Chapter III

Synthesis of 1-aryl-3-(2-arylethenyl) 1H-pyrazole-4-carboxaldehydes
Chemistry of pyrazoles

Pyrazole derivatives which have been the basis of numerous dyes, are also useful as analgesic, antipyretic, anti-inflammatory and anaesthetic drugs.\textsuperscript{173} They are also used as chemical bleaching agents, luminescent, fluorescent substances\textsuperscript{174} and as antioxidants in motor fuels. Sulphonamides based pyrazoles has prolonged bacteriostatic action in \textit{vivo}.\textsuperscript{175} Pyrazole-4-carboxamide and acetamide have been used as antialcoholic agents.\textsuperscript{176}

Steroidal compounds with pyrazole moiety are of interest as psychopharmacological agents.\textsuperscript{177} Pyrimidinopyrazoles are being studied in the fight against cancer.\textsuperscript{178} Pyrazole derivatives have been found to have antimalarial activity\textsuperscript{179} and antihyperglycaemic activity.\textsuperscript{180} Some alkyl, aryl substituted pyrazoles have a pronounced sedative action on the central nervous system.\textsuperscript{181} Certain alkyl pyrazoles have shown quite significant bacteriostatic, bactericidal, fungicidal, analgesic and antipyretic activities.\textsuperscript{182}

Pyrazoles are best synthesised from various hydrazone derivatives. One of the most important method of pyrazole synthesis exploits the reaction of 1,3-diketones with hydrazine derivatives. 3,5-Dimethylpyrazole 217 resulted in more than 80% yield from the reaction of acetylacetone 216 with hydrazine hydrate.\textsuperscript{183} Practically all linear 1,3-diketones afford the corresponding pyrazoles with hydrazines.
Ethyl diazoacetate reacts with the acetylacetone \(218\) to yield ethyl 4-methyl-3-acetylpyrazole-5-carboxylate \(220\) via the pyrazoline \(219\).\(^{184}\)

The reaction of ketone arylhydrazone \(221\) with phosphorous trichloride and methyl acetoacetate represents gives 2-alkenylpyrazole-3(2\(H\))-one \(222\).\(^{185}\)

Pyrazole derivatives \(224\) which act as hypoglycaemic agents have been prepared by condensing \(\alpha,\beta\)-unsaturated ketones \(223\) with hydrazine hydrate or phenylhydrazines.\(^{186}\)
Chapter III Synthesis of 1-aryl-3-(2-arylethenyl)-1H-pyrazole-4-carboxaldehydes

\[
\begin{align*}
\text{R} & \quad \text{SO}_2\text{NH} \quad \text{C} & \quad \text{C} & \quad \text{C} & \quad \text{R}^1 \quad + \quad \text{NH}_2\text{NH}_2 \\
\text{223} & & & & \\
\text{R} & \quad \text{SO}_2\text{NH} \quad \text{C} & & \quad \text{N} & \quad \text{N} & \quad \text{R}^2 & \quad \text{R}^1 \\
\text{224} & & & & \\
\end{align*}
\]

\(^2\) \(R = \text{H (or) Ph}\)

Eq. 137

The reaction of \(\beta\)-keto-\(\beta\)-sulfonylenamines 225 with substituted hydrazines gave the 1,5-disubstituted 4-sulfonylpyrazoles 226.\(^{187}\)

\[
\begin{align*}
\text{MeSO}_2 & \quad \text{C} & & \quad \text{MeSO}_2 \\
\text{NMe}_2 & \quad \text{NMe}_2 & & \quad \text{R}^1 \\
\text{225} & & \quad \text{Rh}_2\text{NH} & \quad \text{Rh}_2\text{NH} \\
\text{226} & & & & \\
\end{align*}
\]

\(R = \text{Ph, } p\text{-tolyl} \quad R^1 = \text{Me, Ph, } p\text{-ClPh, } p\text{-NO}_2\text{Ph}\)

