

A STUDY OF THE RING EXPANSION REACTIONS OF PYRAZOLES AND SUBSTITUTED PYRAZOLES WITH CARBON TETRACHLORIDE AT HIGH TEMPERATURE IN THE VAPOUR PHASE

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The ring expansion reactions of trichloromethyl radicals, generated in the vapour phase from carbon tetrachloride in a flow system at 550° with pyrazoles and N-substituted pyrazoles specially those cases where the diazoles have some similarity with N- and C-substituted pyrazoles, have been investigated. [8]. Unchlorinated ring expansion compounds were the major products obtained from N-substituted pyrazoles while pyrazoles yielded chlorinated products as the major components of the reaction mixture. The products obtained from the reaction of pyrazoles and N-carbon tetrachloride were also compared with those obtained from the reactions of pyrazoles and chloroform [8] under identical conditions.

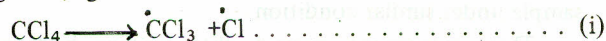
Key words: Pyrazoles and Carbon tetrachloride.

INTRODUCTION

This paper gives an account of results obtained when the vapour phase reactions of carbon tetrachloride with N- and C-substituted pyrazoles were studied [1-3] on the vapour phase reactions of pyrazoles with chloroform. The work with chloroform was initiated with expectations, based on information in the literature [4] that dichlorocarbene, generated from chloroform, reacts with a substrate molecule to give ring expanded products.

$\text{CHCl}_3 \xrightarrow{\cdot\text{CCl}_2}$ heterocycle adducts \rightarrow ring expanded products.

Some of the results obtained seemed to support this idea, but the recent work of L.Zor [5] has shown that some, if not all, of the products obtained are formed by the attack of trichloromethyl radical on the substrate molecule. The use of carbon tetrachloride for generating trichloromethyl and chlorine radicals [6] and their subsequent participation in the addition reaction is known for a long time, eg:



with the above evidence available that $\cdot\text{CCl}_3$ can be generated from CCl_4 as from chloroform, ring expansion reactions with CCl_4 were considered worth-while.

EXPERIMENTAL

1. Reaction of carbon tetrachloride with pyrazole.

A solution of pyrazole (8.0g) in carbon tetrachloride

(63.0cm³) was pyrolyzed and the reaction mixture was carefully collected. The basic components of pyrolysate were analysed by GLC with carbowax 20 M as the stationary phase at 150°. The components were isolated by preparative GLC and I.R. N.M.R. and mass spectra were obtained for each constituent. The spectral data and the comparison of the retention distances with those of the respective authentic samples of each component showed the following reaction products:

1. Pyrimidine.
2. 2-Chloropyrimidine.
3. Pyrazole.

Identification of pyrimidine. This was confirmed as pyrimidine by comparison of its retention distance with that of an authentic sample.

Spectral data of pyrimidine I.R. Spectrum⁸ (liquid film) λ_{max} 680w, 720vs (Possibly C-H vib), 800w, 990 m, 1070w, 1220m, 1360 vs-sharp, 1430m, 1520 vs sharp, 3090, (C-H str. vib) 3200 cm⁻¹.

N.M.R. Spectrum⁸



$\tau(\text{CDCl}_3)$

2-H	...	...	...	0.7s
5-H	...	...	...	2.6 m
4-H and 6-H	...	...	...	1.2 d (intensity = 2 protons)

Coupling constants

J _{2,5}	...	1.5 Hz	J _{4,5}	...	5Hz
J _{4,6}	...	2.5 Hz	J _{5,6}	...	5Hz

Peaks due to 2-H are quite broad because of the effect of nitrogen. 4-H and 6-H are like protons due to the symmetrical nature of the compound.

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for each constituent. The spectral data and the comparison of the retention distances with those of the respective authentic samples of each component showed the following reaction products:-

1. Pyrimidine.
2. 2-Chloropyrimidine.
3. 2-Methylpyrimidine.
4. Pyrazole.

Identification of 2-methylpyrimidine. Colourless liquid, b.p. 138°/758 mm Hg.

Elemented analysis.

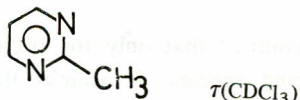
Found : C, 63.78; H, 6.42; N, 29.79.

Calc. for C₅H₆N₂: C, 63.83 ; H, 6.38; N 29.78%.

Spectral data.

ν_{\max} (liquid film) 758, 820, 935, 1000, 1025, 1055, 1140, 1160, 1275, 1400, 1440, (CH³ gp), 1568 (C=C and C=N) 2980 (C-H str.), 3075 (aromatic ring) cm⁻¹.

*N.M.R. Spectrum*⁸



CH ₃	...	...	7.4 s (intensity = 3 protons)
4-H and 6-H	...	...	1.4 d(intensity = 2 protons)
5-H	...	...	2.9 m

Coupling constants.

J _{4,5}	...	...	5 Hz
J _{5,6}	...	...	5 Hz

Protons 4-H and 6-H are indetical due to symmetrical environment. The spectrum shows a doublet and a triplet, typical of A₂x system, with 4-H and 6-H doublet which is considerably broadened by coupling with the adjacent nitrogen atoms.

5. Reaction of carbon tetrachloride with 1-benzylpyrazole. A solution of 1-benzylpyrazole (6.0 g) in carbon tetrachloride (20.0cm³) was pyrolysed and the reaction products so obtained (basic components) when analysed by GLC (analytical) using carbowax 20 M as the stationary phase at 150° which showed five constituents. The components were isolated by preparative GLC and I.R., N.M.R. and mass spectra were obtained for each component. The spectral properties of different components indicated the presence of following compounds.

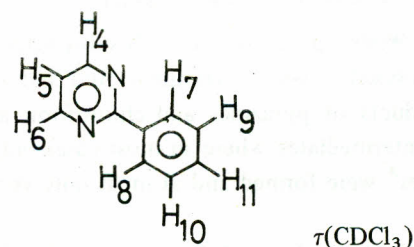
1. Pyrimidine.
2. 2-Chloropyrimidine.
3. Pyrazole.
4. 2-Phenylpyrimidine.

Identification of 2-phenylpyrimidine.

*I.R. Spectrum*⁸

ν_{\max} (KBr). 650s, 700s, 775vs (C-H str. vib), 810m, 837m, 850vw, 940w, 995vw, 1037s, 1080m, 1100w, 1180m 1230vw, 1260m 1325m, 1420vs, 1500vw, 1570vs (C=C and C=N str. vib) 1630w, 1680vw, 1750vw, 1820w, 1920w, 1980m broad, 3075s(aromatic C-H str. vib) 3500w, cm⁻¹

N.M.R. Spectrum



4-H and 6-H	...	...	12.24 d (intensity=2 Protons)
5-H	...	...	2.88 t
7-H and 8-H	1.4-1.62m (intensity = 2 Protons)
9-H, 10-H and 11-H	2.46-2.57m (intensity = 3 Protons)

Coupling constants

J _{4,5}	...	5 Hz
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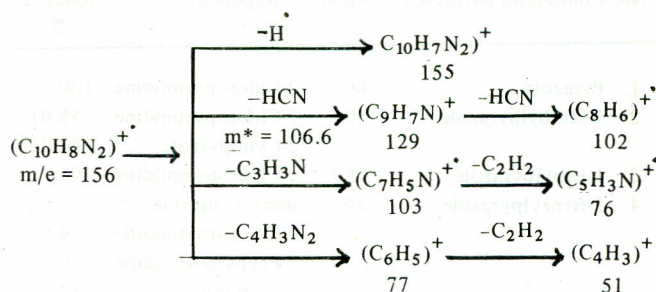
The spectrum of component is characterised in that the phenyl ring protons consist of two well separated regions of absorption with an integrated intensity ratio of 2:3. The other protons of benzene ring show a large shift due to the nitrogen atoms of the pyrimidine ring.

Mass spectrum

Molecular weight = 156.

156 (100), 155 (9.1), 129 (9.3), 103 (76.4) 102 (9.8), 101 (7.3), 77 (30.9) 76 (13.0) 51 (16.4) 50 (12.7)

The fragmentation pattern may be represented as follows:



DISCUSSION

Actually diazoles, the five-membered heterocyclic ring systems containing two nitrogen atoms within the ring, may be considered to be derived from pyrrole by replacing the 2- or 3-methyl group by a nitrogen atom. The diazole having a nitrogen atom in the 1- and 2- positions is known as pyrazole whereas the one having nitrogen atom in 1-1 and 3-positions is called imidazole. Both pyrazoles and imidazoles are aromatic in character and to a certain degree they possess nucleophilic character.

