ABSTRACT

The use of acid-boron trifluoride complexes has been found to be a convenient general method for the preparation of phenolic ketones and phenyl styryl ketones. Resorcinol and pyrogallol react with boron trifluoride-acetic acid complex at room temperature, giving resacetophenone and gallacetophenone in 80-90 percent yield. 2,6-Dimethoxyhydroquinone and antiarol (3,4,5-trimethoxyphenol), when dissolved in boron trifluoride-acetic acid complex and poured into ice after leaving overnight at room temperature, give the corresponding aceto phenones in 60-70 percent yield. With 2-naphthol, a boron trifluoride complex of the ketone is first obtained and boiling with water for a few minutes gives 1-acetyl-2-naphthol in 93 percent yield. When cinnamic acid dissolved in chloroform is saturated with boron trifluoride, resorcinol added, and the solution left overnight at room temperature, 2,4-dihydroxyphenyl styryl ketone is obtained in 70 percent yield. Pyrogallol under similar conditions gives an 80 percent yield of the corresponding phenyl styryl ketone. Both 2,6-dimethoxyhydroquinone and antiarol condense readily with the boron trifluoride complex of cinnamic acid to give 2,5-dihydroxy-4,6-dimethoxyphenyl, and 2-hydroxy-4,5,6-trimethoxyphenyl styryl ketone respectively.

Boron trifluoride and its derivatives have been used as catalysts in condensations and rearrangements during the past century since the commercial production of boron trifluoride by the Harshaw Chemical Company in 1936 made it readily available. The use of boron trifluoride complexes for the synthesis of phenolic ketones, phenyl styryl ketones and other phenolics is of more recent date and has been the subject of extensive investigation in the present work.

Phenolic ketones and phenyl styryl ketones are necessary intermediates for the synthesis of flavonoid com-
pounds, which are naturally occurring coloring matters found in plants. They belong to the large class of oxygen heterocyclics, the chromones.

\[
\begin{array}{c}
\text{2-Hydroxyphenyl styryl ketone} \\
\includegraphics[width=0.5\textwidth]{2-hydroxyphenyl-styryl-ketone.png}
\end{array}
\]

Flavone
(2-phenyl chromone)

The A ring of the vast majority of flavones are derived from phenolic compounds, such as resorcinol and chlorogluconol, from which the phenolic ketones and phenyl styryl ketones can be derived by condensation of the boron trifluoride complexes of the appropriate acid.

Although boron trifluoride is a milder catalyst than other acid catalysts, like the aluminum chloride used in the Friedel-Crafts reaction (Olah), it has certain advantages over other catalysts, as reactions often proceed more smoothly and cleaner products are obtained. However, this method is limited to reactive nuclei having one or more phenolic hydroxyl groups, or their methyl ethers.

**Synthesis of Phenolic Ketones**

Phenolic ketones have been prepared in the present work by condensation of boron trifluoride complexes of acids with mono-, di- and trihydroxy phenols and their derivatives and with naphthols. A simple and convenient method is described for the preparation of 2,5,6-dihydroxy-4,6-dimethoxyacetophenone (I) and 2-hydroxy-4,5,6-trimethoxyacetophenone (II), which cannot be prepared by the Hoesch reaction. This is a variation of the Gattermann aldehyde synthesis in which hydrogen cyanide is replaced by acetonitrile and other nitriles.

\[
\begin{array}{c}
\text{(I)} \\
\includegraphics[width=0.5\textwidth]{phenolic-ketone-1.png}
\end{array}
\]

\[
\begin{array}{c}
\text{(II)} \\
\includegraphics[width=0.5\textwidth]{phenolic-ketone-2.png}
\end{array}
\]

(II) is obtained in relatively low yield by the Friedel-Crafts reaction.

1-Acetyl-2-naphthol (III) is obtained in 95% yield by the boron trifluoride-acid complex method. It cannot be prepared by the Nencki reaction using zinc chloride, and is obtained in poor yield by the Fries migration of 2-naphthyl acetate.

\[
\begin{array}{c}
\text{COMe} \\
\includegraphics[width=0.5\textwidth]{1-acetyl-2-naphthol.png}
\end{array}
\]

Reacting 1-naphthol and boron trifluoride-acetic acid complex at room temperature and boiling the complex with water gives 2-acetyl-1-naphthol (IV) and 4-acetyl-1-naphthol (V) in 70 and 25 percent yields, respectively. When the reaction was carried out on a steam-bath for 4 to 5 hours, (IV) and (V) were obtained in 85 percent and 10 percent respectively.

Condensations of 1- and 2-naphthols with the boron trifluoride complexes of propionic and lactic acid have been studied. Somewhat better yields of the ketones were obtained with propionic acid than with lactic acid, reflecting the effect of chain length and bulk of the two substrates. These ketones have been of interest in the past (Buu-Hoi Ng, 1955), as potential protective agents against lethal radiations. The preparation of phenolic ketones by the boron trifluoride-acid complex method is summarized in Table 1.

A note of the ferric chloride reaction to distinguish between isomers: although phenols generally give a positive ferric chloride reaction, the presence of a hydroxyl group adjacent to a carbonyl group intensifies the coloration due to the chelation effect. Throughout the literature, this method has been used to distinguish between α- and p-isomers of phenolic ketones. Thus p-hydroxyacetophenone gives a light red color with ferric chloride, while o-hydroxyacetophenone gives a reddish violet coloration. This reaction can also be used to distinguish between the 2- and 4-isomers of ketones from 1-naphthol. (See Methods and Materials).

**Synthesis of Phenyl Styryl Ketones**

The general procedure was to saturate a solution of cinnamic acid in chloroform with boron trifluoride at 0°, add the phenol, pass boron trifluoride again, and allow the reaction mixture to stand overnight at room temperature. Thus resorcinol gave 2,4-dihydroxyphenyl styryl ketone (VI) in 70 percent yield. Pyrogallol under similar conditions gave an 80 percent yield of the corresponding chalcone (VII). Following a similar procedure 2-hydroxy-4,6-di-
Table 1. Phenolic ketones prepared by the boron fluoride-acid complex method.

<table>
<thead>
<tr>
<th>Phenol</th>
<th>Acid</th>
<th>Temp C</th>
<th>Time hr</th>
<th>Product</th>
<th>M. p.</th>
<th>Lit. m.p.</th>
<th>(References)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenol</td>
<td>Acetic</td>
<td>28-30</td>
<td>24</td>
<td>2-Hydroxyacetophenone</td>
<td>109</td>
<td>109</td>
<td>(Klingel 1885, Pauly et al. 1915)</td>
</tr>
<tr>
<td>Hydroquinone</td>
<td>Acetic</td>
<td>100</td>
<td>5</td>
<td>2-Acetylhydroquinone</td>
<td>202</td>
<td>202-3</td>
<td>(Amin and Shah 1955)</td>
</tr>
<tr>
<td>Resorcinol</td>
<td>Acetic</td>
<td>28-30</td>
<td>18</td>
<td>Resacetophenone</td>
<td>147</td>
<td>142-4</td>
<td>(Cooper 1955)</td>
</tr>
<tr>
<td>Resorcinol</td>
<td>Acetic</td>
<td>100</td>
<td>4</td>
<td>2,4-Diacetylresorcinol</td>
<td>147</td>
<td>142-4</td>
<td>(Cooper 1955)</td>
</tr>
<tr>
<td>Resorcinol</td>
<td>Acetic</td>
<td>125</td>
<td>6</td>
<td>4,6-Diacetylresorcinol</td>
<td>182</td>
<td>182</td>
<td>(Dean et al. 1953)</td>
</tr>
<tr>
<td>Phloroglucinol</td>
<td>Acetic</td>
<td>28-30</td>
<td>18</td>
<td>2,4-Diacetylphylloroglucinol</td>
<td>168</td>
<td>168</td>
<td>(Dean et al. 1953)</td>
</tr>
<tr>
<td>Phloroglucinol monomethyl ether</td>
<td>Acetic</td>
<td>100</td>
<td>4</td>
<td>2,4-Diacetylphylloroglucinol-1-methyl ether</td>
<td>106</td>
<td>106</td>
<td>(Dean et al. 1953)</td>
</tr>
<tr>
<td>Phloroglucinol dimethyl ether</td>
<td>Acetic</td>
<td>100</td>
<td>4</td>
<td>2,4-Dimethoxy-6-hydroxyacetophenone</td>
<td>82</td>
<td>81</td>
<td>(Dean et al. 1953)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,6-Dimethoxy-4-hydroxyacetophenone</td>
<td>185</td>
<td>185.5</td>
<td>(Cantar et al. 1931)</td>
</tr>
<tr>
<td>C-Methyl-phloroglucinol</td>
<td>Acetic</td>
<td>28-30</td>
<td>24</td>
<td>C-Methylphloroglucinol</td>
<td>210</td>
<td>211</td>
<td>(Nakezawa et al. 1953)</td>
</tr>
<tr>
<td>C-isoAmyl-phloroglucinol</td>
<td>Acetic</td>
<td>28-30</td>
<td>24</td>
<td>2,4,6,Trihydroxy-3-isoamyl acetophenone</td>
<td>190</td>
<td></td>
<td></td>
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<tr>
<td>C-isoAmyl phloroglucinol</td>
<td>Propionic</td>
<td>28-30</td>
<td>24</td>
<td>2,4,6-trihydroxy-3-iso-amyl propiophenone</td>
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<td>Pyrogallol</td>
<td>Acetic</td>
<td>28-30</td>
<td>18</td>
<td>Gallacetophenone</td>
<td>173</td>
<td>171-2</td>
<td>(Badwar et al. 1943)</td>
</tr>
<tr>
<td>2,6-Dimethoxy hydroquinone</td>
<td>Acetic</td>
<td>28-30</td>
<td>18</td>
<td>2,5-Dihydroxy-4,6-dimethoxyacetophenone</td>
<td>b.p.</td>
<td>b.p.184-6</td>
<td>(Mauthner 1937, Sasri et al. 1946)</td>
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<tr>
<td>Antiarol</td>
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<td>28-30</td>
<td>18</td>
<td>2-Hydroxy-4,5,6-trimethoxyaceto-phenone</td>
<td>140</td>
<td>at 27mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>fusion at 1mm</td>
<td></td>
<td>mp 41-42</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mp 30.5-31.5</td>
<td></td>
<td>pt. 32</td>
<td></td>
</tr>
<tr>
<td>1-Naphthol</td>
<td>Acetic</td>
<td>28-30</td>
<td>18</td>
<td>2-Acetyl-1-naphthol</td>
<td>102</td>
<td>103</td>
<td>98</td>
</tr>
<tr>
<td>1-Naphthol</td>
<td>Acetic</td>
<td>100</td>
<td>5</td>
<td>4-Acetyl-1-naphthol</td>
<td>198</td>
<td>198</td>
<td>98</td>
</tr>
<tr>
<td>1-Naphthol</td>
<td>Acetic</td>
<td>100</td>
<td>5</td>
<td>2-Acetyl-1-naphthol</td>
<td>102</td>
<td>103</td>
<td>98</td>
</tr>
<tr>
<td>1-Naphthol</td>
<td>Propionic</td>
<td>28-30</td>
<td>18</td>
<td>2-Acetyl-1-naphthol</td>
<td>198</td>
<td>198</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4-Acetyl-1-naphthol</td>
<td>82</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2-Propanoyl-1-naphthol</td>
<td>187</td>
<td>188-9</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>4-Propanoyl-1-naphthol</td>
<td>82</td>
<td>81</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>2-Propanoyl-1-naphthol</td>
<td>82</td>
<td>81</td>
<td></td>
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<tr>
<td>1-Naphthol</td>
<td>Propionic</td>
<td>100</td>
<td>5</td>
<td>2-Propanoyl-1-naphthol</td>
<td>71</td>
<td>70-71</td>
<td>(Hantzsh 1966, Godzweig et al. 1891)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2-Propanoyl-1-naphthol</td>
<td>71</td>
<td>70-71</td>
<td>(Hantzsh 1966, Godzweig et al. 1891)</td>
</tr>
<tr>
<td>1-Naphthol</td>
<td>Lauric</td>
<td>100</td>
<td>5</td>
<td>2-Lauroyl-1-naphthol</td>
<td>75</td>
<td>74-5</td>
<td>(Brewster et al. 1942)</td>
</tr>
<tr>
<td>2-Naphthol</td>
<td>Acetic</td>
<td>28-30</td>
<td>18</td>
<td>1-Acetyl-2-naphthol</td>
<td>64</td>
<td>64-5</td>
<td>(Fries 1921)</td>
</tr>
<tr>
<td>2-Naphthol</td>
<td>Propionic</td>
<td>28-30</td>
<td>18</td>
<td>1-Propanoyl-2-naphthol</td>
<td>71</td>
<td>70-71</td>
<td>(Gulati et al. 1933)</td>
</tr>
<tr>
<td>2-Naphthol</td>
<td>Propionic</td>
<td>100</td>
<td>5</td>
<td>1-Propanoyl-2-naphthol</td>
<td>71</td>
<td>70-71</td>
<td>(Gulati et al. 1933)</td>
</tr>
<tr>
<td>2-Naphthol</td>
<td>Lauric</td>
<td>28-30</td>
<td>18</td>
<td>1-Lauroyl-2-naphthol</td>
<td>95</td>
<td>95-6</td>
<td>(Desai et al. 1946)</td>
</tr>
<tr>
<td>2-Naphthol</td>
<td>Lauric</td>
<td>100</td>
<td>5</td>
<td>1-Lauroyl-2-naphthol</td>
<td>95</td>
<td>95-6</td>
<td>(Desai et al. 1946)</td>
</tr>
</tbody>
</table>
methoxyphenyl styril ketone (VIII) from phloroglucinol
dimethyl ether, 2,5-dihydroxy-4,6-dimethoxyphenyl styril
ketone (IX) from 2,6-dimethoxyhydroquinone, and 2-hy-
droxy-4,5,6-trimethoxyphenyl styril ketone (X) from anti-
arol, were prepared.

\[
\text{MeO} \quad \begin{array}{c}
\text{O} \\
\text{OH} \\
\text{O} \\
\text{Me} \\
\text{O}
\end{array}
\quad \begin{array}{c}
\text{C=CH} \\
\text{MeO}
\end{array}
\]

(VIII)

\[
\begin{array}{c}
\text{OH} \\
\text{O} \\
\text{Me} \\
\text{O} \\
\text{Me}
\end{array}
\quad \begin{array}{c}
\text{C=CH} \\
\text{MeO}
\end{array}
\]

(IX)

The preparation of chalkones and flavanones by the
boron fluoride-acid complex method is summarized in
Table 2.

\textit{p-Hydroxyacetophenone}

Distilled phenol (10 g) was thoroughly mixed with
boron fluoride-acetic acid complex (50 g) in a round-
bottom flask provided with a calcium chloride guard tube.
The reaction mixture was shaken well and allowed to stand
at 28-30° for 24 hours. The viscous mass was poured over
crushed ice and steam-distilled until one liter of distillate
collected. The residue was cooled and the product col-
clected and crystallized from aqueous ethanol. The color-
less needles (9.5 g), (95%), had m.p. 109°. The substance
gave a light red color with ferric chloride.

The steam distillate was saturated with NaCl and ether
extracted. This yielded a minute amount of an oil which
failed to give a reddish violet color with ferric chloride
(characteristic of O-hydroxy-acetophenone), and was iden-
tified as phenol.

\textit{2-Acetylhydroquinone}

A mixture of hydroquinone (2 g), boron fluoride-acetic
acid complex (10 g) was heated at 100° for 5 hours. The
product obtained after pouring over crushed ice crystal-
lized from aqueous ethanol in yellowish silky needles (1.5
g), (70%), m.p. 202°. It gave a green ferric chloride
reaction.

\textit{Resacetophenone}

(a) A mixture of resorcinol (2 g), boron fluoride-acetic
acid complex (10 g) was kept at room temp (28-30°) for 18
hr and poured over crushed ice (200 g). The product
crystallized from hot water in colorless needles (1.7 g)(85%),
m.p. 147°. It gives a light red ferric chloride reaction.

(b) A mixture of resorcinol (2 g), boron fluoride-acetic
acid complex (10 g) was heated at 100° for 4 hr. The
mixture was poured into water (250 ml) and boiled for 10
min. The product obtained on cooling crystallized from hot
water in colorless needles (1.4 g), (70%), m.p. 147°. It gave
a light red ferric chloride reaction.

\textit{2,4- and 4,6-Diacetyl resorcinol}

A mixture of resorcinol (2.0 g), boron fluoride-acetic
acid complex (10 g) was heated at 125° for 6 hr. The
mixture was cooled and poured into water (250 ml) and
boiled for 10 min. The yellow crystalline product obtained
on cooling was filtered and extracted thoroughly with hot
petroleum ether (60-80°).

The petroleum ether extract on concentration and cool-
ing gave a crystalline product which was filtered and
recrystallized from aqueous ethanol. Colorless needles
(0.4 g), (20%), m.p. 182° (lit. m.p. of 4,6-diacetyl-re-
sorcinol 182°). It gave a red-brown ferric chloride reaction.

The petroleum ether filtrate on evaporation to dryness
yielded a residue which crystallized from aqueous ethanol
in colorless needles (0.4 g), (20%), m.p. 85° (lit. m.p. for
2,4-diacetylresorcinol 85°).

The residue after petroleum ether extraction yielded

\[
\begin{array}{c}
\text{OH} \\
\text{O} \\
\text{C=CH}
\end{array}
\]

(XIII)

\[
\begin{array}{c}
\text{OH} \\
\text{C=CH}
\end{array}
\]

(XIV)
Table 2. Chalkones and Flavanones prepared by the boron fluoride-cinnamic acid complex method

<table>
<thead>
<tr>
<th>Phenol</th>
<th>Acid</th>
<th>Temp</th>
<th>Time</th>
<th>Product</th>
<th>M.p.</th>
<th>Lit. m.p.</th>
<th>(References)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resorcinol</td>
<td>cinnamic</td>
<td>20-30</td>
<td>18</td>
<td>2,4-dihydroxyphenystyl</td>
<td>150</td>
<td>150</td>
<td>(Shinoda et al. 1928)</td>
</tr>
<tr>
<td>Phloroglucinol</td>
<td>b.p. of chloroform</td>
<td>2</td>
<td>5.7</td>
<td>5,7-dihydroxyflavanone</td>
<td>150</td>
<td>202</td>
<td>(Rosenmund et al. 1928)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,4,6-trihydroxyphenyl-styryl ketone</td>
<td>200</td>
<td>203</td>
<td>(Rosenmund et al. 1928)</td>
</tr>
<tr>
<td>Phloroglucinol dimethyl ether</td>
<td></td>
<td>28-30</td>
<td>18</td>
<td>2-hydroxy-4,6-dimethoxy phenyl/styryl ketone</td>
<td>92</td>
<td>91-92</td>
<td>(Kostanecki et al. 1899)</td>
</tr>
<tr>
<td>Pyrogallol</td>
<td></td>
<td>28-30</td>
<td>18</td>
<td>2,3,4-trihydroxyphenyl-styryl ketone</td>
<td>166</td>
<td>165-66</td>
<td>(Ellison 1927)</td>
</tr>
<tr>
<td>2,6-Dimethoxyhydroquinone</td>
<td></td>
<td>28-30</td>
<td>18</td>
<td>2,5-dihydroxy-4,5-dimethoxyphenyl/styryl ketone</td>
<td>160</td>
<td>156-8</td>
<td>(Rajagopalan et al. 1948)</td>
</tr>
<tr>
<td>Antiarol</td>
<td></td>
<td>28-30</td>
<td>18</td>
<td>2-hydroxy-4,5,6-trimethoxy phenyl/styryl ketone</td>
<td>100</td>
<td>103-4</td>
<td>(Olivero et al. 1948, Narasimhachari et al. 1949)</td>
</tr>
<tr>
<td>1-Naphthol</td>
<td></td>
<td>28-30</td>
<td>18</td>
<td>2-cinnamoyl-1-naphthol</td>
<td>125</td>
<td>125</td>
<td>(Kostanecki 1898)</td>
</tr>
<tr>
<td>2-Naphthol</td>
<td></td>
<td>28-30</td>
<td>18</td>
<td>2-naphthaflavanone</td>
<td>118</td>
<td>117</td>
<td>(Tambor et al. 1926)</td>
</tr>
</tbody>
</table>

resacetophenone which crystallized from hot water in colorless needles (0.6 g), (30%), m.p. 147°.

2,4-Diacetylphloroglucinol

Dry phloroglucinol (2 g) was mixed with boron fluoride-acetic acid complex (10 g) and the reaction mixture, after 18 hr standing at 28-30°, was poured over crushed ice (200 g). The boron fluoride complex was boiled with water (50 ml) for 10 min. When the yellow color disappeared and a brown solid resulted, it was filtered. It crystallized from aqueous ethanol in prisms (1.7 g), (85%), m.p. 168°. It gave a red ferric chloride coloration.

2,4-Diacetylphloroglucinol-1-methyl ether

A mixture of phloroglucinol monomethyl ether (2 g) and boron fluoride-acetic acid complex was heated at 100° for 4 hr. The mixture was cooled and poured into water (250 ml) and boiled for 10 min. The colorless crystalline product together with a small amount of sticky material, obtained on cooling, was filtered. It crystallized from aqueous ethanol in colorless needles (1.6 g), (80%), m.p. 106°. It gave a red ferric chloride coloration.

2,4-Dimethoxy-6-hydroxycacetophenone and 2,6-dimethoxy-4-hydroxyacetophenone

A mixture of phloroglucinol dimethyl ether (2.0 g) and boron fluoride-acetic acid complex was heated at 100° for 4 hr. The mixture was cooled and poured into water (250 ml) and boiled for 10 min. The yellowish brown crystalline product obtained on cooling was subjected to steam distillation. The distillate on cooling gave a colorless product which crystallized from ethanol in colorless needles (0.48 g), (24%), m.p. 82° (lit. m.p. for 2,4-dimethoxy-6-hydroxyacetophenone 82°). It gave a red ferric chloride reaction.

The residual mother liquor after steam distillation was filtered hot to separate a small amount of resinous matter. The filtrate on cooling gave a product which crystallized from ethanol in colorless needles (0.8 g), (40%), m.p. 185° (lit. m.p. for 2,6-dimethoxy-4-hydroxyacetophenone 185.5°). It did not give a ferric chloride reaction.

C-Methylphloracetophenone

A mixture of C-methylphloroglucinol (2 g), boron fluoride-acetic acid complex (10 g) was kept at 28-30° for 24 hr and poured over crushed ice (250 g). The complex obtained was collected and boiled with water (50 ml) for 10 min, and the product obtained on cooling crystallized from aqueous ethanol in pale yellow needles (1.0 g), (50%), m.p. 210°. It gave a brownish red ferric chloride reaction.

2,4,6-Trihydroxy-3-isoamylacetophenone

A mixture of C-isoamylphloroglucinol (2 g), boron fluoride-acetic acid complex (10 g) was kept at 28-30° for 24 hr. The reaction mixture was then poured into water (250 ml) and boiled for 10 min. On cooling, a yellow brown crystalline product was obtained which was recrystallized from hexane (Norit) in yellow needles (1.4 g), (70%), m.p. 190°. (Found: C,65.8; H, 8.4. C13H18O3 requires: C, 65.5; H, 8.6%). It gave a red ferric chloride coloration.

2,4,6-Trihydroxy-3-isoamylpropophenone

A mixture of C-isoamylphloroglucinol (1 g), propionic acid-boron fluoride complex (5 g) was kept mechanically...
agitated for 1 hr and then left at 28-30° for 24 hr. The reaction mixture was then treated with water (250 ml) and the mixture boiled for 10 min. After cooling, the semi-solid mass was ether extracted and the ether extract washed with 1% NaHCO₃ solution, dried and distilled. The product obtained after distillation of the ether and chromatographic purification over alumina, crystallized from hexane in pale brown needles (0.6 g), (63%), m.p. 180°. (Found: C, 66.9; H, 7.9. C₁₄ H₂₀ O₄ requires: C, 66.6; H, 7.9%). It gave a brownish red ferric chloride coloration.

