Chapter - 3

CHARACTERIZATION AND
CHROMOGENIC
PROPERTIES OF NEW
REAGENTS
Section (i) : Characterization and analytical properties of 2-acetylpyridine thiosemicarbazone (APT)

Synthesis of 2-acetylpyridine thiosemicarbazone (APT) is described in chapter 2 (Section i.a). APT was characterized by infrared spectra and $^1$H – NMR spectral analyses.

a. Infrared spectra

Infrared spectrum APT was recorded in KBr pellet by employing, Perkin – Elmer 983 G infrared double beam spectrophotometer in wave number region 4000 – 400 cm$^{-1}$. The infrared spectrum of APT is given in Fig 3. i. a. The important IR spectral bands of APT and assignments$^{1,2}$ are presented in Table 3.i.1

<table>
<thead>
<tr>
<th>IR band cm$^{-1}$</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>3459 (m)</td>
<td>$\nu$ (N – H) asymmetric stretch (-NH$_2$)</td>
</tr>
<tr>
<td>3369 (m,br)</td>
<td>$\nu$ (N – H) symmetric stretch (-NH$_2$)</td>
</tr>
<tr>
<td>3184 (m)</td>
<td>$\nu$ (C – H) aromatic stretch (SP$^2$ C – H)</td>
</tr>
<tr>
<td>1608 (m)</td>
<td>$\nu$ (C = N) stretching (Schiff base)</td>
</tr>
<tr>
<td>1501 (s)</td>
<td>Aromatic ring C – C stretch</td>
</tr>
<tr>
<td>1466 (s)</td>
<td>$\delta$ (C – H) stretch of pyridine ring</td>
</tr>
<tr>
<td>1367 (w)</td>
<td>$\nu$ (N – H) stretch (primary amide)</td>
</tr>
<tr>
<td>1150 (m)</td>
<td>$\nu$ (C = S)</td>
</tr>
<tr>
<td>1083 (m)</td>
<td></td>
</tr>
<tr>
<td>1051 m</td>
<td></td>
</tr>
<tr>
<td>996 (w)</td>
<td></td>
</tr>
<tr>
<td>965 (w)</td>
<td></td>
</tr>
<tr>
<td>840 (s)</td>
<td>$\nu$ (C – H) oop bend aromatic</td>
</tr>
<tr>
<td>781 (w)</td>
<td></td>
</tr>
<tr>
<td>664 (s)</td>
<td>$\delta$(C – C) – oop bend aromatic ring</td>
</tr>
</tbody>
</table>

Data presented in Table 3.i.1 support the synthesis of 2-acetylpyridine thiosemicarbazone (APT)
Fig. 3.i.a. Infrared spectrum of 2-acetylpyridine thiosemicarbazone (APT) in KBr pellet.
b. NMR spectra

$^1$H – NMR Spectrum (Fig. 3.i.b) of APT was recorded in dimethyl sulphoxide (DMSO – d$_6$) solvent with TMS as internal reference. The data and assignment are presented in Table 3.i.2.

**TABLE 3.i.2**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Absorption ($\delta$, PPM)</th>
<th>Multiplicity (m)</th>
<th>Relative Intensity</th>
<th>Peak</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.25</td>
<td>Singlet</td>
<td>3H</td>
<td>a</td>
<td>-CH$_3$</td>
</tr>
<tr>
<td>2</td>
<td>7.15-7.49</td>
<td>Multiplet</td>
<td>4H</td>
<td>b</td>
<td>C$_5$H$_4$N pyridine</td>
</tr>
<tr>
<td>3</td>
<td>8.15</td>
<td>Two singlets</td>
<td>1H</td>
<td>c</td>
<td>-NH$_2$</td>
</tr>
<tr>
<td></td>
<td>8.30</td>
<td></td>
<td>1H</td>
<td>d</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10.08</td>
<td>Singlet</td>
<td>1H</td>
<td>e</td>
<td>=N – NH – Hydrazino</td>
</tr>
</tbody>
</table>

Peak ‘a’ is observed at $\delta$ 2.25 and it is a singlet. The value corresponds to aliphatic protons. The area under the peak corresponds to 3 protons. This indicates that the peak may be due to CH$_3$ group. Peak ‘b’ is observed at $\delta$ 7.15-7.49 and it is a multiplet. The value corresponds to pyridine protons. The area under the peak corresponds to 4 protons. This indicates that the peak may be due to C$_5$H$_4$N group.

