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# FLASH VACUUM PYROLYSIS OF PYRIDAZINE N-OXIDES

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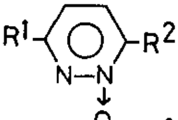
Abstract——Flash vacuum pyrolysis of 6-unsubstituted pyridazine 1-oxides afforded nitriles and pyrroles. 6-Phenylpyridazine 1-oxides gave 2-phenyloxazole together with nitriles and pyrroles. 6-Methylpyridazine 1-oxide and 3,6-dimethylpyridazine 1-oxide afforded naphthalene and benzene, respectively, together with other products. The formation mechanism of these products was speculated.

Flash vacuum pyrolysis(FVP) is an available method for many organic syntheses,[1] and in the previous paper we have reported some observations on the FVP of pyridine N-oxides.[2] These studies showed that the N-O bond is labile under FVP conditions. Thus attention will be called to the pyrolytic behavior of pyridazine N-oxides, which are also expected to be reactive on pyrolysis. In this paper we wish to report the FVP of pyridazine N-oxides.



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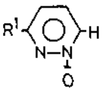
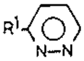
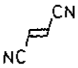
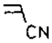
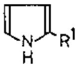
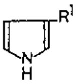
a: $R^1=R^2=H$ b: $R^1=Me$, $R^2=H$ c: $R^1=Ph$, $R^2=H$
d: $R^1=H$, $R^2=Ph$ e: $R^1=R^2=Ph$ f: $R^1=H$, $R^2=Me$
g: $R^1=R^2=Me$

The pyrolyses were carried out according to the method described earlier.[2] First, 1a was pyrolysed at 750°C to afford pyridazine, a mixture of fumalonitrile and maleonitrile, acrylonitrile, and pyrrole.[3] Recovery of the starting material was 20%, although the decomposition of 1a at 650°C was limited and more than 95% of 1a was recovered.

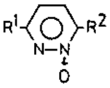
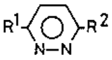
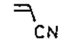
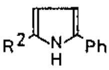
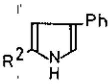
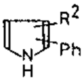
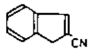
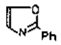
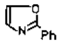
Table 1 *FVP of N-oxides 1a and 1b at 750°C*

|  |  |  |  |  |  |  | other notable products |
|---|---|---|---|---|---|---|---|
| 1a: $R^1$=H | 5% | 10% | | 25% | 1% | | — |
| 1b: $R^1$=Me | 4% | 8% | | 10% | 6% | 2% |  8%<br>MeCN 10% |

FVP(750°C) of 1b gave similar products; 3-methylpyridazine, a mixture of the dinitriles, acrylonitrile, and 2- and 3-methylpyrroles, together with pyridine and acetonitrile as shown in table 1.[3,4]

Then N-oxides of phenylpyridazines(1c,d, and e) were pyrolysed at 750°C and the results are shown in Table2.[5] A characteristic and major product from 1d and 1e was 2-phenyloxazole although it was not obtained from 1c.

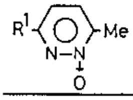
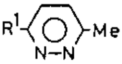
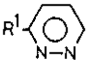
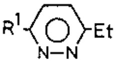
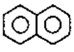
Table 2 FVP of 1c, 1d, and 1e at 750°C

|  |  | PhCN |  |  |  |  | other notable products | |
|---|---|---|---|---|---|---|---|---|
| 1c: $R^1$=Ph<br>$R^2$=H | 20% | 17% | trace | 23% | 4% | — | — | |
| 1d: $R^1$=H<br>$R^2$=Ph | 6% | 14% | 4% | (major)<br>3% | (minor) | — | <br> | 9%<br>28% |
| 1e: $R^1$=$R^2$=Ph | 10% | 15% | trace | 10% | 7% | |  | 11% |

Formation of all the products in Tables 1 and 2 other than deoxygenated products (pyridazines) might be explained by the fragmentation of the intermediary biradical 2 which could be formed via an N-N bond fission of 1. The plausible formation mechanisms of these products are shown in Chart 1.