**Galactecophenone**

This was prepared from pyrogallol (2 g) and boron fluoride-acetic acid complex (10 g) at 28-30° for 18 hr. The product crystallized from hot water containing sulphurous acid in colorless needles (1.8 g), (90%), m.p. 173°. (lit m.p. 171-2 (Badwar 1943)). It gave a dark red ferric chloride reaction.

2,5-Dihydroxy-4,6-dimethoxyacetophenone

A mixture of 2,6-dimethoxyhydroquinone (2 g), boron fluoride-acetic acid complex (10 g) after 18 hr standing at 28-30° and pouring over crushed ice yielded a complex which after decomposition with hot water crystallized from aqueous acetone in yellow needles (1.2 g), (60%), m.p. 162°. (Found: C, 56.3; H, 5.8. C₁₀ H₁₂ O₅ requires: C, 56.6; H, 5.7%). It gave a green ferric chloride reaction which changed to blood-red on standing.

**2-Hydroxy-4,5,6-trimethoxyacetophenone**

A mixture of antiarol (2 g), boron fluoride-acetic acid complex (10 g), on standing for 18 hr at 28-30° and pouring over crushed ice, yielded a yellow solid; the complex was broken by boiling with water and the oily product taken up in ether. The ether extract, after washing with cold 1% aqueous Na₂CO₃ solution, led to an oil which was distilled under reduced pressure and the fraction (1.0 g), (50%), distilling at 140°/1 mm collected. The product which solidified on standing had a fusion point of 32°. (Found C, 58.2; H, 5.9 C₁₁ H₁₄ O₅ requires: C, 58.4; H, 6.1%). It gave a red ferric chloride coloration.

2-Acetyl and 4-acetyl-1-naphthol

(a) A mixture of 1-naphthol (2 g) and boron fluoride-acetic acid complex (10 g), after 18 hr at 28-30°, was treated with boiling water. The semi-solid product (2 g) was taken up in ether and the ether layer washed with 5% Na₂CO₃ solution. The alkaline extract on acidification yielded a pale yellow flocculent mass which crystallized from ethanol in pale yellow needles (0.4 g), (20%), m.p. 198° (Lederer, 1932). It gave no ferric chloride reaction.

Evaporation of the ether extract remaining after base extraction yielded a solid which crystallized from petroleum ether in greenish yellow needles (1.4 g), (70%), m.p. 102° (lit. m.p. for 2-acetyl-1-naphthol 103° (Friedlander, 1895); 98° (Lederer, 1932; Stoughton, 1935). The mixed m.p. with an authentic sample of 2-acetyl-1-naphthol prepared by the Fries migration of 1-naphthyl acetate was undespressed. It gave a green ferric chloride reaction.

The mixture was also separable by chromatography. A solution of the crude reaction product (0.1 g) in benzene (10 ml) was chromatographed on an alumina column. On development with benzene, a yellow band separated, but elution was not possible. Elution with methanol led to a brownish semi-solid substance which crystallized from ethanol in greenish yellow needles (0.04 g), m.p. 102° (2-isomer). The greenish band held strongly on alumina was extracted with hot methanol and the product obtained on evaporation crystallized from ethanol in pale yellow needles (0.01 g), (20%), m.p. 198° (4-isomer).

(b) A mixture of 1-naphthol (2 g) and boron fluoride-acetic acid complex (10 g) at 100° for 5 hr gave a complex which on decomposition with boiling water and treatment with 5% aqueous Na₂CO₃ as above yielded 4-acetyl-1-naphthol, crystallizing from ethanol in pale yellow needles (0.2 g), (10%), m.p. 198°, and 2-acetyl-1-naphthol, crystallizing from hexane in greenish yellow needles (1.7 g), (85%), m.p. 102°.

2-Propionyl- and 4-propionyl-1-naphthol

(a) 1-Naphthol (2 g) and boron fluoride-propionic acid complex (10 g), kept at 28-30° for 18 hr, gave a complex which on decomposition with boiling water and treatment with 5% aqueous Na₂CO₃ gave 4-propionyl-1-naphthol as the Na₂CO₃ soluble fraction, crystallizing from ethanol in needles (0.4 g) (20%) m.p. 187° (lit. m.p. 188-189° (Stoughton 1935)) and 2-propionyl-1-naphthol as the Na₂CO₃ insoluble fraction, crystallizing from hexane in greenish yellow needles (1.3 g), (65%), m.p. 82° (lit. m.p. 81-82°). The latter gave a green coloration with alcoholic ferric chloride.

The mixture was also separable by chromatography over an alumina column. A solution of the crude reaction product (0.1 g) in benzene yielded a methanol elutable fraction crystallizing from hexane in greenish yellow needles (0.03 g), m.p. 82°. The strongly held band was eluted with hot methanol. Evaporation of methanol yielded a product which crystallized from aqueous ethanol in needles (0.01 g), m.p. 187°. It did not give a ferric chloride reaction.