Eq. 138

The reaction of \(N\)-aryltrifluoroacetohydrazonyl bromides 227 with triethylamine is known to give the nitrilimines 228 whose reaction with dimethylfumarate affords the \(N,N\)-dimethyl-1-aryl-3-trifluoromethyl-2-pyrazoline-\(trans\)-4,5-dicarboxylate 229. When dimethylmaleate was used in
place of dimethylfumarate compound 229 and dimethyl-1-aryl-3-trifluoromethylpyrazole-4,5-dicarboxylates 230 were obtained.¹⁸⁸

![Reaction diagram](image)

Eq. 139

The Michael addition / elimination protocol has been extended to the hydrazides and semicarbazides providing a general route to 1-aryl-3-hydroxy-1H-pyrazoles 234 from 4-ethoxymethylene-2-phenyloxazol-5(4H)-one 231 via the intermediates 232 and 233.¹⁸⁹
Chapter III  Synthesis of 1-aryl-3-(2-arylethenyl)-1H-pyrazole-4-carboxaldehydes

\[
\begin{align*}
\text{EtO} \quad \text{HC} & \quad 231 \\
\text{O} \quad \text{O} & \quad \text{Ph} & \quad \text{R}^1 \text{C} \equiv \text{NHNH}_2 \\
\text{1, 4 Dioxane} & \quad \xrightarrow{} & \quad \text{R}^1 \text{X} \equiv \text{C} - \text{NHNH} & \quad \text{O} \quad \text{Ph} \\
\text{232} & \quad \xrightarrow{} & \quad \text{O} \quad \text{PhCNH} & \quad \text{233} \\
& & \quad \text{X} = \text{C} - \text{R}^1 & \quad \text{234} \\
& & & \quad \text{PhCONH} \quad \text{OH}
\end{align*}
\]

\text{Eq. 140}

The one-pot synthesis of the enaminoketone 237 by treatment of \( \alpha \)-phthaloylaminoacetophenone 236 with dimethylformamide-dimethylacetal, followed by cyclization to form 4-aminopyrazole 238 has been reported recently. 190

\[
\begin{align*}
\text{O} & \quad \text{Br} & \quad \text{235} \\
\text{236} \\
\text{DMF, rt} & \quad \text{to 40} \degree \text{C} & \quad \text{236} \\
\text{DMF / DMA} & \quad \text{236} \\
\text{DMF / DMA} & \quad \text{1-16 h, reflux} & \quad \text{NH}_2 \text{NHR, EtOH} & \quad \text{NMe}_2 \quad \text{237}
\end{align*}
\]

\text{Eq. 141}
Chapter III Synthesis of 1-aryl-3-(2-arylethenyl)-1H-pyrazole-4-carboxaldehydes

A new route to the synthesis of pyrazole 240 and pyrimidine C-nucleosides 241, involving a metal catalysed reaction of β-D-ribofuranosyl ketoesters 239 with alkyl cyanoformates as the key step has been reported by Veronese and Morelli.\textsuperscript{191}

![Chemical reaction diagram]

\textbf{Eq. 142}

A new, one-pot preparation of 3(5)substituted-1H-pyrazole 244 that employs Horner-Emmons reaction of aldehydes with dianion of the novel phosphonate 242 and proceeds through cyclization of \textit{N}-sodium salt of \textit{α},\textit{β}-unsaturated tosylhydrazones 243 has been reported.\textsuperscript{192}
Chapter III Synthesis of 1-aryl-3-(2-arylethenyl)-1H-pyrazole-4-carboxaldehydes

\[
\begin{align*}
\text{EtO} & \text{N} \text{Ts} \quad \text{R} \quad \text{Ts} \quad \text{N} \quad \text{N} \\
\text{242} & \quad \text{RCHO} \quad \text{243} \quad \text{THF, TSONa} \quad \text{244} \\
\text{R} & = \text{CHO} \quad \text{CH} = \text{CHO} \quad \text{R'} \quad \text{where R'} = \text{COOH, NMe}_2, \text{Br}
\end{align*}
\]

Eq. 143

The reaction of trifluoroacetylhydrazones with trifluoroacetic anhydride gave 4-trifluoromethylpyrazoles.\textsuperscript{193}

\[
\begin{align*}
\text{Me} & \quad \text{N} \quad \text{N} \quad \text{Nitrile} \\
\text{245} & \quad \text{TFAA, Pyridine} \quad \text{F}_3\text{C} \quad \text{R} \\
& \quad \text{RT, CHCl}_3 \quad \text{R'} \quad \text{246}
\end{align*}
\]

Eq. 144

Solid phase synthesis of pyrazoles

A new synthesis of 5-aminopyrazoles 246 on a solid support via the in situ generation of the resin bound aldehyde nitrile 245 has been reported by Wilson et al.\textsuperscript{194}
Eq. 145

Nafion-TMS mediated Mukiyama aldol reaction of silyl enol ethers 248 with aldehydes 247, obtained from mild oxidation of alcohols with polymer supported perruthenate (PSP), yielded α,β-unsaturated ketones 249, which upon treatment with hydrazine allowed the clean synthesis of 4,5-dihydro-1H-pyrazoles 250.¹⁹⁵
Synthesis of pyrazoles under Vilsmeier conditions

Kira et al have reported the formation of pyrazole-4-carboxaldehyde 251 by treating acetophenone phenylhydrazone with DMF/POCl₃ complex.¹⁹⁶

Eq. 147

Acetophenone azine has also been converted into the pyrazole-4-carboxaldehyde derivative 252 on treatment with the Vilsmeier reagent.¹⁹⁷

Eq. 148

Synthesis of [1]benzopyrano[4,3-c]pyrazoles 254 has been achieved by the Vilsmeier cyclization of o-hydroxyacetophenone phenylhydrazones followed by the treatment of the resulting pyrazole-4-carboxaldehydes 253 with mineral acid.¹⁹⁸
Synthesis of 3-arylethenylpyrazole-4-carboxaldehydes

The synthesis of pyrazole derivatives by the Vilsmeier cyclization of acetophenone phenylhydrazones prompted us to study the effect of Vilsmeier reagents on the 4-aryl-3-buten-2-one phenylhydrazones. 4-aryl-3-buten-2-one phenylhydrazones 255 are known to undergo tautomerism under acidic conditions to give the corresponding pyrazolines 256 and we expected such a rearrangement to occur under the Vilsmeier conditions followed by formylation of the resulting pyrazoline system to give 1,2-diphenyl-3-\(N,N\)-dimethylaminomethylene-4-methyl-1\(H\)-pyrazolines 257 or the pyrazole aldehyde 258. (Scheme 11)
Accordingly 4-phenyl-3-buten-2-one 2,4-dinitrophenylhydrazone 255a was treated with 6 equivalents of Vilsmeier reagent for 8 h at 90 °C. However, the reaction mixture after work up furnished only the 1-phenyl-3-(2-phenylethenyl)-1H-pyrazole-4-carboxaldehyde 259a as an orange-yellow precipitate in excellent yields and not even traces of 257a or 258a could be isolated from the reaction mixture. Attempts to isolate the expected product by stirring the 4-phenyl-3-buten-2-one 2,4-dinitrophenylhydrazone 255a in POCl₃ for 3-4h followed by addition of DMF at 0° C or by heating the starting material with POCl₃ for 30 min. before the addition of DMF were not rewarded with favourable results. The other 4-aryl-3-buten-2-one 2,4-dinitrophenyl hydrazones 255b-d and 4-aryl-3-buten-2-one 2,4-phenylhydrazones 255e-h also gave the corresponding 1-(2,4-dinitrophenyl)-3-(2-arylethenyl)-1H-pyrazole-4-
carboxaldehydes 259b-d and 1-phenyl-3-(2-arylethenyl)-1H-pyrazole-4-carboxaldehydes 259e-h respectively in excellent yields and the results are given in scheme 12 and table 5.