Next, 6-methylpyridazine 1-oxides(1f and 1g) were pyrolysed. These N-oxides were more sensitive to the pyrolysis than 1a-e and more than 50% of them was pyrolysed at 650°C unlike former cases[6] and the products are summarized in Table 3.

Table 3 FVP of 1f and 1g at 650°C

|  |  |  |  | other notable products |
|---|---|---|---|---|
| 1f: $R^1$=H | 8% | 5% | 1% |  18% + [products of low boiling points] |
| 1g: $R^1$=Me | 16% | 1% | 1% |  30% |

Loss of methyl groups($R^2$) and formation of ethylpyridazine (capture of methyl or methylene fragments) are not surprising because similar reactions have been observed in FVP of 2-alkylpyridine 1-oxides.[2,6,7] Although naphthalene from 1f and benzene from 1g were unexpected, the formation of these hydrocarbons is explained by the intermediacy of 3-pyridazinylmethyl radical 3 as illustrated in chart 2.

Thus, rather complicated but interesting reactions were observed in FVP of pyridazine N-oxides.

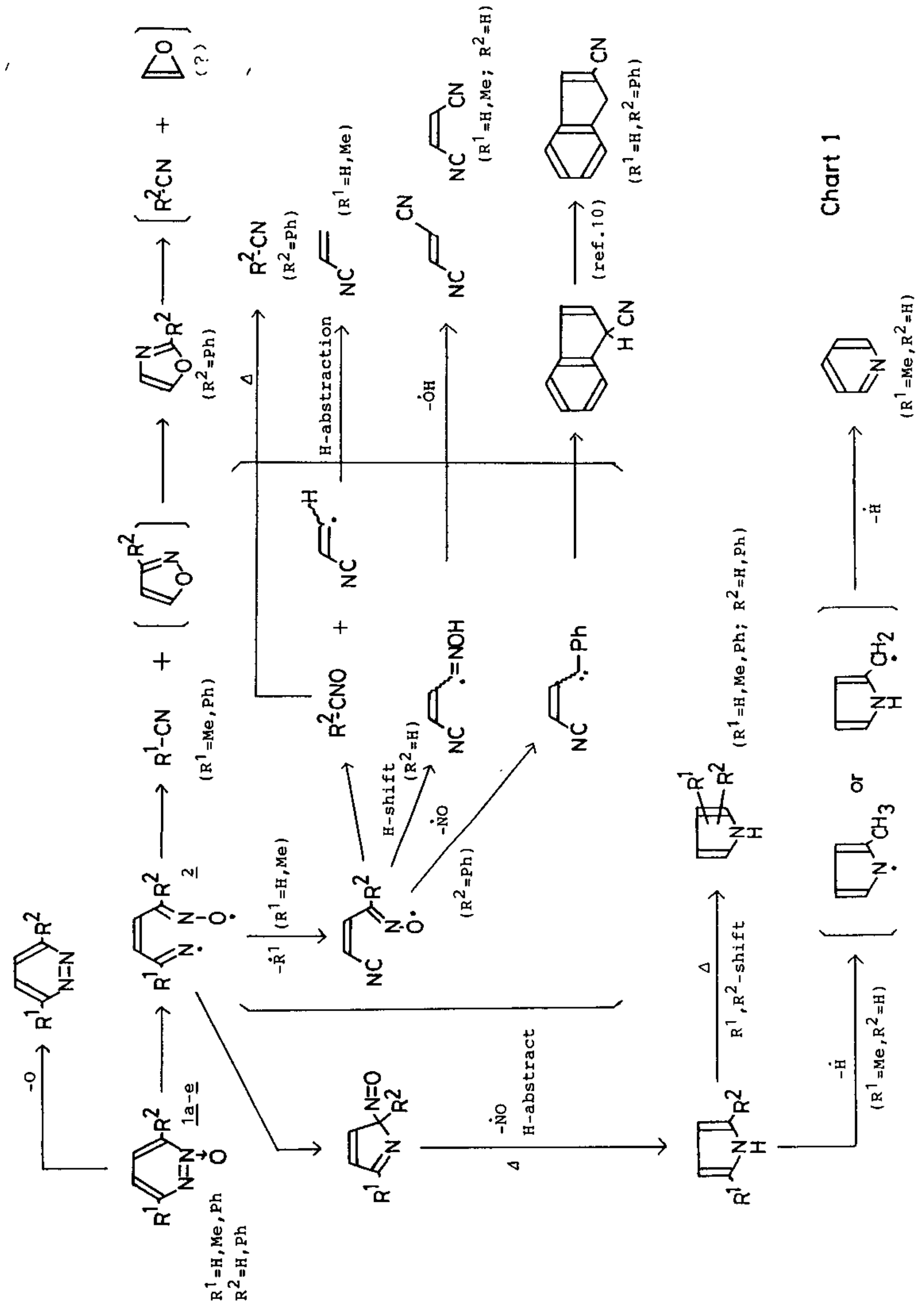

-O
1a-e
R1=H,Me,Ph
R2=H,Ph
2
R1-CN
(R1=Me,Ph)
(R2=Ph)
(?)
-Ṙ1
(R1=H,Me)
H-shift
(R2=H)
-ṄO
(R2=Ph)
R2-CNO
Δ
R2-CN
(R2=Ph)
H-abstraction
(R1=H,Me)
-ȮH
(R1=H,Me; R2=H)
(ref.10)
(R1=H,R2=Ph)
-ṄO
H-abstract
Δ
R1,R2-shift
(R1=H,Me,Ph; R2=H,Ph)
-Ḣ
(R1=Me,R2=H)
or
-Ḣ
(R1=Me,R2=H)