(b) A mixture of 1-naphthol (2 g) and boron fluoride-propionic acid complex (10 g) at 100° for 5 hr gave a complex which on decomposition with boiling water, yielded a product which crystallized from hexane in yellowish green needles (1.6 g), (80%) m.p. 82° (lit. m.p. for 2-propionyl-1-naphthol 81°, 81-82°). It gave a green coloration with alcoholic ferric chloride.

Chromatography of a solution of the crude reaction product (0.1 g) in benzene over an alumina column yielded a band which could be completely eluted with cold methanol. The methanol eluate on evaporation yielded 2-propionyl-1-naphthol which crystallized from hexane in yellowish green needles, m.p. 82°, identical with the product obtained in (a).
2-Lauroyal-1-naphthol

A solution of lauric acid in anhydrous ether was saturated with boron fluoricide. The boron fluoricide-etherate was removed by distillation under reduced pressure. The residue, m.p. 42-45°, was analyzed for boron. (Found: B, 3.86; C₁₇H₂₆O₃·BF₃ requires 4.0%).

A mixture of 1-naphthol (2 g) and boron fluoricide-lauric acid complex (10 g) was heated at 100° for 5 hr. After decomposition with hot water, the product crystallized from hexane in needles (1.40 g), (70%), m.p. 75° lit m.p. 74-5 (Desai et al., 1940). It gave a green coloration with alcoholic ferric chloride.

Chromatography of a solution of the crude reaction product (0.1 g) in benzene over an alumina column yielded a single yellow band which could be completely eluted with cold methanol eluate without leaving any residual band, showing the absence of any 4-isomer. The methanol eluate on evaporation yielded 2-lauroyl-1-naphthol which crystallized from hexane in yellow green needles, m.p. 75°.

1-Acetyl-2-naphthol

A mixture of 2-naphthol (2 g) and boron fluoride-acetic acid complex (10 g), kept at room temp (28-30°) for 18 hr, was treated with ice-water. A complex, m.p. 184°, separated which was then decomposed with boiling water. The brownish semi-solid product crystallized from petroleum ether, b.p. 60-80°, in pale yellow needles (1.9 g), (95%), m.p. 64° lit m.p. 64-65 (Fires, 1921). It gave a red violet ferric chloride reaction.

1-Propionyl-2-naphthol

(a) A mixture of 2-naphthol (2 g) and boron fluoride-propionic acid complex (10 g), after standing at room temp (28-30°) for 18 hr, was treated with boiling water. The product crystallized from hexane in pale yellow needles (1.5 g), (75%), m.p. 71°. It gave a reddish violet coloration with alcoholic ferric chloride.

(b) A mixture of 2-naphthol (2 g), after heating at 100° for 5 hr and treatment with boiling water gave a product which crystallized from hexane in pale yellow needles (1.7 g), (85%), m.p. 71°, identical with the product obtained in (a).

1-Lauroyal-2-naphthol

(a) A mixture of 2-naphthol (2 g) and boron fluoride-lauric acid complex (10 g) in chloroform (50 cc) was mechanically agitated at 28-30° for 18 hr and the complex obtained after distillation of chloroform in vacuo, decomposed by boiling water. The product crystallized from hexane in colorless needles (1.4 g), (70%), m.p. 95°. It gave a pale brown coloration with alcoholic ferric chloride.

(b) A mixture of 2-naphthol (2 g) and boron fluoride-lauric acid complex (10 g) was heated at 100° for 5 hr and the complex decomposed by boiling water. The product crystallized from hexane in colorless needles (1.6 g), (80%), m.p. 95°, identical with the product obtained in (a).

2,4-Dihydroxyphenyl styril ketone

A solution of cinnamic acid (2.96 g, 0.02 mol) in dry chloroform (50 ml) was saturated with boron trifluoride gas at 0° under agitation. Dry resorcinol (1.1 g, 0.01 mol) was added to the clear solution of the complex and boron trifluoride gas again passed through the mixture at 0° under agitation for a few minutes. The mixture was then left to stand at room temp (28-30°) for 18 hr. The yellowish orange mass was then poured over crushed ice, and after attaining room temp the deep orange chloroform layer was washed with 5% aqueous NaHCO₃ and water, dried and distilled. The yellowish orange residue crystallized from aqueous ethanol in yellow plates (0.8 g), (72%), m.p. 150°. (Found: C, 74.7; H, 5.0. C₁₇H₁₈O₃ requires: C, 75.0; H, 5.0%). It gave a reddish brown ferric chloride reaction, dissolved in conc. H₂SO₄ with a red color and gave a reddish solution in cold NaOH.