Scheme 12

![Scheme 12](image)

| Table 5. Synthesis of 1-aryl-3-(2-arylethenyl)-1H-pyrazole-4-carboxaldehydes |
|---|---|---|---|---|
| Product | Substituents | Time | mp | Yield |
| | R¹ | R² | R³ | (h) | (°C) | (%) |
| 259a | NO₂ | NO₂ | H | 8 | 143 | 85 |
| 259b | NO₂ | NO₂ | CH₃ | 8 | 170 | 78 |
| 259c | NO₂ | NO₂ | Cl | 8 | 145 | 79 |
| 259d | NO₂ | NO₂ | OCH₃ | 8 | 140 | 76 |
| 259e | H | H | H | 3 | 96 | 92 |
| 259f | H | H | CH₃ | 3 | 103 | 89 |
| 259g | H | H | Cl | 3 | 107 | 93 |
| 259h | H | H | OCH₃ | 3 | 87 | 84 |
Mechanistic Considerations

Based on the above observations a plausible mechanism for the formation of product 259 can be given as in scheme 13. 4-Aryl-3-buten-2-one arylhydrazone 255 on treatment with the Vilsmeier reagent undergoes diformylation at the \( \alpha \)-carbon to give 260 which on cyclization by the NH group results in the formation of 261. Elimination of dimethylamino group from 261 followed by hydrolysis results in 1-aryl-3-(2-arylethenyl)-1\( H \)-pyrazole-4-carboxaldehydes 259.

Scheme 13

![Chemical diagram showing the mechanism of formation of 259 from 255 through 260 and 261.]
Microwave assisted organic reactions

The rapid heating associated with microwave technology has been applied in a number of disciplines which include the preparation of samples for analysis, application to waste treatment, polymer technology, drug release/targeting and hydrolysis of proteins and peptides. Its application in organic synthesis has not only reduced the reaction time in many fold, but also has proven to give better yields.

Stambouli et al.\textsuperscript{199} have demonstrated that the cycloaddition of the diene 262 with the dienophile 263 under microwave irradiation leads to product 264\textit{a} and 264\textit{b} in good yields, whereas under conventional heating, no products were isolated even after 4 h at 140°C.

\begin{equation}
\begin{array}{c}
\text{262} \quad + \quad \text{OMe} \\
\text{263} \quad \text{OMe} \\
\end{array}
\xrightarrow{\text{DME, PhH, ZnCl}_2, 5 \text{ min.}}
\xrightarrow{\text{MW, 82\%}}
\begin{array}{c}
\text{OMe} \\
\text{264a} \\
\text{OMe} \\
\end{array}
\quad + \\
\quad \begin{array}{c}
\text{OMe} \\
\text{264b} \\
\end{array}
\end{equation}

\text{Eq. 150}

Hantsch 1,4-dihydropyridine has been synthesised with reduction in reaction times and improved yields under microwave irradiation.\textsuperscript{200}
Ferrocenyl substituted heteroaromatic systems 266 have been synthesised in moderate to good yields by treating ferrocenyl substituted acrylaldehyde with esters 265 under microwave irradiation.\textsuperscript{201}

Enantiomerically pure $\beta$-lactam 268 has been prepared from 267 using a two step microwave assisted reaction.\textsuperscript{202}
Herradon et al. have developed a microwave assisted selective benzoylation reaction catalysed by di-n-butyltin oxide.\textsuperscript{203}

\[
\begin{align*}
\text{HO} & \text{OH} & \text{O} \quad \text{(i) Bu}_2\text{SnO, Toluene, MW} \\
\text{OH} & \text{SPh} & \text{OH} & \text{(ii) PhCOCl, Toluene, RT} \\
\end{align*}
\]

Eq. 154

Yaozhong et al. have reported the phase transfer promoted microwave assisted C-alkylation of active methylenes, with good selectivity for monoalkylated products.\textsuperscript{204}

\[
R_1 R_2 + RX \xrightarrow{\text{KOH, K}_2\text{CO}_3, PTC} R_1 R_2 \\
R_1 = \text{SPh, CH}_3\text{CO}; R_2 = \text{COOEt} \\
R = \text{alkyl, allyl, benzyl}
\]

Eq. 155

The microwave irradiation of benzyl ether with a carboxylic acid in the presence of LnBr\textsubscript{3} led to the isolation of ester 269 in 61-84% yield.\textsuperscript{205}

\[
\begin{align*}
\text{Ar} & \text{OR} \xrightarrow{\text{LnBr}_3, \text{RCOOH}} \text{Ar} \text{OR} \text{O} \\
\text{MW, 1.5 min.} & \text{O} \\
\end{align*}
\]

\[269\]

Eq. 156

Microwave irradiation of tri-O-acetyl-D-glucal 270 with a range of alcohols led to the isolation of Ferrier rearrangement product 271 in good yields.\textsuperscript{206}
Chapter III Synthesis of 1-aryl-3-(2-arylthienyl)-1H-pyrazole-4-carboxaldehydes

Clay catalysts have been used in microwave assisted condensation of 'active methylenes' with aldehydes. Thus condensation of 5-nitro-2-furaldehyde 272 with active methylenes was achieved in high yields by adsorption of the reagents on the Lewis acid K_{10}, ZnCl_{2} and irradiation with microwave.\textsuperscript{207}

\[
\text{Eq. 157}
\]

Microwave assisted cyclocondensation can be used to prepare heterobicycles. The reaction of diamine 273 with keto-ester 274 led to the isolation of product 275 in 86% yield, when the reaction was carried out by supporting the reagents onto alumina and irradiating in an open vessel.\textsuperscript{208}

\[
\text{Eq. 158}
\]

\[
\text{Eq. 159}
\]
Alvarez et al. have reported a highly efficient aromatisation process as illustrated below in the transformation of 276 to 277.\(^{209}\)

\[
\begin{align*}
\text{EtO} & \quad \text{HNO}_3, \text{Bentonite} \\
\text{H}_3\text{C} & \quad \text{MW, 1 min., 98.6\%} \\
\text{N} & \quad \text{OEt} \\
\text{CH}_3 & \quad 276 \\
\text{EtO} & \quad \text{H}_3\text{C} \\
\text{N} & \quad \text{OEt} \\
\text{CH}_3 & \quad 277
\end{align*}
\]

Eq. 160

Several groups have described microwave assisted pinacol rearrangements, for example irradiation of 278 with Al\(^{3+}\) - montmorillonite gave the rearranged product 279 in good yields.\(^{210}\)

\[
\begin{align*}
\text{HO} & \quad \text{Al}^{3+} \text{Montmorillonite} \\
\text{CH}_3 & \quad \text{MW, 15 min., 98\%} \\
\text{OH} & \quad 278 \\
\text{O} & \quad 279
\end{align*}
\]

Eq. 161

Villemin and Labiad have examined an interesting ring expansion process as illustrated below.\(^{211}\)

\[
\begin{align*}
\text{SPh} & \quad \text{AgBF}_4, \text{Al}_2\text{O}_3 \\
\text{Cl} & \quad \text{MW, 10 min., 75\%} \\
\text{Cl} & \quad \text{SPh} \\
\text{Cl} & \quad \text{Cl}
\end{align*}
\]

Eq. 162
Synthesis of Pyrazoles under microwave irradiation

Recent reports on the Vilsmeier reactions under microwave irradiation has shown that the reaction time has been reduced from many hours to few seconds or minutes. The longer reaction time required for the cyclization of the 4-aryl-3-buten-2-one 2,4-dinitrophenylhydrazones prompted us to carry out the reaction under microwave condition.

Accordingly, six equivalents of POCl₃ was added to 4-phenyl-3-buten-2-one 2,4-dinitrophenylhydrazone 255a in DMF under ice cold condition. After 10 min. at room temperature, the contents of the flask were subjected to microwave irradiation for 90 sec. at 30% power (210 W). The reaction mixture was then poured into crushed ice. The orange-yellow precipitate obtained was found to be 1-(2,4-dinitrophenyl-3-(2-phenylethynyl)-1H-pyrazole-4-carboxaldehyde 259a. The other 4-phenyl-3-buten-2-one 2,4-dinitrophenyl hydrazones 259b-d and the phenylhydrazones 259e-h were also subjected to the Vilsmeier reaction under microwave irradiation and the results are summarised in table 6.
Table 6. Synthesis of 1-aryl-3-(2-arylethenyl)-1H-pyrazole-4-carboxaldehydes under microwave irradiation