Peaks ‘c’ and ‘d’ are singlets. These are observed at 8.15 and 8.30 ppm. The area under these peaks corresponds to two protons. These are assigned to NH$_2$ group of thiosemicarbazone moiety.

Peak ‘e’ is observed at $\delta$ 10.08 and is a singlet. The area under the peak corresponds to one proton. This peak is assigned to hydrazino group of thiosemicarbazone moiety.
Fig. 3.i.b. $^1$H – NMR spectrum of 2-acetylpyridine thiosemicarbazone (APT) in DMSO-d$_6$ medium
Thus NMR spectrum also supports the synthesis of 2-acetylpyridine thiosemicarbazone (APT).

c. Structure

Bases on IR and NMR spectural data, the following structure (Fig 3.i.C) is assigned for the compound in solid state

\[
\begin{align*}
\text{C} & \quad \text{CH}_3 \\
\text{N} & \quad \text{NH} \\
\text{S} & \quad \text{C} \quad \text{NH}_2 \\
\end{align*}
\]

**Fig 3.i.c. Structure of APT**

d. UV-Visible spectra of APT

The absorption spectra of APT at different pH values are presented in Fig 3.i.d. The spectra of 2 x 10^{-5}M solution of APT were recorded at different pH values. The compound shows single absorption maximum (position depends on pH) which may be due to $\pi - \pi^*$ transition). In alkaline Medium (8-10), this band is shifted towards higher wavelength (lower energy) due to the formation of conjugated negative anion. The shifting of absorption maximum from lower wavelength to higher wavelength is known as bathochromic shift, a common spectral property of Schiff reagent.
Fig 3. Absorption spectra of 2x10^{-5} M solution of 2-acetylpyridine thiosemicarbazone (APT) at different pH values.
A plot was prepared between absorbance and pH at different wavelengths of radiation by following phillip and merrit method. The PKa values were calculated as 5.46 (PK₁) and 8.56 (PK₂). The possible species that may be formed due to deprotonation of the ligand are given in Fig 3.i.e.

e. Analytical properties of APT

The colour reactions of APT with transition metal ions were tested at different pH. Important chromogenic properties of the reagent are summarized in Table 3.i.3.

The data were obtained from appropriate spectra of reaction mixture containing buffer, metal ion and 10 – fold molar excess of reagent to metal ion.

TABLE 3.i.3

<table>
<thead>
<tr>
<th>Metal ion</th>
<th>λₘₐₓ</th>
<th>ε x 10⁴ *</th>
<th>pH range</th>
<th>Colour of the complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu(II)</td>
<td>376</td>
<td>0.26</td>
<td>5.0-70</td>
<td>Pale greenish yellow</td>
</tr>
<tr>
<td>Ni(II)</td>
<td>375</td>
<td>1.6</td>
<td>5.0-7.0</td>
<td>Yellow greenish</td>
</tr>
<tr>
<td>Co(II)</td>
<td>355</td>
<td>1.25</td>
<td>5.0-8.0</td>
<td>Orange yellow</td>
</tr>
<tr>
<td>Zn(II)</td>
<td>360</td>
<td>4.06</td>
<td>5.0-7.0</td>
<td>Pale greenish yellow</td>
</tr>
<tr>
<td>Fe(II)</td>
<td>370</td>
<td>0.17</td>
<td>4.0-7.0</td>
<td>Deep yellow with red tinge</td>
</tr>
<tr>
<td>Fe(III)</td>
<td>375</td>
<td>0.14</td>
<td>4.0-7.0</td>
<td>Deep yellow with red tinge</td>
</tr>
<tr>
<td>Hg(II)</td>
<td>351</td>
<td>5.4</td>
<td>5.0-7.0</td>
<td>Yellow coloured</td>
</tr>
<tr>
<td>V(V)</td>
<td>360</td>
<td>0.37</td>
<td>3.0-7.0</td>
<td>Yellow coloured</td>
</tr>
</tbody>
</table>

* L.mol⁻¹.cm⁻¹
The data in Table 3.1.3 suggest that the reagent may be used for the spectrophotometric determination of copper (II), nickel (II), cobalt (II), zinc (II), iron (II), iron (III), mercury (II) and vanadium (V) in aqueous medium.

