

7.* PHTHALIMIDOALKYL- α -DIAZOKETONES

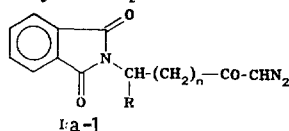
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The molecular ions of phthalimidoalkyl- α -diazoketones that form in the gas phase under electron impact split out a nitrogen molecule and rearrange by a Wolff mechanism to ketenic ions. The alternative intramolecular heterocyclization does not occur. The decomposition mechanism of $[M-N_2]^+$ ions was studied. The structures of some charged fragments that form when the phthalimide nucleus decomposes were established by high resolution spectrometry.

We have previously shown [2] that in the gas phase under electron impact, diazoketones containing a hetero atom or a heteroatomic group which can show anchimeric cooperation in the splitting out of a nitrogen molecule, do not undergo a Wolff rearrangement [3, 4], but cyclize to form heterocyclic systems. The action of acids on solutions of such diazoketones gives analogous products [5]. We conclude that the behavior of such diazoketones in solution can be predicted from a study of their decomposition in mass spectrometry.

Phthalimidoalkyl- α -diazoketones I are frequently used as model compounds in studies of the Wolff rearrangement [6-8]. Under the influence of acids in solution they split out a nitrogen molecule, but the expected tricyclic products do not then form.



I a - g n=0, h - n n=1, j n=2, k n=3, l n=4; I a, i, j, k, l, R=H, b R=CH₃,
c R=C₂H₅, d R=i-C₃H₇, e R=(CH₃)₂-CH-CH₂, f R=C₂H₅-CH-CH₃, g R=C₆H₅CH₂,
h R=C₆H₅

It was therefore of interest to track the behavior of these compounds in the gas phase, where solvation effects and intermolecular reactions are ruled out. Starting from the similarity in diazoketone cyclization when a nitrogen molecule is split out in the gas phase under electron impact and in solution under the influence of acids [2], it might be expected that for diazoketones I the results would be similar to those observed in solution [6-8]; i.e., the Wolff rearrangement is more favored than cyclization, leading to disruption of the stable phthalimide structure. *A priori*, however, the cyclization of a $[M-N_2]^+$ ion at the phthalimide nitrogen or oxygen can not be ruled out.

From the study of the fragmentation paths of I under electron impact we concluded that the fundamental decomposition process is a Wolff rearrangement that proceeds simultaneously with the elimination of a nitrogen molecule from the molecular ion M^+ . These M^+ are unstable, and they decompose as soon as they form, to liberate a nitrogen molecule. M^+ could be recorded only for compound Ig, which is more stable thanks to the stabilizing effect of the benzyl substituent. Nevertheless the presence in our mass spectra of $[M-CHN_2]^+$ ions (Φ_s , see Diagram)[†] is evidence for the existence of M^+ in other cases also. Such a fragment cannot form from M^+ of the corresponding ketene, which might originate in the ion source during the thermal decomposition of a diazoketone [4], because M^+ can not split out a CH particle [9].

*Communication No. 6, see [1].

[†]The peak intensity of Φ_s in the total ion current is 0.1-0.4%; it is therefore not shown in Table 1.

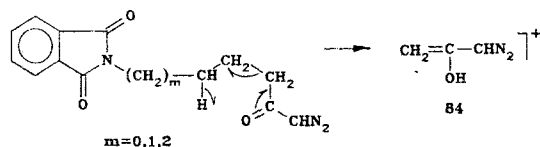
M. V. Lomonosov Moscow State University, Moscow 117234, Scientific-Research Institute for Organic Intermediates and Dyes, Moscow 103787. Translated from *Khimiya Geterotsiklicheskih Soedinenii*, No. 6, pp. 788-793, June, 1985. Original article submitted May 29, 1984.

TABLE 1. Peak Intensities of Characteristic Fragment Ions in Mass Spectra of Compounds Ia-7 as Percent of Total Ion Current

Compound	Peak intensity as % of total ion current								
	[M-N ₂] ⁺	Φ ₁	Φ ₂	Φ ₃	Φ ₄	160	Σ ₁	Σ ₂	84
Ia*	12.0	—	23.9	5.0	—	23.9	36.9	—	—
Ib	6.9	1.0	39.3	1.2	0.2	0.4	34.0	—	—
Ic	4.8	3.2	33.2	3.8	0.3	6.6	26.4	—	—
Id	2.0	3.4	20.0	0.1	1.1	6.8	36.4	—	—
Ie	1.6	4.0	28.4	0.8	0.2	23.9	12.6	—	—
If	1.2	3.3	12.7	1.0	0.7	23.9	23.3	—	—
Ig	0.7	3.5	10.7	0.9	10.9	0.5	29.1	—	—
Ih	0.4	—	8.1	0.1	20.9	0.1	28.2	—	—
Ii	3.4	—	0.5	2.7	1.5	18.6	29.3	9.3	—
Ij	0.4	—	0.9	0.9	14.6	9.8	32.5	5.3	7.6
Ik	0.6	—	0.5	0.5	9.0	22.3	31.7	15.1	5.9
Il	0.4	—	0.1	0.1	4.8	21.4	28.0	6.6	8.2

*For Ia, the values of the ion of mass 160 and Φ₂ are the same.

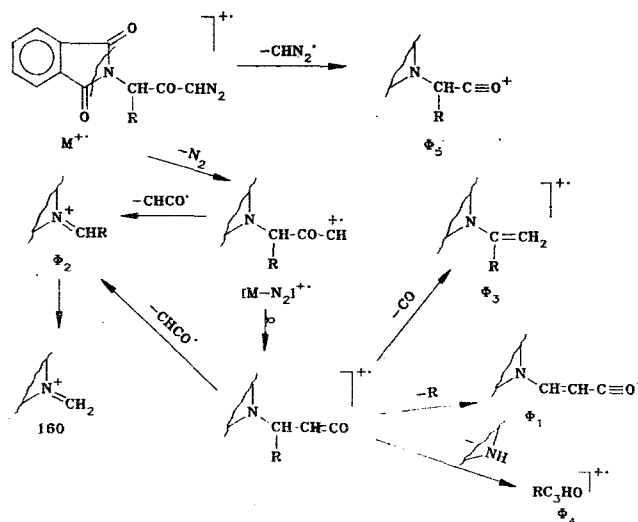
One more confirmation of the existence of M⁺ of I is the intense ion peak at 84,* which forms in the decomposition of compounds with more than three methylene groups in a chain by the McLafferty rearrangement [9]:



Ion 84 is apparently a pseudomolecular ion of the enol form of diazoacetone. Its elemental composition was confirmed by high resolution mass spectrometry. The measured mass was 84.0320 amu; calculated, 84.0323 amu.

The overall primary fragmentation paths of compounds Ia-g (n = 0) are shown in the general diagram:

Diagram



The subsequent fragmentation paths are involved in decomposition of the phthalimide fragment, and give the characteristic ions: 148, 147, 133, 132, 130, 117, 105, 103, 102, 77, and 76; their composition has been considered previously [10-13]. They are therefore not in-

*Here and subsequently in text and diagrams, the numbers characterizing an ion are the ratio of mass to charge (m/z).

TABLE 2. Mass Spectra of Compounds Ia-l

Compound	m/z (ion peak intensity as percent of maximum)				
Ia	201 (55.0)	173 (55.8)	161 (15.8)	160 (100)	133 (20.6)
	117 (16.8)	104 (30.6)	77 (32.2)	76 (35.5)	50 (21.9)
Ib	215 (16.7)	175 (13.5)	174 (100)	147 (25.0)	130 (30.0)
	129 (6.0)	104 (9.0)	102 (5.0)	76 (10.0)	39 (5.0)
Ic	229 (12.7)	201 (12.7)	200 (10.0)	189 (13.2)	188 (100)
	160 (20.4)	130 (31.8)	104 (10.0)	76 (13.6)	41 (10.4)
Id	203 (28.0)	201 (46.0)	200 (33.0)	160 (66.0)	148 (98.0)
	130 (100)	104 (42.0)	76 (60.0)	55 (84.0)	50 (26.0)
Ie	217 (16.1)	216 (100)	201 (14.6)	200 (15.0)	174 (43.0)
	161 (10.8)	160 (90.0)	147 (12.9)	130 (7.5)	76 (7.2)
If	217 (8.8)	216 (51.3)	200 (14.0)	161 (8.9)	160 (100)
	148 (24.2)	130 (22.3)	104 (14.0)	76 (14.9)	69 (17.6)
Ig	250 (95.0)	249 (47.5)	232 (62.5)	200 (31.2)	144 (100)
	133 (41.9)	116 (41.2)	103 (50.0)	77 (41.2)	76 (36.0)
Ih	249 (14.9)	236 (37.5)	144 (100)	130 (30.0)	118 (30.0)
	116 (17.5)	105 (12.0)	104 (20.5)	103 (12.0)	77 (22.5)
Ii	173 (46.5)	160 (100)	133 (18.6)	130 (20.0)	105 (21.4)
	104 (35.3)	103 (25.1)	77 (26.0)	76 (29.3)	55 (27.9)
Ij	160 (66.0)	148 (23.9)	130 (29.5)	105 (22.8)	104 (30.7)
	84 (52.3)	82 (100)	77 (37.5)	76 (39.8)	55 (37.3)
Ik	186 (30.4)	161 (22.1)	160 (100)	148 (20.0)	130 (27.8)
	104 (17.8)	96 (22.8)	84 (28.6)	77 (17.5)	55 (15.7)
Il	161 (25.0)	160 (100)	148 (18.6)	200 (14.3)	130 (24.6)
	110 (22.9)	104 (14.3)	97 (22.1)	84 (39.3)	77 (15.3)

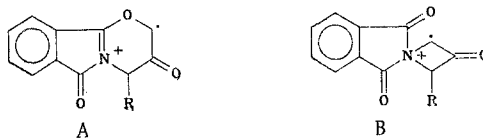
*The ten most intense peaks in the spectrum are shown.

cluded in the decomposition diagram, but their overall intensities Σ_1 are shown in the table of peak intensities of characteristic ions (Table 1). High resolution mass spectrometry showed that ion 132 has the structure given in [10] (found 132.0444, calculated 132.0449) and is different from that in [11, 12]. The elemental composition of ion 133 was also confirmed by high-resolution mass spectrometry (found 133.0314, calculated 133.0289 - C₆H₅O₂).

As the diagram shows, the formation of all the characteristic ions in the spectrum is due to a Wolff rearrangement. It is known that the fundamental decomposition of ketenic ions involves β -scission, which gives a fragment with a conjugated system of short bonds [14]. A $[M - N_2]^+$ ion that forms after a Wolff rearrangement can, by β -scission, eliminate a R¹ radical or a molecule of phthalimide. (The latter process is accompanied by the transfer of hydrogen from an alkyl radical to the phthalimide fragment being eliminated.) As a result the stable ions Φ_1 and Φ_4 form (diagram). The main influence on the peak intensities of the Φ_4 ions is exerted by thermodynamic stability of the olefin fragment that forms.

As Table 1 shows, the peak intensity of Φ_4 ions is several times greater for the fragments stabilized by alkyl groups (Id,f), and about 50 times greater for Ig, where the additional stabilization is due to conjugation with the benzene ring.

The loss of a CO molecule (formation of Φ_3) is another characteristic process of ketene decomposition [3, 4, 14]. Thus it can be confirmed that the $[M - N_2]^+$ ion has a ketene structure as a result of the Wolff rearrangement. In this case the alternative intramolecular cyclization [2] does not happen. For Ia-g we might assume an intramolecular cyclization to form four- and six-membered heterocycles [2]; but that assumes the migration of an amine hydrogen, which is not present in intermediates A or B.



In this connection, the $[M - N_2]^+$ ion that forms in the first decomposition step is stabilized not by cyclization, but by the Wolff rearrangement.

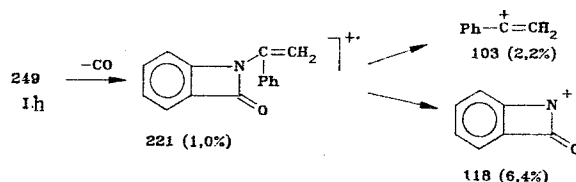
Lengthening the hydrocarbon chain (Ih-l) does not affect the decomposition of the phthalimide fragment (diagram; Table 1); i.e., in this case cyclization does not occur. The Φ_2 ion that forms by splitting out of a COCHN₂ particle from M⁺ is unstable for Ih-l, while

the maximum ion in the mass spectrum is ion 160, which is characteristic of all previously studied N-derivatives of phthalimide [10-13]. In the mass spectra of Ih-7, Φ_4 becomes the most intense ion peak (Table 1); in its subsequent decomposition a radical of large mass is eliminated, due to the β -scission that is characteristic of ketenes [14].

Besides the decomposition paths that we have described, there are also specific fragmentations; even though these do not provide information concerning the course of a Wolff rearrangement or an intramolecular cyclization, they are important in a complete study of the dissociative ionization of phthaliminoalkyl- α -diazoketones. Thus, ion Φ_5 successively eliminates a definite number of hydrogen atoms and molecules to form fragments with a system of conjugated double bonds, until the product is completely conjugated. In compounds Ii-7 the hydrocarbon chain can break at any C-C bond, and such scissions as a rule are accompanied by a rearrangement of hydrogen atoms. Thus there are formed a series of fragments of the general formula $C_8H_4O_2NC_pHR^+$ (where $p = 1, 2, \dots, n$, $R = 2, 3, \dots, 2n$, and $C_8H_4O_2N$ is the phthalimide radical), the peaks of which are of low intensity. Therefore Table 1 shows the overall peak intensities of these ions (Σ_2). In the mass spectra of Ik, 7 (four and five methylene groups, respectively, in the hydrocarbon chain) there is an intense peak of ion 149 (Ik 2.0% I7 1.8% of total ion current). High resolution mass spectrometry showed that its elemental composition is $C_8H_7NO_2$ (found 149.0440, calculated 149.0476); i.e., this ion forms by the successive migration of three hydrogen atoms to a phthalimide fragment. Such a process becomes possible when the hydrocarbon chain is at least four units long. Ions 147 and 148 [10-12] form in the course of the process, due to the migration of one or two hydrogen atoms.

Specific decomposition paths also appear for Ig,h, which contain phenyl substituents. Thus ion Φ_4 of mass 144 (Ig 10.9%, Ih 20.9%) decomposes with ejection of CO molecule (ion 116, 4.5 and 3.7%, respectively) or a CHCO particle (ion 103, 5.4 and 2.2%).

The characteristic ion 232 (7.1%) in the mass spectrum of Ig forms from the Φ_2 fragment by elimination of water by the mechanism previously described [10-12]. Detachment of a hydrogen atom by the Φ_2 ion gives a fragment 249 (5.5%) that is stable thanks to its system of conjugated bonds. A fragment of analogous mass appears in the mass spectrum of the diazoketone Ih (2.9%). In the latter case the ion loses a CO molecule to form a radical ion 221 [10-13], while the subsequent scission of the exocyclic C-N bond gives fragments 118 and 103:



Thus the mass spectra of the diazo compounds Ia-7 show that in the gas phase under electron impact the Wolff rearrangement is an energetically more favored process that completely suppresses cyclization of the $[M - N_2]^+$ radical ion at the heteroatom of the phthalimide fragment, and gives a ketenic ion. Subsequent decomposition of the ketenic ion accounts for the entire picture of the dissociative ionization of these compounds.

EXPERIMENTAL

The test compounds were synthesized at the Branch of the Institute of Chemical Physics (Chernogolovka). Diazoketone mass spectra were obtained on a Varian 112 instrument, with direct introduction of sample into the ion source. Sample temperature was 40-100°, electron ionization energy was 70 eV. High resolution mass spectra were obtained on Varian MAT-311A instrument under analogous conditions. The mass standard was perfluorokerosene.

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SYNTHESIS AND TAUTOMERISM OF 1-SUBSTITUTED

3,3-DIALKYL-3,4-DIHYDROISOQUINOLINES

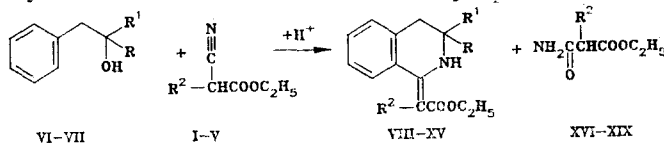
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A number of ethyl esters of 3,3-dialkyl-3,4-dihydroisoquinoline- $\Delta^1(2H)$, α - α -alkylacetic acids have been synthesized. The effect of replacement of α -hydrogen by alkyl radicals on the azomethine-enamine tautomeric equilibrium was shown.

Heterocyclic enamines, including derivatives of 3,4-dihydroisoquinoline, are intermediates in the synthesis of pigments, analytical reagents, and biologically active materials [1, 2].

The synthesis of enamine derivatives of 3,4-dihydroisoquinoline by the Ritter reaction has been demonstrated, and 1-R-3,3-dialkyl-3,4-dihydroisoquinolines were obtained that can exist either as azomethine (where R is CH₃) or as enamine (where R is >CH-COOC₂H₅) [3] depending on the nature of R. The purpose of the present work was to broaden the application of the Ritter reaction for the synthesis of 1-R-3,3-dialkyl-3,4-dihydroisoquinoline derivatives and to study the effect of substituent R on the azomethine-enamine tautomerism. The ethyl esters of the α -cyanocarboxylic acids I-V were synthesized by known procedures [4] and reacted with carbinols VI and VII by the Ritter reaction [5]. The products were the ethyl esters of 3,3-(R, R¹)-3,4-dihydroisoquinoline- $\Delta^1(2H)$, α - α -(R²)-acetic acids (VIII-XV). In contrast to [3], besides the desired products we separated and identified the ethyl esters of α -carbamoylcarboxylic acids, the products of nitrile hydrolysis [6]; with increasing length and branching of R² the yield of the latter increased, up to 30-45%:



VIII-XV R=CH₃; VIII, X, XII-XV R¹=CH₃, IX, XI R¹=C₂H₅; VIII, IX R²=H, X, XI R²=CH₃, XII R²=C₂H₅, XIII R²=*n*-C₃H₇, XIV R²=*n*-C₄H₉, XV R²=*iso*-C₅H₁₁

The properties of the synthesized compounds VIII-XV are given in Table 1. Their tautomerism was studied by PMR and IR spectroscopy.

Compounds VIII and IX are enamines, as evidenced by the signals of the protons at α -carbon and nitrogen. Between -60 and 80° there were no changes in PMR signals. VIII and XI probably exist as enamines that are stabilized by an intramolecular hydrogen bond (IMHB).



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