<table>
<thead>
<tr>
<th>Product</th>
<th>Substituents</th>
<th>Time (sec.)</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>259a</td>
<td>NO₂</td>
<td>90</td>
<td>69</td>
</tr>
<tr>
<td>259b</td>
<td>NO₂</td>
<td>90</td>
<td>59</td>
</tr>
<tr>
<td>259c</td>
<td>NO₂</td>
<td>90</td>
<td>64</td>
</tr>
<tr>
<td>259d</td>
<td>NO₂</td>
<td>90</td>
<td>57</td>
</tr>
<tr>
<td>259e</td>
<td>H</td>
<td>45</td>
<td>79</td>
</tr>
<tr>
<td>259f</td>
<td>H</td>
<td>45</td>
<td>76</td>
</tr>
<tr>
<td>259g</td>
<td>H</td>
<td>45</td>
<td>81</td>
</tr>
<tr>
<td>259h</td>
<td>H</td>
<td>45</td>
<td>68</td>
</tr>
</tbody>
</table>

1-(2,4-Dinitrophenyl)-3-(2-phenylethenyl)-1H-pyrazole-4-carboxaldehyde 259a

1-(2,4-Dinitrophenyl)-3-(2-phenylethenyl)-1H-pyrazole-4-carboxaldehyde 259a was prepared by the Vilsmeier reaction of 4-phenyl-3-buten-2-one 2,4-dinitrophenylhydrazone 255a under conventional heating (yield = 85%) and microwave conditions (yield = 69%). The IR spectrum revealed the aldehyde carbonyl at 1693 cm⁻¹. In ¹H NMR spectrum the aldehydic proton appeared at δ10.12 as a singlet. The rest of the protons appeared as follows: δ 9.25 (s, 1H), 8.90 (s, 1H), 8.69 (d, 1H, J = 7.8 Hz), 8.25 (d, 1H, J = 8.1 Hz), 7.60-7.36 (m,
Chapter III Synthesis of 1-aryl-3-(2-arylethenyl)-1H-pyrazole-4-carboxaldehydes

7H). In $^{13}$C NMR spectrum the carbon signals were observed at $\delta$ 184.96, 151.26, 146.12, 138.64, 135.64, 135.22, 134.22, 129.71, 128.62, 128.00, 127.92, 126.84, 126.68, 122.89, 121.01 and 116.68. In the mass spectrum the molecular ion peak appeared at $m/z$ 364. The elemental analysis values agreed well with the theoretical values.

1-(2,4-Dinitrophenyl)-3-[2-(4-methylphenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259b

1-(2,4-Dinitrophenyl)-3-[2-(4-methylphenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259b was prepared by the Vilsmeier reaction of 4-(4-methylphenyl)-3-buten-2-one 2,4-dinitrophenylhydrazone 255b under conventional heating (yield = 78%) and microwave conditions (yield = 59%). In the IR spectrum the aldehydic carbonyl absorbed at 1683 cm$^{-1}$. In $^1$H NMR spectrum (fig. 14) the signals appeared as follows $\delta$ 10.11 (s, 1H), 9.22 (s, 1H), 8.89 (s, 1H), 8.68 (d, 1H, $J = 9.0$ Hz), 8.26 (d, 1H, $J = 9.0$ Hz), 7.48-7.44 (m, 4H), 7.21 (d, 2H, $J = 7.5$ Hz), 2.34 (s, 3H). In $^{13}$C NMR spectrum (fig. 15) the carbons resonated at $\delta$ 184.97, 151.59, 146.19, 143.02, 138.74, 138.39, 135.45, 134.38, 133.06, 129.36, 128.07, 126.93, 126.71, 123.03, 121.14, 115.75 and 20.93. The molecular ion was observed at $m/z$ 378 (fig. 17). The elemental analysis values agreed well with the proposed structure.
Chapter III  Synthesis of 1-aryl-3-(2-arylethenyl)-1H-pyrazole-4-carboxaldehydes

Fig. 14.  $^1$H NMR spectrum of 1-(4,4-dinitrophenyl)-3-[2-(4-methylphenylethenyl)-1H-pyrazole-4-carboxaldehyde (259b)
Fig. 15. $^{13}$C NMR spectrum of 1-(2,4-dinitrophenyl)-3-[2-(4-methylphenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde (259b)
Fig. 16. Mass spectrum of 1-(2,4-dinitrophenyl)-3-[2-(4-methylphenylethenyl)]1H-pyrazole-4-carboxaldehyde (259b)
1-(2,4-Dinitrophenyl)-3-[2-(4-chlorophenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259c

1-(2,4-Dinitrophenyl)-3-[2-(4-chlorophenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259c was prepared by the Vilsmeier reaction of 4-(4-chlorophenyl)-3-buten-2-one 2,4-dinitrophenylhydrazone 255c under conventional heating (yield = 79%) and microwave conditions (yield = 64%). The IR spectrum revealed the aldehydic carbonyl at 1690 cm\(^{-1}\). In \(^1\)H NMR spectrum the proton signals were observed as follows: \(\delta\) 10.11 (s, 1H), 9.07 (s, 1H), 8.64 (d, 1H, \(J = 8.7\) Hz), 8.21 (d, 1H, \(J = 8.7\) Hz), 7.56-7.46 (m, 4H), 7.41 (s, 1H), 7.37-7.35 (m, 2H). The \(^{13}\)C NMR spectrum showed the carbon signals at \(\delta\) 188.44, 151.52, 138.64, 135.90, 134.67, 133.83, 133.41, 128.91, 128.79, 128.39, 127.96, 126.70, 123.44, 121.05, 119.72 and 117.49. The mass spectrum showed the molecular ion peak at \(m/z\) 398. The structure was also confirmed by elemental analysis.

1-(2,4-Dinitrophenyl)-3-[2-(4-methoxyphenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259d

1-(2,4-Dinitrophenyl)-3-[2-(4-methoxyphenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259d was prepared by the Vilsmeier reaction of 4-(4-methoxyphenyl)-3-buten-2-one 2,4-dinitrophenylhydrazone 255d under conventional heating (yield = 76%) and microwave conditions (yield = 57%). The IR spectrum revealed the aldehyde carbonyl at 1688 cm\(^{-1}\). In \(^1\)H NMR spectrum the aldehyde signal was observed at \(\delta\) 10.11 as a singlet. The rest of
the protons were observed as follows: 9.17 (s, 1H), 8.86 (s, 1H), 8.67 (d, 1H, J = 9.0 Hz), 8.245 (d, 1H, J = 9.0 Hz), 7.54-7.51 (m, 3H), 7.34 (s, 1H), 6.93 (d, 2H, J = 9.0 Hz), 3.81 (s, 3H). In $^{13}$C NMR spectrum the carbon signals were observed at $\delta$ 184.67, 159.94, 151.95, 146.09, 143.16, 138.68, 135.70, 134.29, 128.46, 128.43, 127.98, 126.65, 123.13, 121.08, 114.42, 114.20 and 55.08. In the mass spectrum the molecular ion appeared as the base peak at $m/z$ 394. The elemental analysis values agreed well with the proposed structure.

1-Phenyl-3-(2-phenylethenyl)-1H-pyrazole-4-carboxaldehyde 259e

4-Phenyl-3-buten-2-one phenylhydrazone 255e on treatment with the Vilsmeier reagent gave 1-phenyl-3-(2-phenylethenyl)-1H-pyrazole-4-carboxaldehyde 259e in 92% yield under conventional heating and in 79% yield under microwave irradiation. In the IR spectrum the aldehyde group absorbed at 1683 cm$^{-1}$. In $^1$H NMR spectrum the proton signals appeared as follows $\delta$ 10.20 (s, 1H), 8.12 (d, 2H, J = 7.2 Hz), 7.71 (d, 2H, J = 8.1 Hz), 7.65-7.42 (m, 4H), 7.32-7.26 (m, 3H), 6.91 (d, 2H, J = 8.1 Hz). The $^{13}$C NMR spectrum showed the carbon signals at $\delta$ 184.4, 151.7, 139.4, 137.0, 134.8, 133.1, 130.1, 129.1, 128.9, 128.3, 127.5, 123.1, 120.1 and 117.8. The molecular ion was observed at $m/z$ 274. The structure was also confirmed by elemental analysis.

