Ratio-dependent Products from Xanthophanic Enol and Magnesium Methoxide: Reaction Control by Substrate-chelation

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PRODUCTS which form when certain poly-β-carbonyl systems (frequently masked as pyrones) are treated with sodium methoxide, or limited amounts of magnesium methoxide, arise from a cyclisation basically different from that involved with an excess of magnesium methoxide.[1,2] