related products were isolated in good yield. (Table 6.3)

The formation of compounds I, II, III, IV and V can be explained by the reaction scheme as follows. (Scheme 6.1)
Table - 6.3
Synthesis of N-bromo-bromo-2-(substituted) benzyldiene hydrazino-5-arylamino-1,3,4-thiadiazoles (V)

Reactants: 2-(Substituted) benzyldiene hydrazino-5-arylamino-1,3,4-thiadiazoles (IV) (0.01 mole) and bromine in acetic acid.

<table>
<thead>
<tr>
<th>N-bromo-bromo-(substituted) benzyldiene hydrazino-5-arylamino-1,3,4-thiadiazoles (V)</th>
<th>Yield (%)</th>
<th>M.P. (°C)</th>
<th>Elemental analysis; Found (Calcd.) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-bromo-bromo-(2-hydroxy) benzyldiene hydrazino-5-p-tolylamino-1,3,4-thiadiazole</td>
<td>(Va) 84</td>
<td>194</td>
<td>48.52 3.48 17.38 8.12 (48.60 3.79 17.72 8.10)</td>
</tr>
<tr>
<td>N-bromo-bromo-benzyldiene hydrazino-5-p-tolylamino-1,3,4-thiadiazole</td>
<td>(Vb) 82</td>
<td>165</td>
<td>50.44 3.75 18.40 8.22 (50.65 3.95 18.46 8.44)</td>
</tr>
<tr>
<td>m-tolyl-</td>
<td>(Vc) 80</td>
<td>152</td>
<td>50.60 3.98 18.44 8.38 (50.65 3.95 18.46 8.44)</td>
</tr>
<tr>
<td>o-tolyl-</td>
<td>(Vd) 74</td>
<td>153</td>
<td>50.56 3.80 18.34 8.32 (50.65 3.95 18.46 8.44)</td>
</tr>
<tr>
<td>-phenyl-</td>
<td>(Ve) 81</td>
<td>170</td>
<td>49.22 3.42 19.11 8.65 (49.31 3.56 19.17 8.76)</td>
</tr>
<tr>
<td>m-chlorophenyl-</td>
<td>(Vf) 79</td>
<td>167</td>
<td>44.97 2.87 17.42 7.94 (45.11 3.00 17.54 8.02)</td>
</tr>
<tr>
<td>p-chlorophenyl-</td>
<td>(Vg) 86</td>
<td>170</td>
<td>45.04 3.04 17.35 7.85 (45.11 3.00 17.54 8.02)</td>
</tr>
<tr>
<td>N-bromo-bromo-(substituted) benzylidene hydrazino-5-arylamino-1,3,4-thiadiazoles (V)</td>
<td>Yield (%)</td>
<td>M.P. (°C)</td>
<td>Elemental analysis; Found (Calcd.) (%)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>N-bromo-bromo-(4-methoxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (Vh)</td>
<td>78</td>
<td>162</td>
<td>C: 49.92 (49.87), H: 4.04 (4.15), N: 17.15 (17.11), S: 7.65 (7.82)</td>
</tr>
<tr>
<td>m-tolyl-</td>
<td>82</td>
<td>156</td>
<td>C: 49.78 (49.87), H: 4.17 (4.15), N: 17.04 (17.11), S: 7.74 (7.82)</td>
</tr>
<tr>
<td>o-tolyl-</td>
<td>80</td>
<td>157</td>
<td>C: 49.75 (49.87), H: 4.08 (4.15), N: 17.10 (17.11), S: 7.70 (7.82)</td>
</tr>
<tr>
<td>-phenyl-</td>
<td>78</td>
<td>170</td>
<td>C: 48.42 (48.60), H: 3.53 (3.75), N: 17.53 (17.72), S: 8.08 (8.10)</td>
</tr>
<tr>
<td>-m-chlorophenyl-</td>
<td>79</td>
<td>164</td>
<td>C: 44.70 (44.75), H: 3.18 (3.26), N: 16.22 (16.31), S: 7.34 (7.45)</td>
</tr>
<tr>
<td>-p-chlorophenyl-</td>
<td>76</td>
<td>168</td>
<td>C: 44.62 (44.75), H: 3.20 (3.26), N: 16.30 (16.31), S: 7.32 (7.45)</td>
</tr>
</tbody>
</table>
\[
\text{H}_2\text{N} - \text{NH} - \text{C} - \text{NH} - \text{NH}_2 + \text{R}-\text{N} = \text{C} = \text{S} \xrightarrow{\text{Benzene} \ (1:1)} \text{H}_2\text{N} - \text{C} - \text{NH} - \text{NH}_2 + \text{R}-\text{N} = \text{C} = \text{S} \\
\text{(I)}
\]

Where,
- \( R = p\text{-tolyl} \)
- \( R = m\text{-tolyl} \)
- \( R = o\text{-tolyl} \)
- \( R = \text{Phenyl} \)
- \( R = m\text{-chlorophenyl} \)
- \( R = \beta\text{-chlorophenyl} \)
- \( R' = \beta\text{-hydroxyphenyl} \)
- \( R' = \text{Phenyl} \)
- \( R' = p\text{-methoxyphenyl} \)

\text{Scheme - 6.1}
Experimental

The melting points of all synthesized compounds were recorded using hot paraffin bath and are uncorrected. The carbon and hydrogen analysis was carried out on 'Carlo-Erba - 1106' analyser. Nitrogen estimation was carried out on 'Colman-N-analyser-29'. The IR spectra were recorded on a 'Perkin Elmer - 577' spectrophotometer in the frequency range 4000-400 cm⁻¹ in Nujol mull and as KBr pellets. ¹H-NMR spectra were recorded on 'Bruker AC-300F' spectrometer with TMS as internal standard using CDCl₃ and DMSO-d₆ as solvents. Mass spectra were recorded on a JEOL SX102/DA-6000 spectrometer using Argon/Xenon (6 kV, 10 mA). Chemicals used were of AR grade. Purity of the compounds was checked on silica gel-G plates by TLC.

The reagents used in the synthesis of 2'-{(substituted) benzylidene hydrazino-5-arylamino-1,3,4-thiadiazoles (IVa-m) have been prepared by the already known methods. Details of typical preparations are as follows.

1. Aryl isothiocyanates:

Aryl isothiocyanates were prepared by the procedure described in "Vogel's Text Book of Practical Organic Chemistry"¹⁸.

2. 1-(N-aryl thioamido)-3-thiocarbohydrazides (II):

These have been prepared by the interaction of thiocarbohydrazide with aryl isothiocyanates in benzene medium. Details of typical preparations are as follows.

Preparation of 1-(N-p-tolyl thioamido)-3-thiocarbohydrazide (IIa):

A mixture of thiocarbohydrazide (I) (0.01 mole) and p-tolyl isothiocyanate (0.01 mole) in benzene (15.0 ml) was refluxed for 2.0 hr. Then benzene was distilling off and granular solid was obtained. It was crystallized from benzene, yield 75%, m.p. 152°C.
Similarly other compounds (IIb-f) were prepared by extending the above reaction to different aryl isothiocyanates and the related products were isolated as described in Chapter 5.

3. 1-(N-aryl thioamido)-5-(substituted) benzylidene thiocarbohydrazides (III):

These have been prepared by the interaction of 1-(N-aryl thioamido)-3-thiocarbohydrazides with different aromatic aldehydes in benzene medium. The details of typical preparations are as follows.

Preparation of 1-(N-p-tolyl thioamido)-5-(2-hydroxy) benzylidene thiocarbohydrazide (IIIa):

A mixture of 1-(N-p-tolyl thioamido)-3-thiocarbohydrazide (IIa) (0.01 mole) and (2-hydroxy) benzaldehyde (0.01 mole) in benzene (10.0 ml) was refluxed for 2.0 hr. On distilling off benzene, a solid residue was obtained. It was crystallized from benzene, yield 78%, m.p. 145°C.

Similarly other compounds (IIIb-m) were prepared by extending the above reaction to different aromatic aldehydes and related products were isolated in good yield. (Table 6.1)
Intramolecular cyclisation of 1-(N-aryl thioamido)-5-(substituted) benzylidene thiocarbohydrazides (III) in ethanolic medium:

Synthesis of 2-(substituted) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazoles (IV):

Experiment No. 1:

Preparation of 2-(2'-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVa):

2.0 gm of 1-(N-p-tolyl thioamido)-5-(2'-hydroxy) benzylidene thiocarbohydrazide (IIla) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. The reaction proceeded with the evolution of hydrogen sulphide gas (tested with lead acetate paper). On cooling the reaction mixture it was poured into water, when a white solid was precipitated. It was crystallized from aqueous ethanol (70%) and identified as 2-(2-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVa), yield 80%, m.p. 169°C, having molecular formula C_{16}H_{15}N_{5}S_{1}O_{1}. (Colour - White)

Experiment No. 2:

Preparation of 2-benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVb):

2.0 gm of 1-(N-p-tolyl thioamido)-5-(2'-hydroxy) benzylidene thiocarbohydrazide (IIla) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2'-benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVb), yield 89%, m.p. 170°C, having molecular formula C_{16}H_{15}N_{5}S_{1}. (Colour - White)
Experiment No. 3 :
Preparation of 2-benzylidene hydrazino-5-\textit{m}-tolylamino-1,3,4-thiadiazole (IVc) :

2.0 gm of 1-(N-\textit{m}-tolyl thioamido)-5-benzylidene thiocarbohydrazide (IIIc) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70\%) and identified as 2-benzylidene hydrazino-5-\textit{m}-tolylamino-1,3,4-thiadiazole (IVc), yield 72\%, m.p. 165°C, having molecular formula C_{16}H_{15}N_{5}S_{1}. (Colour - White)

Experiment No. 4 :
Preparation of 2-benzylidene hydrazino-5-\textit{o}-tolylamino-1,3,4-thiadiazole (IVd) :

2.0 gm of 1-(N-\textit{o}-tolyl thioamido)-5-benzylidene thiocarbohydrazide (IIIId) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70\%) and identified as 2-benzylidene hydrazino-5-\textit{o}-tolylamino-1,3,4-thiadiazole (IVd), yield 79\%, m.p. 145°C, having molecular formula C_{16}H_{15}N_{5}S_{1}. (Colour - White)

Experiment No. 5 :
Preparation of 2-benzylidene hydrazino-5-phenylamino-1,3,4-thiadiazole (IVe) :

2.0 gm of 1-(N-phenyl thioamido)-5-benzylidene thiocarbohydrazide (IIIle) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment
No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2-benzylidene hydrazino-5-phenylamino-1,3,4-thiadiazole (IVe), yield 74%, m.p. 169°C, having molecular formula $C_{16}H_{15}N_{5}S_{1}$. (Colour - White)

Experiment No. 6:
Preparation of 2-benzylidene hydrazino-5-$m$-chlorophenylamino-1,3,4-thiadiazole (IVf):

2.0 gm of 1-(N-$m$-chlorophenyl thioamido)-5-benzylidene thiocarbohydrazide (IIIf) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2-benzylidene hydrazino-5-$m$-chlorophenylamino-1,3,4-thiadiazole (IVf), yield 72%, m.p. 171°C, having molecular formula $C_{15}H_{12}N_{5}S_{1}Cl$. (Colour - White)

Experiment No. 7:
Preparation of 2-benzylidene hydrazino-5-$p$-chlorophenylamino-1,3,4-thiadiazole (IVg):

2.0 gm of 1-(N-$p$-chlorophenyl thioamido)-5-benzylidene thiocarbohydrazide (IIIg) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2-benzylidene hydrazino-5-$p$-chlorophenylamino-1,3,4-thiadiazole (IVg), yield 84%, m.p. 175°C, having molecular formula $C_{15}H_{12}N_{5}S_{1}Cl$. (Colour - White)
Experiment No. 8:
Preparation of 2-(4-methoxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVh):

2.0 gm of 1-(N-p-tolyl thioamido)-5-(4-methoxy) benzylidene thiocarbohydrazide (IIIh) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2-(4-methoxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVh), yield 84%, m.p. 176°C, having molecular formula C\(_{17}\)H\(_{17}\)N\(_5\)S\(_1\)O\(_1\). (Colour - White)

Experiment No. 9:
Preparation of 2-(4-methoxy) benzylidene hydrazino-5-m-tolylamino-1,3,4-thiadiazole (IVi):

2.0 gm of 1-(N-m-tolyl thioamido)-5-(4-methoxy) benzylidene thiocarbohydrazide (IIIi) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2-(4-methoxy) benzylidene hydrazino-5-m-tolylamino-1,3,4-thiadiazole (IVi), yield 74%, m.p. 170°C, having molecular formula C\(_{17}\)H\(_{17}\)N\(_5\)S\(_1\)O\(_1\). (Colour - White)

Experiment No. 10:
Preparation of 2-(4-methoxy) benzylidene hydrazino-5-o-tolylamino-1,3,4-thiadiazole (IVj):

2.0 gm of 1-(N-o-tolyl thioamido)-5-(4-methoxy) benzylidene thiocarbohydrazide (IIIj) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in
Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2-(4-methoxy) benzylidene hydrazino-5-\(\sigma\)-tolylamino-1,3,4-thiadiazole (IV\(j\)), yield 75%, m.p. 157°C, having molecular formula \(\text{C}_{17}\text{H}_{17}\text{N}_{3}\text{S}_{1}\text{O}_{1}\). (Colour - White)

Experiment No. 11 :

**Preparation of 2-(4-methoxy) benzylidene hydrazino-5-phenylamino-1,3,4-thiadiazole (IV\(k\)) :**

2.0 gm of 1-(N-phenyl thioamido)-5-(4-methoxy) benzylidene thiocarbohydrazide (III\(k\)) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2-(4-methoxy) benzylidene hydrazino-5-phenylamino-1,3,4-thiadiazole (IV\(k\)), yield 78%, m.p. 174°C, having molecular formula \(\text{C}_{16}\text{H}_{15}\text{N}_{3}\text{S}_{1}\text{O}_{1}\). (Colour - White)

Experiment No. 12 :

**Preparation of 2-(4-methoxy) benzylidene hydrazino-5-\(m\)-chlorophenyl amino-1,3,4-thiadiazole (IV\(l\)) :**

2.0 gm of 1-(N-\(m\)-chlorophenyl thioamido)-5-(4-methoxy) benzylidene thiocarbohydrazide (III\(l\)) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2-(4-methoxy) benzylidene hydrazino-5-\(m\)-chlorophenylamino-1,3,4-thiadiazole (IV\(l\)), yield 76%, m.p. 169°C, having molecular formula \(\text{C}_{16}\text{H}_{14}\text{N}_{3}\text{S}_{1}\text{O}_{1}\text{Cl}_{1}\). (Colour - White)
Experiment No. 13 :
Preparation of 2-(4-methoxy) benzylidene hydrazino-5-p-chlorophenyl-amino-1,3,4-thiadiazole (IVm) :

2.0 gm of 1-(N-p-chlorophenyl thioamido)-5-(4-methoxy) benzylidene thiocarbohydrazide (Illm) was placed in 10 ml ethanol and reaction mixture was refluxed on water bath for 4.0 hr. On following the procedure as described in Experiment No. 1, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as 2-(4-methoxy) benzylidene hydrazino-5-p-chlorophenylamino-1,3,4-thiadiazole (IVm), yield 87%, m.p. 175°C, having molecular formula C_{16}H_{14}N_{5}S_{1}O_{1}Cl_{1}. (Colour - White)

Interaction of 2-(substituted) benzylidene hydrazino-5-arylamino-1,3,4-thiadiazoles (IV) and bromine in acetic acid (1:1 ratio) :
Synthesis of N-bromo-bromo-2-(substituted) benzylidene hydrazino-5-arylamino-1,3,4-thiadiazoles (V) :

Experiment No. 14 :
Preparation of N-bromo-bromo-2-(2'-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (Va) :

To the solution of 2-(2'-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVa) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid with vigorous shaking, till pink colour persisted. Within half an hour, the reaction mixture solidified. On pouring the reaction mixture into crushed ice, a granular solid was obtained. It was crystallized from aqueous ethanol (70%) and identified as N-bromo-bromo-2-(2'-hydroxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (Va), yield 84%, m.p. 194°C, with molecular formula C_{16}H_{15}N_{5}S_{1}O_{1}Br_{2}. (Colour - Cream).
Experiment No. 15:

**Preparation of N-bromo-bromo-2-benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (Vb):**

To the solution of 2-benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (IVb) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (Vb), yield 82%, m.p. 165°C, with molecular formula $\text{C}_{15}\text{H}_{15}\text{N}_{5}\text{S}_1\text{Br}_2$. (Colour - Whitish yellow).

Experiment No. 16:

**Preparation of N-bromo-bromo-2-benzylidene hydrazino-5-m-tolylamino-1,3,4-thiadiazole (Vc):**

To the solution of 2-benzylidene hydrazino-5-m-tolylamino-1,3,4-thiadiazole (IVc) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-benzylidene hydrazino-5-m-tolylamino-1,3,4-thiadiazole (Vc), yield 80%, m.p. 152°C, with molecular formula $\text{C}_{15}\text{H}_{15}\text{N}_{5}\text{S}_1\text{Br}_2$. (Colour - Whitish yellow).

Experiment No. 17:

**Preparation of N-bromo-bromo-2-benzylidene hydrazino-5-o-tolylamino-1,3,4-thiadiazole (Vd):**

To the solution of 2-benzylidene hydrazino-5-o-tolylamino-1,3,4-thiadiazole (IVd) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly, the
product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-benzylidene hydrazino-5-o-tolylamino-1,3,4-thiadiazole (Vd), yield 74%, m.p. 153°C, having molecular formula $C_{16}H_{15}N_5S_1Br_2$. (Colour - Cream).

**Experiment No. 18:**

**Preparation of N-bromo-bromo-2-benzylidene hydrazino-5-phenylamino-1,3,4-thiadiazole (Ve):**

To the solution of 2-benzylidene hydrazino-5-phenylamino-1,3,4-thiadiazole (IVe) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-benzylidene hydrazino-5-phenylamino-1,3,4-thiadiazole (Ve), yield 81%, m.p. 170°C, with molecular formula $C_{15}H_{13}N_5S_1Br_2$. (Colour - Cream).

**Experiment No. 19:**

**Preparation of N-bromo-bromo-2-benzylidene hydrazino-5-m-chlorophenyl amino-1,3,4-thiadiazole (Vf):**

To the solution of 2-benzylidene hydrazino-5-m-chlorophenyl amino-1,3,4-thiadiazole (IVf) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-benzylidene hydrazino-5-m-chlorophenylamino-1,3,4-thiadiazole (Vf), yield 79%, m.p. 167°C, with molecular formula $C_{15}H_{12}N_5S_1Cl_1Br_2$. (Colour - Cream).
Experiment No. 20:

Preparation of N-bromo-bromo-2-benzylidene hydrazino-5-p-chlorophenyl amino-1,3,4-thiadiazole (Vg):

To the solution of 2-benzylidene hydrazino-5-p-chlorophenyl amino-1,3,4-thiadiazole (IVg) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-benzylidene hydrazino-5-p-chlorophenylamino-1,3,4-thiadiazole (Vg), yield 86%, m.p. 170°C, with molecular formula C_{15}H_{12}N_{2}S_{2}Cl_{1}Br_{2} (Colour - Cream).

Experiment No. 21:

Preparation of N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-p-tolyl amino-1,3,4-thiadiazole (Vh):

To the solution of 2-(4-methoxy) benzylidene hydrazino-5-p-tolyl amino-1,3,4-thiadiazole (IVh) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-p-tolylamino-1,3,4-thiadiazole (Vh), yield 78%, m.p. 162°C, with molecular formula C_{17}H_{17}N_{2}S_{1}O_{1}Br_{2} (Colour - Ash).

Experiment No. 22:

Preparation of N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-m-tolyl amino-1,3,4-thiadiazole (Vi):

To the solution of 2-(4-methoxy) benzylidene hydrazino-5-m-tolyl amino-1,3,4-thiadiazole (IVi) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly,
the product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-<i>m</i>-tolylamino-1,3,4-thiadiazole (Vi), yield 82%, m.p. 156°C, with molecular formula C<sub>17</sub>H<sub>17</sub>N<sub>5</sub>S<sub>1</sub>O<sub>1</sub>Br<sub>2</sub>. (Colour - Ash).

**Experiment No. 23:**

**Preparation of N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-<i>o</i>-tolyl amino-1,3,4-thiadiazole (Vj):**

To the solution of 2-(4-methoxy) benzylidene hydrazino-5-<i>o</i>-tolyl amino-1,3,4-thiadiazole (IVj) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-<i>o</i>-tolylamino-1,3,4-thiadiazole (Vj), yield 80%, m.p. 157°C, with molecular formula C<sub>17</sub>H<sub>17</sub>N<sub>5</sub>S<sub>1</sub>O<sub>1</sub>Br<sub>2</sub>. (Colour - Light yellow).

**Experiment No. 24:**

**Preparation of N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-phenyl amino-1,3,4-thiadiazole (Vk):**

To the solution of 2-(4-methoxy) benzylidene hydrazino-5-phenyl amino-1,3,4-thiadiazole (IVk) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 14. On working out similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-phenylamino-1,3,4-thiadiazole (Vk), yield 78%, m.p. 170°C, with molecular formula C<sub>16</sub>H<sub>15</sub>N<sub>5</sub>S<sub>1</sub>O<sub>1</sub>Br<sub>2</sub>. (Colour - Whitish yellow).
Experiment No. 25:
Preparation of N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-
m-chlorophenyl amino-1,3,4-thiadiazole (VI):

To the solution of 2-(4-methoxy) benzylidene hydrazino-5-m-
chlorophenyl amino-1,3,4-thiadiazole (IV) (0.01 mole) in acetic acid, was
added bromine in glacial acetic acid as described in Experiment No. 14. On
working out similarly, the product obtained was crystallized from aqueous
ethanol (70%) to yield N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-
5-m-chlorophenylamino-1,3,4-thiadiazole (VI), yield 79%, m.p. 164°C, with
molecular formula C_{16}H_{14}N_{5}S_{1}O_{1}Cl_{1}Br_{2}. (Colour - Light yellow).

Experiment No. 26:
Preparation of N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-5-
p-chlorophenyl amino-1,3,4-thiadiazole (Vm):

To the solution of 2-(4-methoxy) benzylidene hydrazino-5-p-
chlorophenyl amino-1,3,4-thiadiazole (IVm) (0.01 mole) in acetic acid, was
added bromine in glacial acetic acid as described in Experiment No. 14. On
working out similarly, the product obtained was crystallized from aqueous
ethanol (70%) to yield N-bromo-bromo-2-(4-methoxy) benzylidene hydrazino-
5-p-chlorophenylamino-1,3,4-thiadiazole (Vm), yield 76%, m.p. 168°C, with
molecular formula C_{16}H_{14}N_{5}S_{1}O_{1}Cl_{1}Br_{2}. (Colour - Light yellow).
References


Chapter - 7

Synthesis of 3-phenylimino-4-[2'--(substituted) alkyl/ benzylidene amino] phenyl-5-arylimino-1,2,4-dithiazolidines

Formation of dibromo derivatives

Abstract

3-Phenylimino-4-[2'--(substituted) alkyl/benzylidene amino] phenyl-5-arylimino-1,2,4-dithiazolidines (IV) have been synthesized by the interaction of N-aryl-S-chloro isothiocarbamoyl chloride and 1-phenyl-3-[2'-(substituted) alkyl/benzylidene amino] phenyl thiocarbamides (II) followed by the basification with dilute ammonium hydroxide solution. The thiocarbamides (II) were prepared by the condensation of 1-phenyl-3-(2'-amino) phenyl thiocarbamide (I) and different aliphatic and aromatic aldehydes. Initially, the parent thiocarbamide (I) was prepared by refluxing the mixture of o-phenylene diamine and phenyl isothiocyanate. Compounds (IV) on bromination in 1:1 ratio with bromine in acetic acid afforded dibromo derivatives (V). The structures of all these synthesized compounds were confirmed on the basis of chemical transformation, elemental analysis, equivalent weight determination, IR, $^1$H-NMR and Mass spectral studies.

Introduction

The chemistry of 1,2,4-dithiazolidines have been extensively studied in past years. The literature has been enriched with progressive finding about the synthesis of 1,2,4-dithiazolidines by using the reagents N-aryl-S-chloro isothiocarbamoyl chloride$^{1-10}$ and by oxidative cyclization using bromine and iodine$^{11-17}$ as well as other routes.$^{18-21}$ It is known from the literature that Schiff's bases exhibit anticancer and antibacterial activities.$^{22-23}$ With the aim to explore synthesis of 3,4,5-substituted-1,2,4-dithiazolidines, the present chapter is dealing the synthesis of such highly substituted 1,2,4-dithiazolidines.
Results and Discussion

The parent compound 1-phenyl-3-(2'-amino) phenyl thiocarbamide (I) was prepared by refluxing the mixture of o-phenylene diamine (0.01 mole) and phenyl isothiocyanate (0.01 mole) in chloroform medium for 2.0 hr. The reaction mixture was cooled and the solvent was distilled off, when a solid was separated. It was washed with petroleum ether (60-80°C) and crystallized from ethanol, yield 75%, m.p. 145°C.

\[
\begin{align*}
\text{NH}_2 & \quad \text{N} = \text{C} = \text{S} \\
\text{CHCl}_3 & \quad (1:1) \\
\text{NH} - \text{C} - \text{NH} & \quad \text{S} \\
\end{align*}
\]

(I)

Preparation of 1-phenyl-3-[2'-(2-hydroxy) benzylidene amino] phenyl thiocarbamide (IIa) :

1-Phenyl-3-(2'-amino) phenyl thiocarbamide (I) (0.01 mole) and (2-hydroxy) benzaldehyde (0.01 mole) in chloroform (10.0 ml) was refluxed for 2.0 hr on a boiling water bath. After completion of reaction, the solvent was distilled off, when a solid was separated. It was washed with petroleum ether (60-80°C) and crystallized from ethanol, yield 78%, m.p. 145°C.

\[
\begin{align*}
\text{NH}_2 & \quad \text{N} = \text{C} = \text{S} \\
\text{OH} & \quad \text{CH}=\text{O} \\
\text{CHCl}_3 & \quad (1:1) \\
\text{NH} - \text{C} - \text{NH} & \quad \text{S} \\
\end{align*}
\]

(IIa)
Properties of (IIa):

1. The compound was turmaric coloured crystalline solid having melting point 145°C.
2. From analytical data, molecular formula was found to be $\text{C}_{26}\text{H}_{17}\text{N}_3\text{S}_1\text{O}_4$.
3. It was insoluble in water but soluble in organic solvents such as chloroform, ether, ethanol etc.
4. It gave positive test for N and S elements.
5. IR Spectrum:

The IR\textsuperscript{24,25} spectral analysis of compound (IIa) showed the presence of following absorption bands. (Plate No.- 7.1)

<table>
<thead>
<tr>
<th>Absorption observed (cm\textsuperscript{-1})</th>
<th>Assignment</th>
<th>Literature value (cm\textsuperscript{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3393</td>
<td>O–H stretching</td>
<td></td>
</tr>
<tr>
<td>3206</td>
<td>N–H stretching</td>
<td></td>
</tr>
<tr>
<td>1600</td>
<td>C=N stretching</td>
<td></td>
</tr>
<tr>
<td>1338</td>
<td>C–N stretching</td>
<td></td>
</tr>
<tr>
<td>1223</td>
<td>C=S stretching</td>
<td></td>
</tr>
</tbody>
</table>

6. $^1$H-NMR Spectrum:

The $^1$H-NMR spectral analysis of compound (IIa) showed the presence of following peaks (Plate No.-7.2). The chemical shift can be correlated as below.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Signal position ($\delta$ ppm)</th>
<th>Relative No. of H-atoms</th>
<th>Multiplicity</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.44</td>
<td>1H</td>
<td>Singlet</td>
<td>CH=N</td>
</tr>
<tr>
<td>2</td>
<td>6.92-7.89</td>
<td>13H</td>
<td>Multiplet</td>
<td>Ar–H</td>
</tr>
<tr>
<td>3</td>
<td>9.37</td>
<td>1H</td>
<td>Singlet</td>
<td>NH</td>
</tr>
<tr>
<td>4</td>
<td>9.61</td>
<td>1H</td>
<td>Singlet</td>
<td>NH</td>
</tr>
<tr>
<td>5</td>
<td>11.12</td>
<td>1H</td>
<td>b-Singlet</td>
<td>Ar–OH</td>
</tr>
</tbody>
</table>
On the basis of above chemical properties and spectral data, the compound (IIa) has been assigned structure, 1-phenyl-3-[2′-(2-hydroxy) benzylidene amino] phenyl thiocarbamide. The other compounds (IIb-h) were prepared by extending the above reaction to different aliphatic and aromatic aldehydes and the related products were isolated in good yield. (Table 7.1)

**Preparation of 3-phenylimino-4-[2′-(2-hydroxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVa):**

1-Phenyl-3-[2′-(2-hydroxy) benzylidene amino] phenyl thiocarbamide (IIa) (0.01 mole) was reacted with N-phenyl-S-chloroisothiocarbamoyl chloride (0.01 mole) in boiling chloroform medium over water bath for 3.0 hr. The evolution of hydrogen chloride gas was clearly noticed. On cooling the reaction mixture and distilling off chloroform afforded a sticky mass, which on washing with petroleum ether (60-80°C) gave a granular solid. The solid was acidic to litmus. It was crystallized from ethanol and on determination of equivalent weight, it was found to be monohydrochloride (IIIa), yield 78%, m.p. 89°C. On basification with dilute ammonium hydroxide solution it afforded a free base, 3-phenylimino-4-[2′-(2-hydroxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVa). It was crystallized from aqueous ethanol, m.p. 84°C.
Plate No. 7.1

Plate No. 7.2
Table - 7.1

Synthesis of 1-phenyl-3-[2'-(substituted) alkyl/benzyl-idene amino] phenyl thiocarbamides (II)

Reactants :- 1-Phenyl-3-(2'-amino) phenyl thiocarbamide (I) (0.01 mole) and aliphatic/aromatic aldehydes (0.01 mole)

<table>
<thead>
<tr>
<th>Aliphatic / Aromatic aldehydes</th>
<th>1-Phenyl-3-[2'-(substituted) alkyl/benzyl-idene amino] phenyl thiocarbamides (II)</th>
<th>Yield (%)</th>
<th>M.P. (°C)</th>
<th>Elemental analysis Found (Calcd.) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Hydroxy benzoaldehyde</td>
<td>1-Phenyl-3-[2'-(2-hydroxy) benzylidene amino] phenyl thiocarbamide (IIa)</td>
<td>78</td>
<td>145</td>
<td>N 11.97 9.18</td>
</tr>
<tr>
<td></td>
<td>2-Hydroxy-4-methoxy benzoaldehyde</td>
<td>75</td>
<td>142</td>
<td>N 11.03 8.34</td>
</tr>
<tr>
<td></td>
<td>4-Chloro benzoaldehyde</td>
<td>77</td>
<td>135</td>
<td>N 11.42 8.70</td>
</tr>
<tr>
<td></td>
<td>4-N,N-Dimethylamino benzoaldehyde</td>
<td>81</td>
<td>134</td>
<td>N 14.85 8.45</td>
</tr>
<tr>
<td></td>
<td>4-Methoxy benzoaldehyde</td>
<td>82</td>
<td>131</td>
<td>N 11.50 8.75</td>
</tr>
<tr>
<td></td>
<td>Benzaldehyde</td>
<td>84</td>
<td>140</td>
<td>N 12.60 9.58</td>
</tr>
<tr>
<td></td>
<td>Acetaldehyde</td>
<td>80</td>
<td>143</td>
<td>N 15.75 11.72</td>
</tr>
<tr>
<td></td>
<td>Furfuraldehyde</td>
<td>75</td>
<td>135</td>
<td>N 12.97 9.88</td>
</tr>
</tbody>
</table>
Properties of (IVa):

1. The compound was turmaric coloured solid having melting point 84°C.
2. From analytical data, molecular formula was found to be \( C_{27}H_{28}N_4S_2O_1 \).
3. It was insoluble in water but soluble in organic solvents such as chloroform, ethanol etc.
4. It gave positive test for N and S elements.
5. It was found to be non-desulphurizable when boiled with alkaline lead acetate solution.
6. On pyrolysis it gave characteristic smell of phenyl isothiocyanate.
7. **IR Spectrum** :

The IR spectral analysis of compound (IVa) showed the presence of following absorption bands. (Plate No.-7.3)

<table>
<thead>
<tr>
<th>Absorption observed (cm^{-1})</th>
<th>Assignment</th>
<th>Literature value (cm^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3754</td>
<td>O-H stretching</td>
<td>3600 - 3200</td>
</tr>
<tr>
<td>1635</td>
<td>C=N stretching</td>
<td>1690 - 1470</td>
</tr>
<tr>
<td>1338</td>
<td>C-N stretching</td>
<td>1350 - 1280</td>
</tr>
<tr>
<td>747</td>
<td>C=S stretching</td>
<td>800 - 600</td>
</tr>
<tr>
<td>511</td>
<td>S-S stretching</td>
<td>550 - 400</td>
</tr>
</tbody>
</table>

8. **¹H-NMR Spectrum** :

The ¹H-NMR spectral analysis of compound (IVa) showed the presence of following peaks (Plate No.-7.4). The chemical shift can be correlated as below.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Signal position (δ ppm)</th>
<th>Relative No. of H-atoms</th>
<th>Multiplicity</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.66-7.98</td>
<td>18H</td>
<td>Multiplet</td>
<td>Ar–H</td>
</tr>
<tr>
<td>2</td>
<td>8.88</td>
<td>1H</td>
<td>Singlet</td>
<td>CH=N</td>
</tr>
<tr>
<td>3</td>
<td>13.20</td>
<td>1H</td>
<td>b-Singlet</td>
<td>Ar–OH</td>
</tr>
</tbody>
</table>

9. **Mass Spectrum** :

The Mass spectral analysis of compound (IVa) showed the presence of following molecular ion peaks. (Plate No.-7.5)
<table>
<thead>
<tr>
<th>Molecular ions (m/e)</th>
<th>Fragment ions</th>
<th>Relative intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/Z = 480</td>
<td>M⁺</td>
<td>0.8</td>
</tr>
<tr>
<td>m/e = 481</td>
<td>(M+1)</td>
<td>95</td>
</tr>
<tr>
<td>m/e = 403</td>
<td>M⁺ - Ph</td>
<td>27</td>
</tr>
<tr>
<td>m/e = 389</td>
<td>M⁺ - Ph-N</td>
<td>27</td>
</tr>
<tr>
<td>m/e = 284</td>
<td>M⁺ - C₁₃H₁₀N₁O</td>
<td>28</td>
</tr>
<tr>
<td>m/e = 210</td>
<td>M⁺ - C₁₄H₁₀N₂S₂</td>
<td>100</td>
</tr>
<tr>
<td>m/e = 120</td>
<td>PhNCH₂O⁺</td>
<td>22</td>
</tr>
<tr>
<td>m/e = 107</td>
<td>PhCHOH⁺</td>
<td>32</td>
</tr>
<tr>
<td>m/e = 93</td>
<td>Ph-OH⁺</td>
<td>50</td>
</tr>
</tbody>
</table>

On the basis of above chemical properties and spectral data, the compound (IVa) has been assigned structure, 3-phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine. The other compounds (IVb-p) were prepared by extending the above reaction to other 1-phenyl-3-[2'-(substituted) alkyl/benzyl-idene amino] phenyl thiocarbamides (IIb-h) and the related dithiazolidines were isolated in good yield. (Table 7.2)

**Preparation of 3-phenylimino-4-[2'-(2-hydroxy) {N-bromo-bromo benzylidene amino}] phenyl-5-phenylimino-1,2,4-dithiazolidine (Va):**

To the solution of 3-phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVa) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid with vigorous shaking, within half an hour the reaction mixture solidified. On pouring the reaction mixture into little crushed ice, the granular solid was obtained. This product was crystallized from aqueous ethanol (70%), yield 78%, m.p. 160°C.
Plate No. 7.5
### Table 7.2

**Synthesis of 3-Phenylimino-4-[2'-(substituted) alkylidene/benzylidene amino] phenyl-5-arylimino-1,2,4-dithiazolidinones (IV)**

Reactants: 1-Phenyl-3-[2'- (substituted) alkylidene/benzylidene amino] phenyl thiocarbamides (II) (0.01 mole) and N-aryl-S-chloro isothiocarbamoyl chloride (0.01 mole)

<table>
<thead>
<tr>
<th>3-Phenylimino-4-[2'-(substituted) alkyl/benzyl-idene amino] phenyl-5-arylimino-1,2,4-dithiazolidine hydrochlorides (III)</th>
<th>Yield (%)</th>
<th>M.P. (°C)</th>
<th>Eq. wt. Found (Calcd.)</th>
<th>3-Phenylimino-4-[2'-(substituted) alkyl/benzyl-idene amino] phenyl-5-arylimino-1,2,4-dithiazolidine (IV)</th>
<th>M.P. (°C)</th>
<th>Elemental analysis Found (Calcd.) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine hydrochloride (IIIA)</td>
<td>78</td>
<td>89</td>
<td>510.0 (516.5)</td>
<td>3-Phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVA)</td>
<td>84</td>
<td>67.48 (4.14) 11.61 (13.32)</td>
</tr>
<tr>
<td>. . . 4-[2'-(2-hydroxy-4-methoxy) benzylidene amino]</td>
<td>74</td>
<td>87</td>
<td>538.0 (546.5)</td>
<td>. . . 4-[2'-(2-hydroxy-4-methoxy) benzylidene amino] (IVB)</td>
<td>85</td>
<td>65.75 (4.22) 10.91 (12.48)</td>
</tr>
<tr>
<td>. . . 4-[2'-(4-chloro) benzylidene amino]</td>
<td>72</td>
<td>92</td>
<td>528.0 (535.0)</td>
<td>. . . 4-[2'-(4-chloro) benzylidene amino] (IVC)</td>
<td>90</td>
<td>65.03 (3.75) 11.18 (12.76)</td>
</tr>
<tr>
<td>. . . 4-[2'-(4-N,N-dimethylamino) benzylidene amino]</td>
<td>75</td>
<td>122</td>
<td>502.0 (507.5)</td>
<td>. . . 4-[2'-(4-N,N-dimethylamino) benzylidene amino] (IVD)</td>
<td>108</td>
<td>68.60 (4.52) 13.72 (12.57)</td>
</tr>
<tr>
<td>. . . 4-[2'-(4-methoxy) benzylidene amino]</td>
<td>78</td>
<td>112</td>
<td>528.0 (530.5)</td>
<td>. . . 4-[2'-(4-methoxy) benzylidene amino] (IVE)</td>
<td>102</td>
<td>67.94 (4.27) 11.28 (12.92)</td>
</tr>
<tr>
<td>. . . 4-[2'-benzylidene amino]</td>
<td>80</td>
<td>126</td>
<td>495.0 (500.5)</td>
<td>. . . 4-(2'-benzylidene amino) (IVF)</td>
<td>121</td>
<td>69.77 (4.28) 12.01 (13.73)</td>
</tr>
<tr>
<td>. . . 4-(2'-ethylidene amino)</td>
<td>77</td>
<td>108</td>
<td>435.0 (438.5)</td>
<td>. . . 4-(2'-ethylidene amino) (IVG)</td>
<td>105</td>
<td>65.61 (4.22) 13.87 (15.85)</td>
</tr>
<tr>
<td>. . . 4-(2'-furfurylidene amino)</td>
<td>69</td>
<td>87</td>
<td>485.0 (491.5)</td>
<td>. . . 4-(2'-furfurylidene amino) (IVH)</td>
<td>85</td>
<td>65.82 (4.11) 12.22 (13.97)</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>3-Phenylimino-4-[2'-(substituted) alkyl/benzyl-idene amino] phenyl-5-arylimino-1,2,4-dithiazolidine hydrochlorides (III)</th>
<th>Yield (%)</th>
<th>M.P. (°C)</th>
<th>Eq. wt. Found (Calcd.)</th>
<th>3-Phenylimino-4-[2'-(substituted) alkyl/benzyl-idene amino] phenyl-5-arylimino-1,2,4-dithiazolidine hydrochlorides (IV)</th>
<th>M.P. (°C)</th>
<th>Elemental analysis Found (Calcd.) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-p-tolylimino-1,2,4-dithiazolidine hydrochloride (IIIa)</td>
<td>78</td>
<td>98</td>
<td>449.0 (454.5)</td>
<td>3-Phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVi)</td>
<td>91</td>
<td>67.94 4.37 11.30 12.87 (68.01 (4.45) (11.33) (12.95)</td>
</tr>
<tr>
<td>...4-[2'-(2-hydroxy-4-methoxy) benzylidene amino] .......... (IIIj)</td>
<td>70</td>
<td>95</td>
<td>556.0 (560.5)</td>
<td>...4-<a href="IVj">2'-(2-hydroxy-4-methoxy)</a></td>
<td>85</td>
<td>66.30 4.47 10.60 12.18 (66.40 (4.58) (10.68) (12.21)</td>
</tr>
<tr>
<td>...4-[2'-(4-chloro) benzylidene amino] .......... (IIIk)</td>
<td>75</td>
<td>102</td>
<td>579.0 (581.0)</td>
<td>...4-[2'-(4-chloro) benzylidene (IVk)</td>
<td>100</td>
<td>61.70 3.82 10.18 11.78 (61.76 (3.86) (10.29) (11.76)</td>
</tr>
<tr>
<td>...4-[2'-(4-N,N-dimethylamino) benzylidene amino] .......... (IIIl)</td>
<td>77</td>
<td>118</td>
<td>546.0 (557.0)</td>
<td>...4-<a href="IVl">2'-(4-N,N-dimethylamino)</a></td>
<td>104</td>
<td>68.97 4.14 13.41 12.22 (69.09 (5.18) (13.42) (12.28)</td>
</tr>
<tr>
<td>......4-[2'-(4-methoxy) benzylidene amino] .......... (IIIm)</td>
<td>79</td>
<td>108</td>
<td>538.0 (544.5)</td>
<td>......4-<a href="IVm">2'-(4-methoxy)</a></td>
<td>99</td>
<td>68.45 3.47 10.97 12.55 (68.50 (4.72) (11.02) (12.59)</td>
</tr>
<tr>
<td>......4-(2'-benzylidene amino)... (IIIo)</td>
<td>81</td>
<td>118</td>
<td>508.0 (514.5)</td>
<td>......4-(2'-benzylidene amino)... (IVn)</td>
<td>97</td>
<td>70.11 4.42 11.65 13.31 (70.29 (4.60) (11.71) (13.38)</td>
</tr>
<tr>
<td>......4-(2'-ethyldiene amino)... (IIIo)</td>
<td>76</td>
<td>97</td>
<td>450.0 (452.5)</td>
<td>......4-(2'-ethyldiene amino)... (IVo)</td>
<td>91</td>
<td>66.22 4.75 13.38 15.31 (66.34 (4.80) (13.46) (15.38)</td>
</tr>
<tr>
<td>......4-(2'-furfurylidene amino)... (IIIp)</td>
<td>67</td>
<td>95</td>
<td>503.0 (505.5)</td>
<td>......4-(2'-furfurylidene amino)... (IVp)</td>
<td>88</td>
<td>66.43 4.22 11.84 13.61 (66.52 (4.47) (11.94) (13.60)</td>
</tr>
</tbody>
</table>
Chapter - 7

(N = CH)

(IVa)

Br Br

OH

Br, in

CH₃C₆OH

(Va)

Properties of (Va):

1. The compound was yellowish white coloured solid having melting point 160°C.
2. From analytical data, molecular formula was found to be C₂₇H₂₀N₄S₂O₁Br₂.
3. It was insoluble in water but soluble in organic solvents such as chloroform, ethanol etc.
4. It gave positive test for N, S and Br elements.
5. IR Spectrum:

The IR spectral analysis of compound (Va) showed the presence of following absorption bands. (Plate No.-7.6)

<table>
<thead>
<tr>
<th>Absorption observed (cm⁻¹)</th>
<th>Assignment</th>
<th>Literature value (cm⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3752</td>
<td>O–H stretching</td>
<td>3600 - 3200</td>
</tr>
<tr>
<td>1654</td>
<td>C= N stretching</td>
<td>1690 - 1470</td>
</tr>
<tr>
<td>1349</td>
<td>C–N stretching</td>
<td>1350 - 1280</td>
</tr>
<tr>
<td>746</td>
<td>C–S stretching</td>
<td>800 - 600</td>
</tr>
<tr>
<td>527</td>
<td>S–S stretching</td>
<td>550 - 400</td>
</tr>
</tbody>
</table>
6. **\(^1\)H-NMR Spectrum:**

The \(^1\)H-NMR spectral analysis of compound (Va) showed the presence of following peaks (Plate No.-7.7). The chemical shift can be correlated as below.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Signal position ((\delta) ppm)</th>
<th>Relative No. of H-atoms</th>
<th>Multiplicity</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.80-7.98</td>
<td>18H</td>
<td>Multiplet</td>
<td>Ar–H</td>
</tr>
<tr>
<td>2</td>
<td>11.35</td>
<td>1H</td>
<td>b-Singlet</td>
<td>Ar–OH</td>
</tr>
</tbody>
</table>

On the basis of above chemical properties and spectral data, the compound (Va) has been assigned structure, 3-phenylimino-4-[2'-(2-hydroxy)-{N-bromo-bromo benzylidene amino}] phenyl-5-phenylimino-1,2,4-dithiazolidine. The other compounds (Vb-p) were prepared by extending the above reaction of bromination to other 1,2,4-dithiazolidines (IVb-p) and the related products were isolated in good yield. (Table 7.3)

The formation of compounds I, II, III, IV and V can be explained by the reaction scheme as follows. (Scheme 7.1)
Table - 7.3

Synthesis of 3-phenylimino-4-[2'- (2-substituted) {N-bromo-bromo alkyl/benzyl-idene amino}] phenyl-5-arylminoo-1,2,4-dithiazolidines (V)

Reactants : - 3-Phenylimino-4-[2'- (substituted) alkyl/benzyl-idene amino] phenyl-5-arylminoo-1,2,4-dithiazolidines (IV) (0.01 mole) bromine acetic acid.

<table>
<thead>
<tr>
<th>3-Phenylimino-4-[2'- (substituted) {N-bromo-bromo alkyl/benzyl-idene amino}] phenyl-5-arylminoo-1,2,4-dithiazolidines (V)</th>
<th>Yield (%)</th>
<th>M.P. (°C)</th>
<th>Elemental analysis; Found (Calcd.) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Phenylimino-4-[2'- (2-hydroxy) {N-bromo-bromo benzylidene amino}] phenyl-5-arylminoo-1,2,4-dithiazolidine</td>
<td>(Va) 78</td>
<td>160</td>
<td>C: 58.85 (58.90) H: 3.60 (3.63) N: 10.17 (10.18) S: 11.60 (11.63)</td>
</tr>
<tr>
<td>......4-[2'- (2-hydroxy-4-methoxy) {N-bromo-bromo benzylidene amino}] ..................</td>
<td>(Vb) 72</td>
<td>141</td>
<td>C: 57.95 (57.93) H: 3.68 (3.79) N: 9.42 (9.65) S: 10.95 (11.03)</td>
</tr>
<tr>
<td>......4-[2'- (4-chloro) {N-bromo-bromo benzylidene amino}] .................</td>
<td>(Vc) Not Isolated</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>......4-[2'- (4-N,N-dimethylamino) {N-bromo-bromo benzylidene amino}] ..................</td>
<td>(Vd) 71</td>
<td>145</td>
<td>C: 68.60 (68.63) H: 4.83 (4.93) N: 13.78 (13.80) S: 12.55 (12.62)</td>
</tr>
<tr>
<td>......4-[2'- (4-methoxy) {N-bromo-bromo benzylidene amino}] ..................</td>
<td>(Ve) 79</td>
<td>148</td>
<td>C: 59.50 (59.57) H: 3.87 (3.90) N: 9.80 (9.92) S: 11.22 (11.34)</td>
</tr>
<tr>
<td>......4-[2'- (N-bromo-bromo benzylidene amino)]......</td>
<td>(Vf) 77</td>
<td>138</td>
<td>C: 60.58 (60.67) H: 3.65 (3.75) N: 10.34 (10.48) S: 11.85 (11.98)</td>
</tr>
<tr>
<td>......4-[2'- (N-bromo-bromo ethylidene amino)]......</td>
<td>(Vg) 70</td>
<td>155</td>
<td>C: 55.82 (55.93) H: 3.71 (3.81) N: 11.79 (11.86) S: 13.42 (13.55)</td>
</tr>
<tr>
<td>......4-[2'- (N-bromo-bromo furfurylidene amino)]......</td>
<td>(Vh) 67</td>
<td>143</td>
<td>C: 57.10 (57.14) H: 3.55 (3.61) N: 10.52 (10.66) S: 12.09 (12.19)</td>
</tr>
<tr>
<td>3-Phenylimino-4-[2'- (substituted) {N-bromo-bromo alkyl/benzyl-idene amino}] phenyl-5-arylimino-1,2,4-dithiazolidines (V)</td>
<td>Yield (%)</td>
<td>M.P. °C</td>
<td>Elemental analysis; Found (Calcd.) (%)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3-Phenylimino-4-[2'- (2-hydroxy) {N-bromo-bromo benzylidene amino}] phenyl-5-p-tolylimino-1,2,4-dithiazolidine</td>
<td>(Vi) 71</td>
<td>154</td>
<td>C 59.97 (60.00) H 3.88 (3.92) N 9.92 (10.00) S 11.32 (11.42)</td>
</tr>
<tr>
<td>......4-[2'- (4-chloro) {N-bromo-bromo benzylidene amino}] ..........</td>
<td>(Vk) Not Isolated</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>......4-[2'- (4-N,N-dimethylamino) {N-bromo-bromo benzylidene amino}] ..........</td>
<td>(Vl) 72</td>
<td>148</td>
<td>(60.91) C 60.81 (4.56) H 4.45 (11.84) N 11.81 (10.79)</td>
</tr>
<tr>
<td>......4-[2'- (4-methoxy) {N-bromo-bromo benzylidene amino}] ..........</td>
<td>(Vm) 80</td>
<td>152</td>
<td>(60.20) C 60.11 (4.15) H 4.06 (9.68) N 9.57 (11.07)</td>
</tr>
<tr>
<td>......4-[2'- (N-bromo-bromo benzylidene amino)] ......</td>
<td>(Vn) 78</td>
<td>141</td>
<td>(61.31) C 61.20 (4.01) H 3.97 (10.21) N 10.18 (11.52)</td>
</tr>
<tr>
<td>......4-[2'- (N-bromo-bromo ethylidene amino)] ......</td>
<td>(Vo) 74</td>
<td>157</td>
<td>(55.79) C 56.62 (4.11) H 4.03 (13.16) N 13.13 (13.09)</td>
</tr>
<tr>
<td>......4-[2'- (N-bromo-bromo furfurylidene amino)] ......</td>
<td>(Vp) 70</td>
<td>162</td>
<td>(57.88) C 57.81 (3.89) H 3.85 (10.38) N 10.21 (11.75)</td>
</tr>
</tbody>
</table>
where,

- $R$ : 2-hydroxy benzaldehyde
- $R$ : 2-hydroxy-4-methoxy benzaldehyde
- $R$ : 4-chloro benzaldehyde
- $R$ : 4-$N,N$-dimethylamino benzaldehyde
- $R$ : 4-methoxy benzaldehyde
- $R$ : benzaldehyde
- $R$ : acetaldehyde
- $R$ : furfuraldehyde
- $R'$ : phenyl
- $R'$ : $p$-tolyl

**Scheme - 7.1**
The melting points of all synthesized compounds were recorded using hot paraffin bath and are uncorrected. The carbon and hydrogen analysis was carried out on 'Carlo-Erba - 1106' analyser. Nitrogen estimation was carried out on 'Colman-N-analyser-29'. The IR spectra were recorded on a 'Perkin Elmer - 577' spectrophotometer in the frequency range 4000-400 cm\(^{-1}\) in Nujol mull and as KBr pellets. \(^1\)H-NMR spectra were recorded on 'Bruker AC-300F' spectrometer with TMS as internal standard using CDCl\(_3\) and DMSO-\(d_6\) as solvents. Mass spectra were recorded on a JEOL SX102/DA-6000 spectrometer using Argon/Xenon (6 kV, 10 mA). Chemicals used were of AR grade. Purity of the compounds was checked on silica gel-G plates by TLC.

The reagents used in the synthesis of 3-phenylimino-4-[2'-(substituted) alkyl/benzylidene amino] phenyl-5-arylimino-1,2,4-dithiazolidines (IVa-p) have been prepared by the already known methods. Details of typical preparations are as follows.

1. **Phenyl isothiocyanate** :

   Phenyl isothiocyanate was prepared by the procedure described in "Vogel's Text Book of Practical Organic Chemistry"\(^26\).

2. **N-Aryl-S-chloro isothiocarbamoyl chloride (arylimino chloromethane suphenyl chloride)** :

   N-Aryl-S-chloro isothiocarbamoyl chloride\(^27\) was prepared by the controlled reaction of chlorine with phenyl isothiocyanate as described in Experimental section of Chapter-4 in Part-II. (Other N-aryl-S-chloro isothiocarbamoyl chlorides were prepared by following same procedure).
3. **1-Phenyl-3-(2'-amino) phenyl thiocarbamide (I):**

The parent compound 1-phenyl-3-(2'-amino) phenyl thiocarbamide (I) was prepared by refluxing the mixture of o-phenylene diamine (0.01 mole) and phenyl isothiocyanate (0.01 mole) in chloroform medium (20.0 ml) for 2.0 hrs. The reaction mixture was cooled, and chloroform distilled off, when a solid was obtained. It was washed with petroleum ether (60-80°C) and crystallized from ethanol, yield 75%, m.p. 145°C.

4. **1-Phenyl-3-[2'-(substituted) alkyl/ benzyl-idene amino] phenyl thiocarbamides (II):**

These have been prepared by the interaction of 1-phenyl-3-(2'-amino) phenyl thiocarbamide with different aliphatic and aromatic aldehydes in chloroform medium. The details of typical preparations are as follows.

**Preparation of 1-phenyl-3-[2'-(2-hydroxy) benzylidene amino] phenyl thiocarbamide (IIa):**

1-Phenyl-3-(2'-amino) phenyl thiocarbamide (I) (0.01 mole) and 2-hydroxy benzaldehyde (0.01 mole) in chloroform (10.0 ml) was refluxed for 2.0 hrs. On distilling off chloroform, a solid residue was obtained. It was crystallized from ethanol to yield 1-phenyl-3-[2'-(2-hydroxy) benzylidene amino] phenyl thiocarbamide (IIa), yield 70%, m.p. 140°C.

Similarly other thiocarbamides (IIb-h) were prepared by extending the above reaction to different aliphatic and aromatic aldehydes and related products were isolated in good yield. (Table 7.1)
Interaction of 1-phenyl-3-[2'-(substituted) alkyl/benzyl-idene amino] phenyl thiocarbamides (II) and N-aryl-S-chloro isothiocarbamoyl chloride:

Synthesis of 3-phenylimino-4-[2'-(substituted) alkyl/benzyl-idene amino] phenyl-5-arylimino-1,2,4-dithiazolidines (IV):

Experiment No. 1:
Preparation of 3-phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVa):

1-Phenyl-3-[2'-(2-hydroxy) benzylidene amino] phenyl thiocarbamide (IIa) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-phenyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed over water bath for 3.0 hr. The evolution of hydrogen chloride gas was observed. After completion of reaction, the reaction mixture was cooled and chloroform was distilled off, to afford a sticky mass, which on washing repeatedly with petroleum ether (60-80°C) gave a granular solid. It was crystallized from ethanol. It was acidic to litmus and on determination of equivalent weight, it was found to be monohydrochloride of (IIa), yield 78%, m.p. 89°C. On basification with dilute ammonium hydroxide solution it afforded a free base, 3-phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVa). It was crystallized from ethanol, m.p. 84°C, having molecular formula C_{27}H_{26}N_{4}S_{2}O_{1}. (Colour - Turmeric)

Experiment No. 2:
Preparation of 3-phenylimino-4-[2'-(2-hydroxy-4-methoxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVb):

1-Phenyl-3-[2'-(2-hydroxy-4-methoxy) benzylidene amino] phenyl thiocarbamide (IIb) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-phenyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in
chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-[2'- (2-hydroxy-4-methoxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IIIb), yield 74%, m.p. 87°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVb), m.p. 85°C, having molecular formula C_{28}H_{22}N_{4}S_{2}O_{1}. (Colour - Yellow)

Experiment No. 3:

Preparation of 3-phenylimino-4-[2'- (4-chloro) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVc):

1-Phenyl-3-[2'- (4-chloro) benzylidene amino] phenyl thiocarbamide (IIc) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-phenyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-[2'- (4-chloro) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IIIc), yield 72%, m.p. 92°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVc), m.p. 90°C, having molecular formula C_{27}H_{19}N_{4}S_{2}Cl_{1}. (Colour - Yellowish white)

Experiment No. 4:

Preparation of 3-phenylimino-4-[2'- (4-N,N-dimethyl amino) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVd):

1-Phenyl-3-[2'- (4-N,N-dimethyl amino) benzylidene amino] phenyl thiocarbamide (IId) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-phenyl-S-chloro isothiocarbamoyl chloride (0.01 mole)
in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-[2'-{(4-N,N-dimethyl amino) benzylidene amino} phenyl-5-phenylimino-1,2,4-dithiazolidine (III), yield 75%, m.p. 122°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IV), m.p. 108°C, having molecular formula C_{29}H_{25}N_{5}S_{2}. (Colour - Yellowish white)

**Experiment No. 5**:

**Preparation of 3-phenylimino-4-[2'-{(4-methoxy) benzylidene amino} phenyl-5-phenylimino-1,2,4-dithiazolidine (IV):**

1-Phenyl-3-[2'-{(4-methoxy) benzylidene amino} phenyl thiocarbamide (II) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-phenyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product was obtained. It was identified as monohydrochloride of 3-phenylimino-4-[2'-{(4-methoxy) benzylidene amino} phenyl-5-phenylimino-1,2,4-dithiazolidine (III), yield 78%, m.p. 112°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IV), m.p. 102°C, having molecular formula C_{28}H_{22}N_{5}S_{2}O. (Colour - Yellowish white)

**Experiment No. 6**:

**Preparation of 3-phenylimino-4-(2'-benzylidene amino) phenyl-5-phenylimino-1,2,4-dithiazolidine (IV):**

1-Phenyl-3-(2'-benzylidene amino) phenyl thiocarbamide (II) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-phenyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added.
The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-(2'-benzylidene amino) phenyl-5-phenylimino-1,2,4-dithiazolidine (IIIf), yield 80%, m.p. 126°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVf), m.p. 121°C, having molecular formula C_{22}H_{20}N_{4}S_{2}. (Colour - Yellowish white)

Experiment No. 7:

Preparation of 3-phenylimino-4-(2'-ethylidene amino) phenyl-5-phenylimino-1,2,4-dithiazolidine (IVg):

1-Phenyl-3-(2'-ethylidene amino) phenyl thiocarbamide (IIg) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-phenyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-(2'-ethylidene amino) phenyl-5-phenylimino-1,2,4-dithiazolidine (IIIg), yield 77%, m.p. 108°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVg), m.p. 105°C, having molecular formula C_{22}H_{18}N_{4}S_{2}. (Colour - Turmeric)

Experiment No. 8:

Preparation of 3-phenylimino-4-(2'-furfurylidene amino) phenyl-5-phenylimino-1,2,4-dithiazolidine (IVh):

1-Phenyl-3-(2'-furfurylidene amino) phenyl thiocarbamide (IIh) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-phenyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On...
proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-(2'-fururylidene amino) phenyl-5-phenylimino-1,2,4-dithiazolidine (Illh), yield 69%, m.p. 87°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVh), m.p. 85°C, having molecular formula C_{22}H_{19}N_{4}S_{2}O_{1}. (Colour - Dark brown)

Experiment No. 9:
Preparation of 3-phenylimino-4-[2'-(2-hydroxy) benzyldiene amino] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVi):

1-Phenyl-3-[2'-(2-hydroxy) benzyldiene amino] phenyl thiocarbamide (IIa) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-p-tolyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-[2'-(2-hydroxy) benzyldiene amino] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IIIi), yield 78%, m.p. 98°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVi), m.p. 91°C, with molecular formula C_{28}H_{22}N_{4}S_{2}O_{1}. (Colour - Turmeric)

Experiment No. 10:
Preparation of 3-phenylimino-4-[2'-(2-hydroxy-4-methoxy) benzyldiene amino] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVj):

1-Phenyl-3-[2'-(2-hydroxy-4-methoxy) benzyldiene amino] phenyl thiocarbamide (IIb) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-p-tolyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in
Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-[2'-(2-hydroxy-4-methoxy)benzylidene amino]phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IIIj), yield 70%, m.p. 95°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVj), m.p. 85°C, with molecular formula $C_{29}H_{24}N_4S_2O_2$. (Colour - Pale brown)

Experiment No. 11:
Preparation of 3-phenylimino-4-[2'-(4-chloro) benzylidene amino] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVk):

1-Phenyl-3-[2'-(4-chloro) benzylidene amino] phenyl thiocarbamide (IIC) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-p-tolyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-[2'-(4-chloro) benzylidene amino]phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IIIk), yield 75%, m.p. 102°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVj), m.p. 100°C, with molecular formula $C_{29}H_{24}N_4S_2Cl$. (Colour - Red)

Experiment No. 12:
Preparation of 3-phenylimino-4-[2'-(4-N,N-dimethyl amino) benzylidene amino] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVf):

1-Phenyl-3-[2'-(4-N,N-dimethyl amino) benzylidene amino] phenyl thiocarbamide (IId) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-p-tolyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in
Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-[2'--(4-N,N-dimethyl amino) benzylidene amino]phenyl-5-p-tolylimino-1,2,4-dithiazolidine (III/), yield 77%, m.p. 118°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IV/), m.p. 104°C, with molecular formula C_{30}H_{27}N_{5}S_{2}. (Colour - Turmeric)

Experiment No. 13:
Preparation of 3-phenylimino-4-[2'--(4-methoxy) benzylidene amino]phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVm):

1-Phenyl-3-[2'--(4-methoxy) benzylidene amino] phenyl thiocarbamide (IIe) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-p-tolyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-[2'--(4-methoxy) benzylidene amino]phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IIIm), yield 79%, m.p. 108°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVm), m.p. 99°C, with molecular formula C_{29}H_{24}N_{4}S_{2}O. (Colour - Light yellow)

Experiment No. 14:
Preparation of 3-phenylimino-4-(2'-benzylidene amino) phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVn):

1-Phenyl-3-(2'-benzylidene amino) phenyl thiocarbamide (IIf) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-p-tolyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1.
On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-(2'-benzylidene amino) phenyl-5-\(p\)-tolylimino-1,2,4-dithiazolidine (III\(n\)), yield 81%, m.p. 118°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IV\(n\)), m.p. 97°C, with molecular formula \(\text{C}_{28}\text{H}_{22}\text{N}_4\text{S}_2\). (Colour - Redish yellow)

**Experiment No. 15 :**

**Preparation of 3-phenylimino-4-(2'-ethylidene amino) phenyl-5-\(p\)-tolylimino-1,2,4-dithiazolidine (IV\(o\)) :**

1-Phenyl-3-(2'-ethylidene amino) phenyl thiocarbamide (II\(g\)) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-\(p\)-tolyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride of 3-phenylimino-4-(2'-ethylidene amino) phenyl-5-\(p\)-tolylimino-1,2,4-dithiazolidine (III\(o\)), yield 76%, m.p. 97°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IV\(o\)), m.p. 91°C, with molecular formula \(\text{C}_{23}\text{H}_{21}\text{N}_4\text{S}_2\). (Colour - Redish brown)

**Experiment No. 16 :**

**Preparation of 3-phenylimino-4-(2'-furfurylidene amino) phenyl-5-\(p\)-tolylimino-1,2,4-dithiazolidine (IV\(p\)) :**

1-Phenyl-3-(2'-furfurylidene amino) phenyl thiocarbamide (II\(h\)) (0.01 mole) was suspended in chloroform (15.0 ml). To this a solution of N-\(p\)-tolyl-S-chloro isothiocarbamoyl chloride (0.01 mole) in chloroform was added. The reaction mixture was refluxed as described in Experiment No. 1. On proceeding similarly, the product obtained was identified as monohydrochloride...
of 3-phenylimino-4-(2'-furfurlylidene amino) phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IIIp), yield 67%, m.p. 95°C. It was basified with dilute ammonium hydroxide solution and crystallized from aqueous ethanol (70%) to yield a free base (IVp), m.p. 88°C, with molecular formula C_{26}H_{20}N_{4}S_{2}O_{1}. (Colour - Brown)

Interaction of 3-phenylimino-4-[2'-substituted) alkyl/benzyl-idene amino] phenyl-5-arylimino-1,2,4-dithiazolidines (IV) and bromine in acetic acid :

Synthesis of 3-phenylimino-4-[2'-(substituted) {N-bromo-bromo alkyl/benzyl-idene amino}] phenyl-5-arylimino-1,2,4-dithiazolidines (V) :

Experiment No. 17 :

Preparation of 3-phenylimino-4-[2'-(2-hydroxy) {N-bromo-bromo benzylidene amino}] phenyl-5-phenylimino-1,2,4-dithiazolidine (Va):

To the solution of 3-phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVA) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid with vigorous shaking, within half an hour, the reaction mixture solidified. On pouring the reaction mixture into little crushed ice with water, the granular solid was obtained. It was crystallized from ethanol, yield 78%, m.p. 160°C, having molecular formula C_{27}H_{20}N_{4}S_{2}O_{1}Br_{2}. (Colour - Pale yellow)

Experiment No. 18 :

Preparation of 3-phenylimino-4-[2'-(2-hydroxy-4-methoxy) {N-bromo-bromo benzylidene amino}] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vb):

To the solution of 3-phenylimino-4-[2'-(2-hydroxy-4-methoxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVb) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was
crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2′-(2-hydroxy-4-methoxy) {N-bromo-bromo benzylidene amino}] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vb), yield 72%, m.p. 141°C, having molecular formula C_{28}H_{22}N_{4}S_{2}O_{1}Br_{2}. (Colour - Pale yellow)

**Experiment No. 19:**

**Preparation of 3-phenylimino-4-[2′-(4-chloro) {N-bromo-bromo benzylidene amino}] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vc):**

To the solution of 3-phenylimino-4-[2′-(4-chloro) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVc) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product eluded isolation.

**Experiment No. 20:**

**Preparation of 3-phenylimino-4-[2′-(4-N,N-dimethyl amino) {N-bromo-bromo benzylidene amino}] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vd):**

To the solution of 3-phenylimino-4-[2′-(4-N,N-dimethyl amino) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVd) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2′-(4-N,N-dimethyl amino) {N-bromo-bromo benzylidene amino}] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vd), yield 71%, m.p. 145°C, having molecular formula C_{29}H_{25}N_{5}S_{2}Br_{2}. (Colour - Pale yellow)
Experiment No. 21:

Preparation of 3-phenylimino-4-[2'-{(4-methoxy) \{N-bromo-bromo benzylidene amino\}] phenyl-5-phenylimino-1,2,4-dithiazolidine (Ve):

To the solution of 3-phenylimino-4-[2'-(4-methoxy) benzylidene amino] phenyl-5-phenylimino-1,2,4-dithiazolidine (IVe) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-(4-methoxy) (N-bromo-bromo benzylidene amino)] phenyl-5-phenylimino-1,2,4-dithiazolidine (Ve), yield 79%, m.p. 148°C, having molecular formula $C_{28}H_{22}N_4S_2O_4Br_2$. (Colour - Cream)

Experiment No. 22:

Preparation of 3-phenylimino-4-[2'-(N-bromo-bromo benzylidene amino)] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vf):

To the solution of 3-phenylimino-4-(2'-benzylidene amino) phenyl-5-phenylimino-1,2,4-dithiazoliodine (IVf) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-(N-bromo-bromo benzylidene amino)] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vf), yield 77%, m.p. 138°C, having molecular formula $C_{27}H_{20}N_4S_2Br_2$. (Colour - Whitish yellow)

Experiment No. 23:

Preparation of 3-phenylimino-4-[2'-(N-bromo-bromo ethylidene amino)] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vg):

To the solution of 3-phenylimino-4-(2'-ethylidene amino) phenyl-5-phenylimino-1,2,4-dithiazoliodine (IVg) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding
similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-(N-bromo-bromo ethylidene amino)] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vg), yield 70%, m.p. 155°C, having molecular formula $\text{C}_{22}\text{H}_{18}\text{N}_4\text{S}_2\text{Br}_2$. (Colour - Whitish)

Experiment No. 24:
Preparation of 3-phenylimino-4-[2'-(N-bromo-bromo furfurylidene amino)] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vh):

To the solution of 3-phenylimino-4-(2'-furfurylidene amino) phenyl-5-phenylimino-1,2,4-dithiazoliodine (IVh) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-(N-bromo-bromo furfurylidene amino)] phenyl-5-phenylimino-1,2,4-dithiazolidine (Vh), yield 67%, m.p. 143°C, having molecular formula $\text{C}_{25}\text{H}_{12}\text{N}_4\text{S}_2\text{O}_1\text{Br}_2$. (Colour - Brown)

Experiment No. 25:
Preparation of 3-phenylimino-4-[2'-(2-hydroxy) {N-bromo-bromo benzylidene amino}] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vi):

To the solution of 3-phenylimino-4-[2'-(2-hydroxy) benzylidene amino] phenyl-5-p-tolylimino-1,2,4-dithiazoliodine (IVi) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-(2-hydroxy) {N-bromo-bromo benzylidene amino}] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vi), yield 71%, m.p. 154°C. The molecular formula was established as $\text{C}_{28}\text{H}_{22}\text{N}_4\text{S}_2\text{O}_1\text{Br}_2$. (Colour - Cream)
Experiment No. 26:

Preparation of 3-phenylimino-4-[2'-{(2-hydroxy-4-methoxy) {N-bromo-bromo benzylidene amino}}] phenyl-5-p-toly limino-1,2,4-dithiazolidine (Vj):

To the solution of 3-phenylimino-4-[2'-{(2-hydroxy-4-methoxy) benzylidene amino}] phenyl-5-p-toly limino-1,2,4-dithiazolidine (IVj) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-{(2-hydroxy-4-methoxy) {N-bromo-bromo benzylidene amino}}] phenyl-5-p-toly limino-1,2,4-dithiazolidine (Vj), yield 70%, m.p. 138°C. The molecular formula was established as C_{29}H_{24}N_{4}S_{2}O_{2}Br_{2}. (Colour - Brown)

Experiment No. 27:

Preparation of 3-phenylimino-4-[2'-{(4-chloro) {N-bromo-bromo benzylidene amino}}] phenyl-5-p-toly limino-1,2,4-dithiazolidine (Vk):

To the solution of 3-phenylimino-4-[2'-{(4-chloro) benzylidene amino}] phenyl-5-p-toly limino-1,2,4-dithiazolidine (IVk) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product eluded isolation.

Experiment No. 28:

Preparation of 3-phenylimino-4-[2'-(4-N,N-dimethyl amino) {N-bromo-bromo benzylidene amino}] phenyl-5-p-toly limino-1,2,4-dithiazolidine (Vl):

To the solution of 3-phenylimino-4-[2'-(4-N,N-dimethyl amino) benzylidene amino] phenyl-5-p-toly limino-1,2,4-dithiazolidine (IVl) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-(4-N,N-Dimethyl amino) benzylidene amino] phenyl-5-p-toly limino-1,2,4-dithiazolidine (Vl), yield 70%, m.p. 138°C. The molecular formula was established as C_{29}H_{24}N_{4}S_{2}O_{2}Br_{2}. (Colour - Brown)
dimethyl amino) (N-bromo-bromo benzyldiene amino) phenyl-5-p-tolylimino-1,2,4-dithiazolidine (VI), yield 72%, m.p. 148°C. The molecular formula was established as $C_{36}H_{27}N_5S_2Br_2$. (Colour - Pale yellow)

**Experiment No. 29:**

**Preparation of 3-phenylimino-4-[2'-(4-methoxy) (N-bromo-bromo benzyldiene amino)] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vm):**

To the solution of 3-phenylimino-4-[2'-(4-methoxy) benzyldiene amino] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVm) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'- (4-methoxy) (N-bromo-bromo benzyldiene amino)] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vm), yield 80%, m.p. 152°C. The molecular formula was established as $C_{29}H_{24}N_4S_2O_1Br_2$. (Colour - Pale yellow)

**Experiment No. 30:**

**Preparation of 3-phenylimino-4-[2'-(N-bromo-bromo benzyldiene amino)] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vn):**

To the solution of 3-phenylimino-4-(2'-benzyldiene amino) phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVn) (0.01 mole) in acetic acid, was added bromine in glacial acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-(N-bromo-bromo benzyldiene amino)] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vn), yield 78%, m.p. 141°C. The molecular formula was established as $C_{28}H_{22}N_4S_2Br_2$. (Colour - Whitish yellow)
Experiment No. 31:

Preparation of 3-phenylimino-4-[2'-[(N-bromo-bromo ethylidene amino)] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vo):

To the solution of 3-phenylimino-4-(2'-ethylidene amino) phenyl-5-p-tolylimino-1,2,4-dithiazolidine (IVo) (0.01 mole) in acetic acid, was added bromine in acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-[(N-bromo-bromo ethylidene amino)] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vo), yield 74%, m.p. 157°C. The molecular formula was established as C_{23}H_{20}N_{4}S_{2}Br_{2}. (Colour - Ash)

Experiment No. 32:

Preparation of 3-phenylimino-4-[2'-[(N-bromo-bromo furfurylidene amino)] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vp):

To the solution of 3-phenylimino-4-(2'-furfurylidene amino) phenyl-5-p-tolylimino-1,2,4-dithiazoliodine (IVp) (0.01 mole) in acetic acid, was added bromine in acetic acid as described in Experiment No. 17. On proceeding similarly, the product obtained was crystallized from aqueous ethanol (70%) to yield 3-phenylimino-4-[2'-[(N-bromo-bromo furfurylidene amino)] phenyl-5-p-tolylimino-1,2,4-dithiazolidine (Vp), yield 70%, m.p. 162°C. The molecular formula was established as C_{26}H_{21}N_{4}S_{2}O_{1}Br_{2}. (Colour - Brown)
References


