Ortho Effects in Organic Molecules on Electron Impact. VIII. Intramolecular Aromatic Substitution in (Arylmethylene)barbituric Acids

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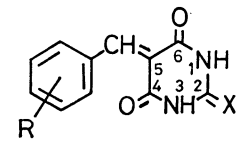
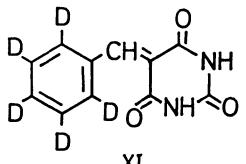
Mass spectral decomposition process involving intramolecular aromatic substitution with the ejection of either the hydrogen or the substituent in the ortho position from the $M^{+\cdot}$ ion is noticed in the eleven 5-(arylmethylene)barbituric acids studied. It has been generally noticed that for such a cyclization to occur, the presence of an α,β-unsaturated carbonyl function, in conjugation with the ring, is essential in aromatic systems.

The mass spectral behaviour[1-5] of cinnamic acid, methyl cinnamate, benzylideneacetophenone, and benzylideneacetone is characterized by the formation of intense $M-H^{\urcorner+}$ ion. An intramolecular cyclization mechanism has been proposed for the above mentioned decomposition process leading to a benzopyrylium ion. Similar observation has also been made in the case of *o*-methoxycinnamic acid[6] and alkyl *o*-chlorostyryl ketones.[7] In order to understand this process more clearly and to establish the generality of this process, the mass spectral study of 5-(arylmethylene)barbituric acids has been chosen in the present work, where the carbonyl function is a part of the ring system.



	R	X
I	H	O
II	H	S
III	o-Cl	O
IV	p-Cl	O
V	o-NO_2	O
VI	m-NO_2	O
VII	o-OCH_3	O
VIII	p-OCH_3	O
IX	m-OH	O
X	p-OH	O



XI

Scheme 1.

Results and Discussion

The mass spectra of all the substituted (arylmethylene)barbituric acids (I—XI) (Scheme 1) present intense molecular ions except in the case of the ortho-isomers. The expected intense $M-H^{\urcorner+}$ or $M-R^{\urcorner+}$ (in the case of the ortho substituent) ions are noticed in all the spectra. In fact, in the case of *o*-chloro(III) and *o*-nitro(V) compounds, the molecular ion is non-existent and the $M-R^{\urcorner+}$ ions happen to be the base peaks. A cyclization mechanism involving an intramolecular aromatic substitution is being proposed for the formation of the above mentioned ions. It is envisaged that the oxygen of the heterocyclic ring attacks the ortho-carbon atom of the phenyl ring giving rise to a cyclized molecular ion, which then expels either the ortho hydrogen or the substituent affording the intense ion 'a' (Scheme 2). That the hydrogen, which is expelled for the formation of 'a' comes from the phenyl ring is substantiated by the fact that the compound(XI) gives exclusively $M-D^{\urcorner+}$ on electron impact and the $M-H^{\urcorner+}$ ion in this compound is totally absent. Furthermore, that the cyclization takes place with the ortho-carbon is supported by the observation that only the ortho substituents are lost during this mode of fragmentation, while in the case of meta- and para- isomers $M-H^{\urcorner+}$ ion only is noticed. These observations provide indirect proof for the mechanism suggested for the formation of the ion 'a'. The driving force for the cyclization appears to be the formation of the stable ion 'a', which is fully conjugated.

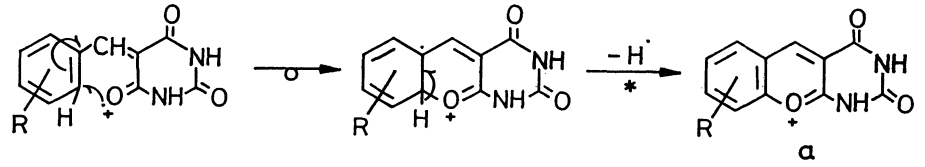
The other general mass spectral fragmentation processes noticed in these compounds are the formation of the ion 'b', by the ejection of a NHCO moiety from 'a', and the fragments 'c' and 'd' from the molecular ion (Scheme 3). Although no metastable evidence is seen for the formation of 'c' and 'd' directly from the $M^{+\cdot}$ ion, these ions are shifted to m/z 134 and m/z 107 (Table 1) respectively in the d_5-compound(XI), while the ion 'b' is shifted only the m/z 176. That the NHCO, that is expelled from 'a' for the formation

TABLE 1. PARTIAL MASS

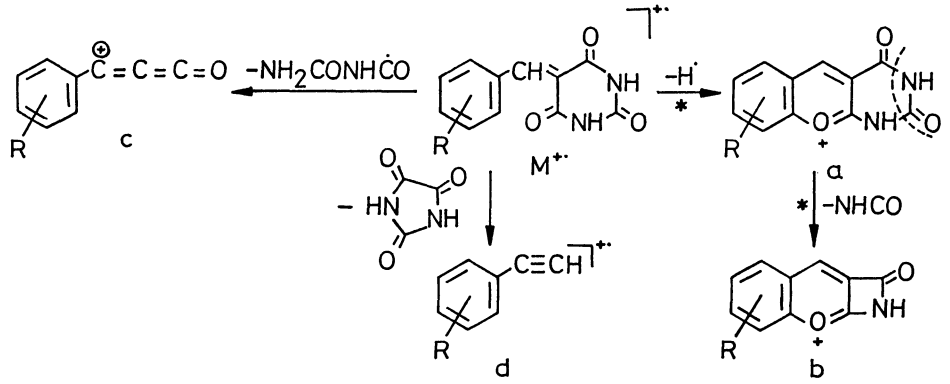
Ions		I	II	III	IV	V	VI	VII	VIII	IX
				Cl^{35}	Cl^{35}					
$M^{+\cdot}$	Rel Int	70	100	0.33	86	—	70	20	100	100
	(*m/z*)	(216)	(232)	(250)	(250)	(261)	(261)	(246)	(246)	(232)
a	Rel Int	100	55	100	100	100	45	100	56	75
	(*m/z*)	(215)	(231)	(215)	(249)	(215)	(260)	(215)	(245)	(231)
b	Rel Int	64	16	70	55	78	22	60	43	52
	(*m/z*)	(172)	(172)	(172)	(206)	(172)	(217)	(172)	(202)	(188)
c	Rel Int	14	10	3	28	—	7	2	11	20
	(*m/z*)	(129)	(129)	(163)	(163)	—	(174)	(159)	(159)	(145)
d	Rel Int	25	45	6	38	—	—	5	11	19
	(*m/z*)	(102)	(102)	(136)	(136)	—	—	(132)	(132)	(118)

of the fragment 'b', is from the 1 and 2 positions of the hetero ring is adduced from the fact that compound II loses exclusively NHCS from 'a' but not the NHCO moiety.

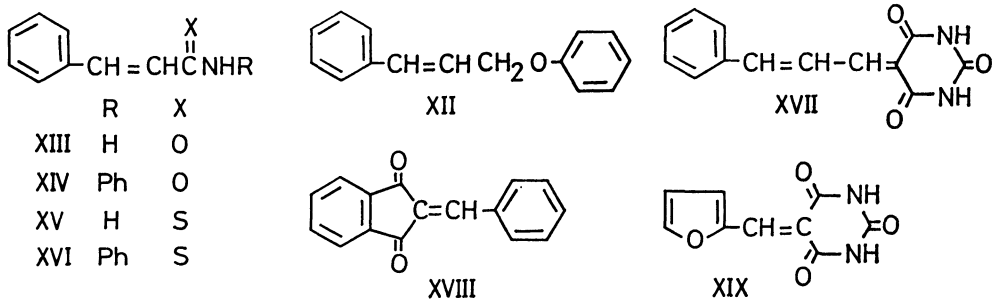
In order to examine the general nature of the electron impact cyclization process, the mass spectra of compounds XII—XIX (Scheme 4) were studied. The mass spectra of cinnamyl alcohol[8,9] and cinnamyl phenyl ether(XII) do not show any prominent M–H^{+} ion indicating that the alcohol and ether oxygens do not readily take part in the cyclization reaction. The base peak in the mass spectrum of 2-benzylidene-1,3-indandione(XVIII) is the M–H^{+} ion, suggesting that the cyclization process is very facile in this compound. Furthermore, 5,5,5′,5′-tetramethyl-2,2′-benzylidenedi(1,3-cyclohexanedione) eliminates a molecule of dimedone during the electron impact[10] giving rise to an intense fragment at m/z 228 (72%) which corresponds to the molecular ion of 2-benzylidene-5,5-dimethyl-1,3-cyclohexanedione. This ion loses a hydrogen radical to give the base peak for which a cyclized structure has been proposed. Cinnamamide(XIII), whose mass spectrum was not studied hitherto, showed M–H^{+} ion as the base peak. This observa-



Scheme 2.



Scheme 3.



Scheme 4.

SPECTRA OF COMPOUNDS I—XIX

X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
100	100	2	78	31	64	59	100	64	100
(232)	(221)	(210)	(147)	(223)	(163)	(239)	(242)	(234)	(206)
75	97	—	100	1	100	53	—	100	—
(231)	(219)	—	(146)	(222)	(162)	(238)	—	(233)	—
59	63	—	—	—	—	—	—	—	—
(188)	(176)	—	—	—	—	—	—	—	—
19	28	—	—	—	—	—	—	—	—
(145)	(134)								
19	42	—	—	—	—	—	—	—	—
(118)	(107)								

tion, together with the earlier ones reveal that any carbonyl oxygen (aldehyde, ketone, acid, ester, and amide) takes part readily in the cyclization in the absence of any other facile fragmentation process. However, the loss of $H^{\cdot}$ from the $M^{+\cdot}$ of cinnamanilide-(XIV) is not a facile process, perhaps, due to a more favourable α-cleavage with respect to the carbonyl function, which leads to stable species. On the contrary the thioanalogues XV and XVI of XIII and XIV respectively exhibit more intense $M-H^{+}$ ions in their mass spectra (Table 1). In fact the ratio of the intensity of the $M-H^{+}$ ion with that of the $M^{+\cdot}$ ion $[(M-H^{+})/(M^{+\cdot})]$ is 1.28 for XV and 1.563 for XVI. This may, most probably, be due to the greater size and the lower electronegativity of the sulfur atom.

The formation of six-membered ring during the cyclization reaction is energetically more favourable than the formation of an eight-membered ring and hence the mass spectrum of XVII does not contain any $M-H^{+}$ ion. It is also noticed that 5-furfurylidenebarbituric acid(XIX) does not eject a hydrogen radical from the molecular ion implying that an aromatic hydrogen is required for the cyclization process. 3-Phenylpropionic acids and their corresponding methyl esters, where the double bond in the side chain is reduced, do not lose[11] any hydrogen radical from the $M^{+\cdot}$ on electron impact suggesting that the α,β-unsaturation is necessary for the cyclization process to occur.

From these observations, it can be generalized that the cyclization of the type discussed above becomes facile in the presence of an α,β-unsaturated carbonyl function in conjugation with the aromatic ring and in the absence of other favourable competing fragmentation processes.

Experimental

All the compounds discussed in this work are known in literature and were prepared by the methods already reported.[12,13] The purity of all the compounds was confirmed by TLC. The mass spectra were taken on a VARIAN MAT CH-7 mass spectrometer. The spectra were run at 70 eV with the emission current of 100 μA. The temperature of the ion source was 125 °C. The samples were introduced into the mass spectrometer through direct probe insertion at temparatures between 100 °C—170 °C.

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