Chapter 2
The general method of synthesis of Schiff's bases and their complexes is reported in this chapter.

The aldehydes and thiazolyl amines used for the preparation of the Schiff's bases were synthesized in the laboratory by the standard methods. Following aldehydes were used:

1) 5-methyl salicylaldehyde
2) 5-chloro-salicylaldehyde
3) β-hydroxy-α-naphthaldehyde

Following thiazoleamines were used in the synthesis.

1) 4-phenyl-2-aminothiazole
2) 4-(p-methyl phenyl)-2-aminothiazole
3) 4-(p-methoxy-phenyl)-2-aminothiazole
4) 4-(p-chloro-phenyl)-2-aminothiazole

I.A) Synthesis of Aldehydes

The o-hydroxy-aldehydes were synthesised by Duff reaction (1).

150 g of glycerol and 35 g of boric acid were heated at 170° C for 30 minutes in a beaker with stirring to expell the water present in the glycerol. An intimate mixture of 50 g of phenol and 50 g of hexamine was prepared by grinding
the material together thoroughly. The mixture was then added with vigorous stirring to the glycerol-boric acid mixture previously cooled to 150° C. The reactants were stirred for 20 minutes during which the temperature was maintained between 150° to 165° C by heating or cooling as necessary. Finally the reaction mixture was cooled to 115° C and was then acidified with a mixture of 50 ml concentrated sulphuric acid and 150 ml water. The whole mixture was then boiled under a current of steam. The solid aldehyde collected was recrystallized from absolute alcohol.

Physical constants of the aldehydes are given in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Phenol used</th>
<th>Aldehyde obtained</th>
<th>M.P. °C</th>
<th>Yield in g</th>
<th>% yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Reported:Observed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-Cresol</td>
<td>5-methyl salicyl-aldehyde</td>
<td>56</td>
<td>55</td>
<td>8.5</td>
</tr>
<tr>
<td>p-Chlorophenol</td>
<td>5-chloro salicyl-aldehyde</td>
<td>99</td>
<td>96</td>
<td>5.5</td>
</tr>
<tr>
<td>β-naphthol</td>
<td>β-hydroxy-α-naphthaldehyde</td>
<td>82</td>
<td>81</td>
<td>8.0</td>
</tr>
</tbody>
</table>

B) Synthesis of Thiazole amines

(a) Thiazole amines (4-aryl-2-amino thiazole) were synthesised by the method given by Dash et al (2).
A mixture of 6.8 g of \( p \)-substituted acetophenone (synthesised in the laboratory by method b), 12.7 g of iodine and 7.6 g of thiourea was heated under reflux for eight hours on water bath and again 12 to 16 hours after removal of the condenser. The period of the heating influences the yield of the final product. The crude reaction product was kept in contact with ether with occasional shaking for 48 hours (to remove the unchanged ketone which otherwise led to a gummy product). Final removal of iodine was affected by treatment with thiosulphate solution. The resulting product which was nearly colourless was boiled with water and filtered hot. The filtrate was treated with concentrated ammonia to liberate the base. The product obtained was recrystallized from 50% ethanol. Physical constants are given in Table 2.

\[
\begin{align*}
R = H, \text{CH}_3, \text{OCH}_3, \text{Cl}
\end{align*}
\]
(b) Synthesis of p-substituted acetophenones

p-substituted acetophenones were synthesized by the method given by Vogel (3).

A solution of 0.5 mole of aromatic hydrocarbon in 200 ml of carbon disulphide was placed in a 1-litre three neck flask fitted with a mercury sealed stirrer, a dropping funnel and a reflux condenser bearing a tube to carry off hydrogen-chloride gas evolved. To this solution was added 1:1 mole of powdered aluminium-chloride was added and then with rapid stirring 0.5 mole of acetic anhydride was added through dropping funnel. This addition required about 15 min during which the temperature of the mixture rose to the boiling point of carbon-disulphide and a rapid evolution of hydrogen chloride took place. After all the acetic anhydride

<table>
<thead>
<tr>
<th>R</th>
<th>M.P. °C</th>
<th>Yield in g</th>
<th>% yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>151</td>
<td>148</td>
<td>5.7</td>
</tr>
<tr>
<td>CH₃</td>
<td>127</td>
<td>125</td>
<td>5.7</td>
</tr>
<tr>
<td>OCH₃</td>
<td>184</td>
<td>182</td>
<td>5.4</td>
</tr>
<tr>
<td>Cl</td>
<td>163</td>
<td>162</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Table 2