5,7-Dihydroxyflavanone and 2,4,6-trihydroxyphenyl styril ketone

Cinnamic acid (2.96 g, 0.02 mol) was dissolved in chloroform (50 ml) and boron trifluoride gas passed at 0° under mechanical agitation until saturated. Dry phloroglucinol (1.26 g, 0.01 mol) was added and boron trifluoride gas again passed under mechanical agitation at 0° for a few minutes. Stirring was continued for 3 hr more, and the reaction mixture allowed to stand at room temp for 18 hr. It was then refluxed for 2 hr, during which the color changed from yellow to reddish orange. Worked up as usual, the dark brown oily residue from the chloroform layer solidified on treatment with cold methanol. Three crystallizations from aqueous methanol gave yellowish needles (0.9 g) which melted between 175-190°. Chromatography on a column of Florex, using chloroform as solvent and chloroform-benzene (1:1) as eluent, yielded bright yellow needles (0.6 g), (48%), which on recrystallization from methanol had m.p. 200° (lit. m.p. for 5,7-dihydroxyflavanone 202°; 203-204° (Shinoda et al., 1928). It gave a pink color with magnesium and HCl and a brown color with alcoholic ferric chloride.

The reddish zone held on the Florex column was eluted with ethanol and led to a bright red oily residue, which on contact with a few drops of methanol solidified. Three crystallizations from aqueous ethanol gave orange-red needles (0.025 g), (2%), m.p. 210° (lit. m.p. 210°(op. cit.), with 1.2 mol H₂O 189-190°). It gave a reddish brown color with alcoholic ferric chloride.

2-Hydroxy-4,6-dimethoxyphenyl styril ketone

The chalcone obtained from cinnamic acid (2.96 g, 0.02 mol) and phloroglucinol dimethyl ether (1.54 g), 0.01 mol) crystallized from dilute methanol in yellowish orange needles (1.20 g), (77%), m.p. 92° (lit. m.p. 91-92° (Kostan- ecki et al., 1899). It gave a dark red ferric chloride reaction.

2,3,4-Trihydroxyphenyl styril ketone

Following a similar procedure as in the case of the resorcinol derivative 2,3,4-trihydroxyphenyl styril ketone was obtained from pyrogallol (1.26 g, 0.01 mol) and cinnamic acid (2.96 g, 0.02 mol). The product crystallized
from aqueous methanol in reddish orange needles (0.96 g), (80%), m.p. 166°. It gave a reddish brown ferric chloride coloration. (Found: C, 70.2; H, 4.9. C_{15}H_{12}O_{4} requires: C, 70.3; H, 4.7%).

2,5-Dihydroxy-4,6-dimethoxyphenyl styryl ketone

The chalcone was prepared from 2,6-dimethoxyhydroquinone (0.89 g, 0.005 mol) and cinnamic acid (1.48 g, 0.01 mol). The reaction mixture turned greenish and finally red. The product crystallized from aqueous ethanol in yellow needles (0.60 g), (67%), m.p. 160°. (Found: C, 68.3; H, 5.5. C_{15}H_{12}O_{4} requires: C, 68.0; H, 5.3%). It gave a brown coloration with alcoholic ferric chloride.

2-Hydroxy-4,5,6-trimethoxyphenyl styryl ketone

The chalcone was prepared from antiarol (1.9 g, 0.01 mol) and cinnamic acid (2.96 g, 0.02 mol). The product crystallized from aqueous ethanol in yellow needles (1.4 g), (73%), m.p. 100°. (Found: C, 68.3; H, 5.5. C_{15}H_{12}O_{4} requires: C, 68.0; H, 5.3%). It gave a brown coloration with alcoholic ferric chloride.

2-Hydroxy-4,5,6-trimethoxyphenyl styryl ketone

The chalcone was prepared from 2,6-dimethoxyhydroquinone (0.89 g, 0.005 mol) and cinnamic acid (1.48 g, 0.01 mol). The reaction mixture turned greenish and finally red. The product crystallized from aqueous ethanol in yellow needles (0.60 g), (67%), m.p. 160°. (Found: C, 68.3; H, 5.5. C_{15}H_{12}O_{4} requires: C, 68.0; H, 5.3%). It gave a brown coloration with alcoholic ferric chloride.

2-Cinnamoyl-1-naphthol

Following the standard procedure, 2-cinnamoyl-1-naphthol was obtained from cinnamic acid (2.96 g, 0.02 mol) and 1-naphthol (1.43 g, 0.01 mol). The product crystallized from dilute methanol in orange yellow needles (1.1 g), (76%), m.p. 125°. It dissolved in conc. H_{2}SO_{4} with a yellowish red color and gave a dark brown ferric chloride reaction.

2-Napthaflavanone

The condensation of cinnamic acid (2.96 g, 0.02 mol) and 2-naphthol (1.4 g, 0.01 mol) was carried out at 0° and then at room temp as usual. The chloroform layer yielded a dark oily residue which dissolved in hot methanol. The methanolic solution on chilling deposited pale brown needles, m.p. 110°, which did not give a ferric reaction and did not dissolve in cold 2% NaOH solution. The substance was purified by recrystallization from petroleum ether when colorless needles (0.98 g), (70%), m.p. 118° were obtained. The substance dissolved in conc. H_{2}SO_{4} with a yellow color.

LITERATURE CITED


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