1-Phenyl-3-[2-(4-methylphenyl)ethenyl]-1H-pyrazole
-4-carboxaldehyde 259f

4-(Methylphenyl)-3-buten-2-one phenylhydrazone 255f on treatment with the Vilsmeier reagent gave 1-phenyl-3-[2-(4-methylphenyl)ethenyl]-1H-pyrazole-4-
carboxaldehyde 259f in 89% yield under conventional heating and in 76% yield under microwave irradiation. The IR spectrum showed the aldehyde carbonyl at 1689 cm\(^{-1}\). In \(^1\)H NMR spectrum the proton signals were observed as follows: \(\delta\) 10.02 (s, 1H), 8.16 (s, 1H), 7.81 (d, 2H, \(J = 8.1\) Hz), 7.65-7.56 (m, 3H), 7.43-7.37 (m, 2H), 7.23-7.18 (m, 2H), 6.83 (d, 2H, \(J = 8.1\) Hz), 2.28 (s, 3H). The carbon signals in the \(^{13}\)C NMR spectrum were observed at \(\delta\) 185.6, 152.2, 139.6, 137.3, 134.7, 133.9, 132.1, 129.4, 128.9, 128.0, 126.0, 122.1, 119.8, 114.3 and 21.2. In the mass spectrum the molecular ion was observed at \(m/z\) 288. The elemental analysis values agreed well with the proposed structure.

1-Phenyl-3-[2-(4-chlorophenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259g

The synthesis of 1-phenyl-3-[2-(4-chlorophenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259g was achieved by the Vilsmeier reaction of 4-(chlorophenyl)-3-buten-2-one phenylhydrazone 255g in 93% yield under conventional heating and in 81% yield by carrying out the reaction under microwave irradiation. In the IR spectrum the aldehyde group absorbed at 1693 cm\(^{-1}\). \(^1\)H NMR spectrum showed the signals at \(\delta\) 10.16 (s, 1H), 8.36 (d, 2H, \(J = 7.2\) Hz), 8.12 (d, 2H, \(J = 8.1\) Hz), 7.81-7.65 (m, 4H), 7.52-7.45 (m, 2H), 6.86 (d, 2H, \(J = 8.1\) Hz). In \(^{13}\)C NMR spectrum the carbon signals were observed at \(\delta\) 185.3, 151.8, 138.2, 135.3, 134.9, 134.6, 132.9, 131.5, 128.9, 128.6, 127.1, 123.4, 121.3 and 118.1. The mass spectrum showed the molecular ion peak at \(m/z\) 308. The elemental analysis values agreed well with the theoretical values.
1-Phenyl-3-[2-(4-methoxyphenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259h

1-Phenyl-3-[2-(4-methoxyphenyl)ethenyl]-1H-pyrazole-4-carboxaldehyde 259h was prepared by the Vilsmeier reaction of 4-(4-methoxyphenyl)-3-buten-2-one phenylhydrazone 255h under conventional heating (yield = 84%) and microwave conditions (yield = 68%). The aldehyde carbonyl absorbed at 1689 cm\(^{-1}\) in the IR spectrum. The \(^{1}\)H NMR spectrum revealed the protons to be at \(\delta\) 10.08 (s, 1H), 8.37 (s, 1H), 7.86 (d, 2H, \(J = 7.5\) Hz), 7.66 (s, 1H), 7.55-7.45 (m, 4H), 7.40-7.34 (m, 2H), 6.91 (d, 2H, \(J = 8.4\) Hz), 3.83 (s, 3H). In \(^{13}\)C NMR spectrum the carbon signals appeared as follows: \(\delta\) 183.6, 159.5, 151.2, 138.6, 133.5, 132.1, 129.2, 128.9, 128.0, 127.4, 122.1, 119.2, 114.7, 113.7, 54.8. The molecular ion peak appeared at \(m/z\) 304 in the mass spectrum. The structure was also confirmed by elemental analysis.