Fig 3.i.e : Different species of APT in solution at different pH values
Section (ii) : Characterization and analytical properties of 2 – acetylthiophene thiosemicarbazone (ATT)

Synthesis of 2-acetylthiophene thiosemicarbazone (ATT) is given in chapter 2 (Section iii.c). ATT was characterized by infrared, $^1$H – NMR and Mass spectral analysis.

a. Infrared spectra

Infrared spectrum of ATT was recorded in KBr medium in the wave number region 4000 – 400 cm$^{-1}$ using Bruker IFS 66 V FT – IR spectrometer. IR spectrum of ATT is given in Fig 3.ii.a. Important IR bands and their assignments$^{1,2}$ are given in Table 3.ii.1.

<table>
<thead>
<tr>
<th>IR band cm$^{-1}$</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>3405 (m)</td>
<td>$\nu$ (N-H) asymmetric-stretch (-NH$_2$)</td>
</tr>
<tr>
<td>3232 (m,br)</td>
<td>$\nu$ (N-H) symmetric stretch (-NH$_2$)</td>
</tr>
<tr>
<td>3141 (m)</td>
<td>$\nu$ (C-H) thiophene (SP$^2$ C – H)</td>
</tr>
<tr>
<td>1605 (ð)</td>
<td>$\nu$ (C = N) Schiff base</td>
</tr>
<tr>
<td>1585 (ð)</td>
<td>Aromatic ring C – C stretch (thiophene)</td>
</tr>
<tr>
<td>1532 (ð)</td>
<td>$\delta$ (NH) of &gt; NH and – NH$_2$ groups</td>
</tr>
<tr>
<td>1501 (ð)</td>
<td></td>
</tr>
<tr>
<td>1453 (s,br)</td>
<td>$\delta$ C – H stretch of thiophene ring</td>
</tr>
<tr>
<td>1431 (s,br)</td>
<td>$\delta$ C – H stretch of thiophene ring</td>
</tr>
<tr>
<td>1367 (w)</td>
<td>$\nu$ (N – H) stretch (primary amide)</td>
</tr>
<tr>
<td>1287 (s)</td>
<td></td>
</tr>
<tr>
<td>1232 (m)</td>
<td>$\nu$ (C = S)</td>
</tr>
<tr>
<td>1092 (m)</td>
<td></td>
</tr>
<tr>
<td>745 (w)</td>
<td>Heterocyclic ring C – C – oop bend</td>
</tr>
<tr>
<td>628-620 (b)</td>
<td>$\nu$(C – S) thiophene ring</td>
</tr>
</tbody>
</table>

Data and assignment support the synthesis of 2-acetylthiophene thiosemicarbazone (ATT)
Fig. 3. ii.a. Infrared spectrum of 2-acetylthiophene thiosemicarbazone (ATT) in KBr pellet.
b. **NMR spectra**

$^1$H - NMR spectrum of ATT recorded on varian XL - 300 MIL high resolution instrument in CDCl$_3$ solvent with TMS as internal reference is given in Fig 3.ii.b. The data and assignments$^{12}$ are presented in Table 3.ii.2.

**TABLE 3.ii.2**

$^1$H - NMR spectral data of ATT

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Absorption ($\delta$,ppm)</th>
<th>Multiplicity (m)</th>
<th>Relative intensity</th>
<th>Peak</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.31</td>
<td>Singlet</td>
<td>3H</td>
<td>a</td>
<td>-CH$_3$</td>
</tr>
<tr>
<td>2</td>
<td>6.52</td>
<td>Singlet (broad)</td>
<td>2H</td>
<td>b</td>
<td>-NH$_2$</td>
</tr>
<tr>
<td>3</td>
<td>7.03 - 7.37</td>
<td>Multiplet</td>
<td>3H</td>
<td>c</td>
<td>Thiophene</td>
</tr>
<tr>
<td>5</td>
<td>8.77</td>
<td>Singlet</td>
<td>1H</td>
<td>d</td>
<td>Hydrazino (&gt;NH)</td>
</tr>
</tbody>
</table>

Peak ‘a’ is observed at $\delta$ 2.31. It is a singlet. The peak value corresponds to aliphatic protons. The area under the peak represents three protons. Therefore the peak is due to the CH$_3$ group present in the compound.