When pyrazoles and N-substituted pyrazoles were pyrolysed, it was interesting to find that unlike the reaction products of pyrazoles and chloroform involving carbenes as intermediates where in most cases only 2-chloropyrimidines⁸ were formed and at most only very small quantities

Table 1. Products of the pyrolysis of carbon tetrachloride with pyrazoles

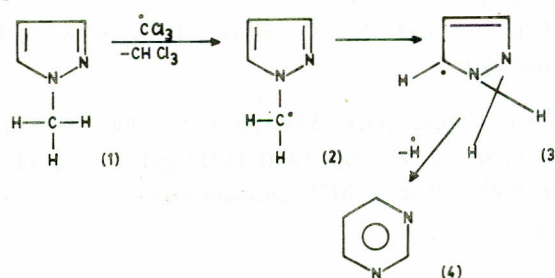
No. Compound pyrolysed	Yield	Components	Relative %
1. Pyrazole	75%	Pyrimidine	30
		2-chloropyrimidine	70
2. 1-Methylpyrazole	50%	Pyrimidine	63
		2-chloropyrimidine	11.8
		Pyrazole	25.1
3. 1-Ethylpyrazole.	71%	Pyrimidine	70
		2-chloropyrimidine	4.5
		2-methylpyrimidine	15
		Pyrazoles	10.5
4. 1-Benzylpyrazole	50%	Pyrimidine	34.86
		2-chloropyrimidine	4.73
		Pyrazole.	6.22
		2-Phenyl-pyrimidine.	54.17

Table 2. Reaction products of the pyrolysis of chloroform with pyrazoles.

No. Compound pyrolysed	Yield	Components	Relative %
1. Pyrazole	80%	2-Chloropyrimidine	100
2. 1-Methylpyrazole	50%	2-Chloropyrimidine	58.01
		2-Cynopyrrole	42.02
3. 1-Ethylpyrazole	75%	2-Chloropyrimidine	100
4. 1-Benzylpyrazole	50%	Benzyl chloride	3.0
		2-Chloropyrimidine	4.9
		2-Phenylpyrimidine	39.7
		α -Carboline	52.3

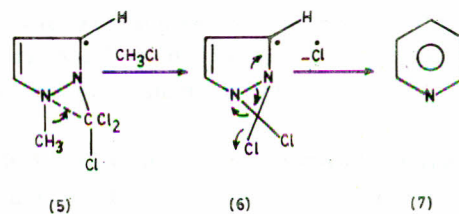
of the reaction between pyrazoles and carbon tetrachloride gave mostly unchlorinated ring expanded products along with minor amounts of chlorinated products.

Pyrolysis of 1-methylpyrazoles. The major difference between the reaction products of 1-methylpyrazole and carbon tetrachloride compared with that of the reaction products obtained by the pyrolysis of 1-methylpyrazole and chloroform⁸ at 550° is, that in the former case, pyrimidine is the major product 2-chloropyrimidine is decreased, and cyanopyrrole is absent (Tables 1-2). The formation of pyrimidine is explained by the following mechanism:—



It is assumed that only the trichloromethyl radical is the attacking species. It attacks the methyl group by abstracting a hydrogen atom and so forms the radical (2) which rearranges to the bicyclic system (3) and then converts into pyrimidine (4) by the loss of hydrogen atom⁹. The relatively easy loss of the hydrogen radical⁹ is important under high temperature conditions of the reaction.

The formation of 2-chloropyrimidine can be explained by the following mechanism.



It is possible that the trichloromethyl radical attacks at the 2-position converting (1) into the radical (5). The intermediate (5) loses a molecule of methyl chloride and is transformed into 2-chloropyrimidine (7) via the bicyclic system (6) by the elimination of chloroquinone radical. It is assumed that pyrazole resulted from the demethylation of 1-methylpyrazole under high temperature conditions of the reaction. The formation of the reaction products obtained by the pyrolysis of pyrazole, 1-ethylpyrazole and 1-Benzylpyrazole can be explained by the mechanism similar to that given to explain the formation of corresponding products from 1-methylpyrazole.

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