Chart 1

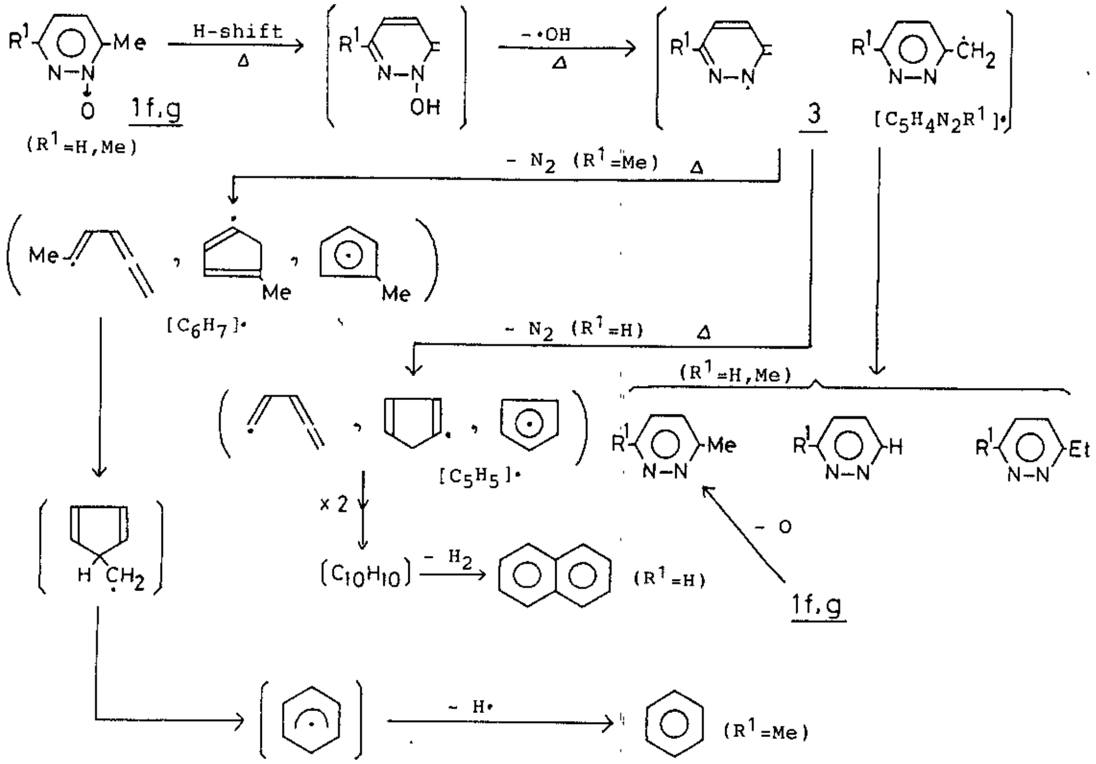


Chart 2

EXPERIMENTAL

General Procedures. Pyridazine N-oxides were prepared by oxidation of corresponding pyridazines with m-chloroperbenzoic acid or with $H_2O_2$-AcOH.[8,9] N-oxides were distilled into a quartz pyrolysis tube (15 cm X 1 cm) from a flask heated by surrounding it with the Nichrome wire. The quartz tube was heated with a furnace. Products were collected in a cold trap (liquid $N_2$).

Pyrolysis of Pyridazine N-oxides. Pyrolysis of 1a-1g were conducted without a carrier at 650°C or 750°C/0.01 mmHg. Only slight decompositions were observed for 1a-1e in the FVP at 650°C. The recoveries of 1a-1e at 650°C were 92 to 95%. Collected reaction mixture was distilled at room temperature under ca. 0.1 mmHg and seperated into a residual part and a distillable part. The former parts of 1b, 1d, and 1f were chromatographed. 2-Cyanoindene was identified by the alternative synthesis according to the method of Wentrup et al.[10] 2-Phenyloxazole was identified with nmr, ir, and high ms. All the other products were identified with the authentic samples by nmr and gc-ms. The yields were obtained from GC using the standard samples, and the ratios of structual isomers were determined by nmr. Conversion of maleonitrile to fumalonitrile was observed under the FVP conditions. Parent pyrrole was not stable in FVP, and the decomposition to highly volatile products and polymeric products was observed at 750°C. Interchangeable isomerization between 2- and 3-substituted