A broad peak ‘b’ is observed at $\delta$ 6.52. The area under this peak corresponds to two protons. It is assigned to NH$_2$ group.

Peak ‘c’ is observed in the range 7.00 - 7.31 ppm. It is observed as a multiple. It is assigned to thiophene ring protons.

Peak ‘d’ is observed at $\delta$ 8.77. It is a singlet. The area under this peak corresponds to one proton. It is assigned to hydrazino protons. Thus NMR spectral data corroborates the data obtained in IR spectra.
c. **Mass Spectra**

Mass spectrum of ATT is given in Fig 3.ii.C. It shows single at 199 (m/z) corresponding to its molecular ion peak. By presuming the molecular formula as C$_7$H$_9$N$_3$S$_2$, the number of unsaturated sites in odd election ion are calculated using the following equation.

\[ U = n - \frac{1}{2} K + \frac{1}{2} M + 1 \]

The ‘U’ value is found to be 5 for this compound.

Mass spectral data of ATT incorporating other peaks are given in Table 3.ii.3. Fragmentation pattern of the compound is given in Fig 3.ii.d.

<table>
<thead>
<tr>
<th>m/z value</th>
<th>Source of fragment</th>
</tr>
</thead>
<tbody>
<tr>
<td>199</td>
<td>M$^+$; Molecular ion peak</td>
</tr>
<tr>
<td>184</td>
<td>M - 15; Loss of methyl radical</td>
</tr>
<tr>
<td>182</td>
<td>M - 17; Loss of NH$_3$ Molecule</td>
</tr>
<tr>
<td>139</td>
<td>M - 60; Loss of C (S) - NH$_2$ radical</td>
</tr>
<tr>
<td>124</td>
<td>M - 75; Loss of NH - C(S) - NH$_2$</td>
</tr>
<tr>
<td>84</td>
<td>M - 116; Formation of thiophene radical cation</td>
</tr>
<tr>
<td>60</td>
<td>M - 139; Formation of NH$_2$ -$^+$ C = S cation</td>
</tr>
</tbody>
</table>
Fig. 3.ii.c. Mass spectrum of 2-acetyltiophene thiosemicarbazone (ATT).
Fig 3.ii.d Mass spectral fragmentation pattern of 2-Acetylthiophene thiosemicarbazone.
d. Structure

Based on IR, NMR and mass spectral data, the following structure is assigned (Fig 3.ii.e) for the compound in solid state.

![Structure of ATT](image)

**Fig. 3.ii.e. Structure of ATT**

e. **UV – Visible spectra of ATT**

The absorption spectra of ATT at different pH values are given in Fig 3.ii.f. The spectral of $4 \times 10^{-5}$ M solution of ATT were recorded at different pH values. The compound shows two absorption maxima one at 260 and another at 325 nm. In alkaline medium; the intensities of these bands are high, suggesting the formation of conjugated structure of the compound in solution.

A plot was prepared between absorbance and wavelength of radiation employed by employing Phillips and merrit method\(^3\). The pKa value is calculated as a corresponding to the formation of monoanion. The possible species that may be formed in alkaline medium (above pH, 9.0) is given in Fig 3.ii.g in alkaline medium.
Fig. 3.ii.g. Absorption spectra of $4 \times 10^{-5}$ M solution of 2-acetylthiophene thiosemicarbazone (ATT) at different pH values.
Fig 3.1i.g. Different forms of ATT at different pH values
f. **Analytical properties of ATT**

The colour reactions of ATT with different transition metal ions were tested at different pHs. Important chromogenic properties of the reagent are presented in Table 3.ii.4. The data were obtained from appropriate spectra of reaction mixture prepared using buffer solution of suitable pH, metal ion and ATT (10 – fold Molar excess to metal ion) solution.