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<table>
<thead>
<tr>
<th>R</th>
<th>M.P. °C</th>
<th>Yield in g</th>
<th>% yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>151</td>
<td>148</td>
<td>5.7</td>
</tr>
<tr>
<td>CH₃</td>
<td>127</td>
<td>125</td>
<td>5.7</td>
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<tr>
<td>OCH₃</td>
<td>184</td>
<td>182</td>
<td>5.4</td>
</tr>
<tr>
<td>Cl</td>
<td>163</td>
<td>162</td>
<td>5.0</td>
</tr>
</tbody>
</table>
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was added, the mixture was heated on a water bath and stirred for 30 minutes at the end of which there was practically no more evolution of gas. The reaction mixture was then cooled to room temperature and decomposed by pouring it into ice and water. After decomposition the mixture was extracted with ether and the ether layer was washed first with water and then with 10% sodium hydroxide solution and finally with water. It was then dried over calcium chloride. The ether layer is removed and the residue was subjected to distillation under vacuum and further purified by one more vacuum of the products distillation.

Physical constants are given in Table 3.

<table>
<thead>
<tr>
<th>Hydrocarbon used</th>
<th>Acetophenone</th>
<th>B.P. °C</th>
<th>Yield %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Reported</td>
<td>Observed</td>
</tr>
<tr>
<td>Toluene</td>
<td>p-methyl acetophenone</td>
<td>225</td>
<td>223</td>
</tr>
<tr>
<td>Anisole</td>
<td>p-methoxy acetophenone</td>
<td>264</td>
<td>262</td>
</tr>
<tr>
<td>p-chlorobenzene</td>
<td>p-chloroacetophenone</td>
<td>236</td>
<td>232</td>
</tr>
</tbody>
</table>

II. Synthesis of Tridentate Schiff's bases

A solution of o-hydroxy-aldehyde in ethanol was added to the ethanolic solution of 4-aryl-2-aminothiazole in
equimolar quantity. The mixture was refluxed on a water bath for half an hour. The Schiff's base thus formed was filtered by suction, recrystallized from ethanol and dried under vacuum. Purity of the Schiff's bases was checked by molecular weight determination, elemental analysis and TLC.

III. Purification of Solvents

The solvents ethanol and methanol, required for the preparation of the metal complexes were purified by the literature methods (4).

IV. Preparation of Metal Complexes

Schiff's base complexes can be prepared by using a variety of methods.

1) Schiff's bases are prepared by condensation of aldehyde and amine in alcoholic medium. The solution of the Schiff's base or refluxing with the metal ion solution gives crystalline complex.

2) If a solid complex is not formed in the above reaction, dilute solution of ammonia is added so as to precipitate the complex.

3) Solution of metal ion, aldehyde and amine are refluxed to give crystalline product and if crystalline
product is not obtained the precipitation is carried out by using dilute ammonia.

4) Metal ion and aldehyde are met to react to give aldehyde complex which on refluxing with amine gives complex of Schiff's base.

The complexes in the present work were obtained as crystalline products on either refluxing the metal ion solution with aldehyde and amine solution or by refluxing the metal ion solution and Schiff's base solution. None of the complexes are obtained as precipitates by addition of ammonia thereby ruling out the formation of undesirable hydroxide products.

(a) Cobalt(II) Complexes

An ethanolic solution of 0.01 mole of cobalt acetate (Albright and Wilson Ltd., London) was added to the ethanolic solution containing 0.02 mole of o-hydroxy aldehyde and 0.02 mole of 4-aryl-2-aminothiazole or 0.02 mole of the Schiff's base. The reaction mixture was then refluxed on a water bath for 30 minutes. On standing overnight the dark red coloured crystals separated which were filtered, washed with ethanol and dried under vacuum.
(b) **Nickel(II) Complexes**

An ethanolic solution 0.01 mole of Nickel acetate (Thomas Baker and Co., London) was added to the ethanolic solution of 0.02 mole of o-hydroxy-aldehyde and 0.02 mole of 4-aryl-2-aminothiazole or 0.02 mole of Schiff's base. The reaction mixture was refluxed on a water bath for one hour. The shining yellow coloured crystals separate on standing for 24 hours in the refrigerator. The crystals separated were filtered, washed with hot ethanol and dried under vacuum.