pyrroles is well-known (see ref.1), and under here-mentioned conditions was occurred a facile isomerization of 2-methylpyrrole to 3-methylpyrrole. Similarly, FVP of 3-phenylisoxazole at 750°C gave 47% of 2-phenyloxazole and 23% of benzonitrile, without being accompanied by the recovery of starting material. Thus it is a reasonable speculation that 2-phenyloxazole formation occurred via an intermediate 3-phenylisoxazole (Chart 1).

REFERENCES AND FOOTNOTES

1. a) R.F.C. Brown, "Pyrolytic Methods in Organic Chemistry"; Academic Press: New York 1980.
   b) U.E. Wiersum, Recl. Trav. Chim. Pays-Bas, 101, 317, 365 (1982).
2. a) A. Ohsawa, T. Kawaguchi, and H. Igeta, J. Org. Chem., 47, 3497 (1982).
   b) idem, Chem. Lett., 1981, 1737.
   c) idem, Synthesis, 1983, 1037.
3. Oxazole was not detected (by GC-MS).
4. Recovery of 1b was 22%, while more than 95% of 1b was recovered at 650°C.
5. Recoveries of 1c, 1d, and 1e were 25%, 4%, and 7% respectively.
6. The thermal sensitivity of 6-methylpyridazine 1-oxides may be explained by an interaction between the oxygen atom and the methyl group in 6-position, in analogy with the FVP of 2-alkylpyridine N-oxides; see ref.2.
7. Neither pyrroles nor isoxazoles were obtainedfrom 1f and 1g.
8. T. Itai and S. Sako, Chem. Pharm. Bull., 10, 987 (1962).
9. a) M. Ogata, Chem. Pharm. Bull., 11, 1522 (1963).
   b) M. Ogata and H. Kano, ibid., 11, 35 (1963).
10. C. Wentrup and C.D. Crow, Tetrahedron, 26, 3965, 4386 (1970).

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