**TABLE 3.ii.4**

Chromogenic properties of ATT

<table>
<thead>
<tr>
<th>Metal ion</th>
<th>( \lambda_{max} ) (nm)</th>
<th>( \varepsilon \times 10^4 ) *</th>
<th>pH range</th>
<th>Colour of the complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu(II)</td>
<td>370</td>
<td>1.83</td>
<td>3-0-6.0</td>
<td>Pale greenish yellow</td>
</tr>
<tr>
<td>Hg(II)</td>
<td>370</td>
<td>1.24</td>
<td>7.0-9.0</td>
<td>Yellowish green</td>
</tr>
</tbody>
</table>

* L.mol\(^{-1}\).cm\(^{-1}\)

The data in Table 3.ii.4 suggest that the reagent (ATT) is a selective for the spectrophotometric determination of copper(II) and mercury(II) in aqueous medium.
Section (iii): Characterization and analytical properties of 2-acetylpyridine semicarbazone (APS)

Synthesis of 2-acetylpyridine semicarbazone (APS) was characterized by infrared spectra and \(^1\)H–NMR spectral analyses.

**a. Infrared spectra**

Infrared spectrum of APS was recorded in KBr pellet by employing Perkin-Elmer 983 G infrared double beam spectrophotometer in wave number region 4000 – 400 cm\(^{-1}\). The infrared spectrum of APS is given in Fig 3.iii.a. The important IR spectral bands of APS and assignment\(^{1,2}\) are presented in Table 3.iii.1

<table>
<thead>
<tr>
<th>IR band (cm(^{-1}))</th>
<th>Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3403 (m)</td>
<td>(v) (N - H) asymmetric stretch (-NH(_2))</td>
</tr>
<tr>
<td>3375 (m,br)</td>
<td>(v) (N - N) symmetric stretch (-NH(_2))</td>
</tr>
<tr>
<td>3200 (m)</td>
<td>(v) (C - H) aromatic stretch ((sp^2c - H))</td>
</tr>
<tr>
<td>1686 (m)</td>
<td>(v) (C = N) and (v) (C = O) merged</td>
</tr>
<tr>
<td>1578 ((\delta))</td>
<td>Aromatic ring C – C stretch</td>
</tr>
<tr>
<td>1498 ((\delta))</td>
<td></td>
</tr>
<tr>
<td>1459 ((\delta,br))</td>
<td>(\delta) C- H stretch of pyridine ring</td>
</tr>
<tr>
<td>1426 ((\delta,br))</td>
<td>(\delta) C – H stretch of pyridine ring</td>
</tr>
<tr>
<td>1248 ((\delta))</td>
<td>(v) (C = O)</td>
</tr>
<tr>
<td>1151 (m)</td>
<td></td>
</tr>
<tr>
<td>1094 (w)</td>
<td></td>
</tr>
<tr>
<td>1051 (w)</td>
<td></td>
</tr>
<tr>
<td>733 ((\delta))</td>
<td>(\delta) (C – C) – oop bend aromatic ring</td>
</tr>
</tbody>
</table>

Data and assignment support the synthesis of 2-acetylpyridine semicarbazone (APS)
Fig. 3.iii.a. Infrared spectrum of 2-acetylpyridine semicarbazone (APS) in KBr pellet.
b. NMR spectra

\(^1\)H-NMR spectrum (Fig. 3.iii.b) of APS was recorded in CDCl\(_3\) solvent with TMS as internal reference. The data and assignments\(^{12}\) are presented in Table 3.iii.2

**TABLE 3.iii.2**

\(^1\)H-NMR spectral data of APS

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Absorption ((\delta\text{, ppm}))</th>
<th>Multiplicity (m)</th>
<th>Relative intensity</th>
<th>Peak</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.31</td>
<td>Singlet</td>
<td>3H</td>
<td>a</td>
<td>-CH(_3)</td>
</tr>
<tr>
<td>2</td>
<td>6.42</td>
<td>S(broad)</td>
<td>2H</td>
<td>b</td>
<td>-NH(_2)</td>
</tr>
<tr>
<td>3</td>
<td>7.10-7.59</td>
<td>Multiplet</td>
<td>4H</td>
<td>c</td>
<td>Pyridine C(_5) H(_4)</td>
</tr>
<tr>
<td>4</td>
<td>8.77</td>
<td>Singlet</td>
<td>1H</td>
<td>d</td>
<td>Hydrazino = N – NH–</td>
</tr>
</tbody>
</table>