(c) **Copper(II) Complexes**

A solution of 0.01 mole of copper acetate (AR Grade, B.D.H.) in methanol was added to the methanolic solution of 0.02 mole of o-hydroxy-aldehyde and 0.02 mole of 4-aryl-2-aminithiazole or 0.02 mole of Schiff's base. The mixture was refluxed on water bath for five minutes and then the temperature of the water bath was maintained at 45 to 50° C for half an hour. The olive green coloured crystals separates were filtered, washed with hot methanol and dried under vacuum.

(d) **Zinc(II) Complexes**

0.01 mole of zinc acetate (B.D.H.) in ethanol was added to ethanolic solution of 0.02 mole of o-hydroxy-aldehyde
and 0.02 mole of 4-aryl-2-aninothiazole or 0.02 mole of Schiff's base. The mixture was heated on a water bath until the orange coloured crystals began to form. The crystals separated were washed with hot ethanol and dried under vacuum.

V. Analysis of Schiff's bases and metal complexes

Carbon and hydrogen analysis of Schiff's bases as well as complexes were performed by conventional microanalytical techniques. Nitrogen was estimated by Kjeldald method (5). Chlorine was estimated by Carius method (5) and sulphur was estimated by Carius method (5). Molecular weight was determined by Rast's method as described by Vogel (6).

The estimation of cobalt, nickel, copper and zinc was carried out gravimetrically (7) by decomposing the complexes with concentrated sulphuric acid.

VI. Physical Measurements

Physical constant (Melting Point) of the Schiff's bases as well as complexes were measured in a sealed glass tubes using parafin bath. The melting points are uncorrected.

Ultraviolet and visible region spectra were taken in chloroform solution on Beckman DU-2 spectrophotometer using quartz cells at room temperature.
Infrared spectra were taken in KBr pallets or Nujol mull on Perkin-Elmer 221 IR-spectrophotometer or Beckman IR-20 spectrophotometer in the 4000-250 cm\(^{-1}\) region. NIR spectra and reflectance spectra were taken on Carl Zeiss Vsliz spectrophotometer.

Mass spectra of the Schiff's bases and the zinc complexes were run on Perkin-Elmer mass spectrometer using a 70 ev electron beam energy and an inlet temperature of 300\(^\circ\) C.

Electrical conductivity of the complexes in nitrobenzene solution were measured with Philips conductivity bridge model PR 9500 with dip type cell FV 9055. The bridge was calibrated with a standard solution of potassium chloride.

Magnetic susceptibility measurements were carried out by Gouy method at room temperature. The tube was calibrated by using mercury tetrathiocyanato cobalt and tris-ethylene-diamino nickel thiosulphate. Diamagnetic correction were applied using Pascal's constants (8).
Plan of the present research work

Schiff's bases possess suitable bonding and coordinating characteristic and hence prolific growth research has been seen in the field of synthesis of the metal complexes and their characterisation by using conventional techniques. Much of the hitherto reported work is related to studies of solid complexes. There is however very less activity in the field of solution chemistry, thermodynamic aspects of complex formation, kinetics and equilibria or ligand exchange. Application of newer techniques like x-ray absorption, ESCA, ORD, fluorescence, Mossbaur spectra, thermal analysis and Mass spectra are gradually being added to the existing analytical tools for structural investigations. Detailed calculations of absorption spectroscopic properties, x-ray crystallography and biological activity are the least studied aspects of complexes of the Schiff's bases. The present work deals with syntheses and characterisation of complexes of Schiff's bases prepared from aromatic heterocyclic amines. The incorporation of heterocyclic part in the ligand has introduced an additional coordination site thereby unabling the ligand to behave as a tridentate one. The present work aims at the detailed spectral analysis leading to the evaluation of ligand field parameters and interelectron repulsion parameters in $d^7$ and $d^8$ ions of the first transition series. The study has been extended to the synthesis and characterisation of $d^9$ case. The mass
spectra of the ligands and their zinc(II) complexes have been studied and possible fragmentation schemes have been proposed.

Plan of Future

The possible extension of the present work will logically be centered upon more investigations on ligand field theory of $d^2$, $d^3$ (octahedral) and $d^2$, $d^3$, $d^7$, $d^8$ (tetrahedral) cases. Ligands with variety of donor sites and also structural and stereochemical flexibility will be prepared and will be used for the above purpose. Application of ESCA, ORD, Mössbauer spectra and thermal analysis will be studied. Attempts will be made to investigate the choice of coordination site if alternative coordination sites are available in molecules containing thiazole and similar rings. It is also possible to study the solution chemistry and biological activity of the complexes. It is intended that as a part of extension of our research activities the above aspects will be developed in our laboratories.
REFERENCES