Peak ‘a’ is observed at \(\delta\) 2.31 and it is a singlet. The value corresponds to aliphatic protons. The area under the peak corresponds to 3 protons. This indicates that the peak may be due to –CH\(_3\) group. Peak ‘b’ is observed at \(\delta\) 6.421 and it is a singlet. The value corresponds to amino protons. The area under the peak corresponds to two protons. These are assigned to NH\(_2\) group of semicarbazone moiety.

Peak ‘c’ is observed at \(\delta\) 7.10-7.59 and it is a multiplet. The value corresponds to pyridine protons. The area under the peak corresponds to 4 protons. This indicates that the peak may be due to C\(_5\)H\(_4\)N group.

Peak ‘d’ is observed at \(\delta\) 8.77 and is a singlet. The area under the peak corresponds to one protons. This peak is assigned to hydrazino group of semicarbazone moiety.
Fig. 3.iii.b.1 H – NMR spectrum of 2-acetylpyridine semicarbazone (APS) in DMSO-d₆ medium
Thus NMR spectrum also supports the synthesis of 2-acetylpyridine semicarbazone (APS)

c. Structure

Based on IR and NMR spectral data, the following structure (Fig 3.iii.c) is assigned for this compound.

![Structure of APS](image)

Fig 3.iii.c. Structure of APS

d. UV-Visible spectra of APS

The absorption spectra of APS at different pH values are presented in Fig 3.iii.d. The spectra of 2x10^{-5} M solution of APS were recorded at different pH values. The compound shows single absorption maximum (position depends on pH) which may be due to \( \pi - \pi^* \) transition. In alkaline medium (8 – 10), this band is shifted towards higher wavelength (lower energy) due to the formation of conjugated negative anion. The shifting of absorption maximum from lower wavelength to higher
Fig 3.iii.d Absorption spectra of 2x10^{-5} M solution of 2-acetylpyridine semicarbazone (APS) at different pH values
wavelength is known as bathochromic shifts, a common spectral property of Schift reagent.

A plot was prepared between absorbance and pH at different wavelengths of radiation by following phillip and merrit method\(^3\). The pKa values were calculated as 6.61 (pK\(_1\)) and 8.30 (pK\(_2\)). The possible species that may be formed due to deprotonation of the ligand are given in Fig 3.iii.e

![Chemical structures showing different forms of APS at different pH values](image.png)

**Fig. 3.iii.e** Different forms of APS at different pH values
Analytical properties of APS

The colour reactions of APS with transition metal ions were tested at different pHs. Important analytical properties of the reagent are summarized in Table 3.iii.3. The data were obtained from appropriate spectra of reaction mixture containing buffer, metal ion and 10 – fold molar excess of reagent (to metal ion)

**TABLE 3.iii.3**

<table>
<thead>
<tr>
<th>Metal ion</th>
<th>$\lambda_{\text{max}}$ (nm)</th>
<th>$\varepsilon \times 10^4 \ast$</th>
<th>pH range</th>
<th>Colour of the complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu(II)</td>
<td>355</td>
<td>0.98</td>
<td>5.0-7.0</td>
<td>Yellow</td>
</tr>
<tr>
<td>Ni(II)</td>
<td>350</td>
<td>2.80</td>
<td>8.0-10.0</td>
<td>Pale yellow</td>
</tr>
<tr>
<td>Co(II)</td>
<td>360</td>
<td>1.45</td>
<td>5.0-8.0</td>
<td>Orange yellow</td>
</tr>
<tr>
<td>Zn(II)</td>
<td>355</td>
<td>0.81</td>
<td>5.0-7.0</td>
<td>Greenish yellow</td>
</tr>
</tbody>
</table>

$\ast$ L.mol$^{-1}$cm$^{-1}$

The data in Table 3.iii.3 suggest that the reagent may be used for the spectrophotometric determination of copper (II), nickel (II), cobalt (II) and zinc (II) in aqueous medium.
References

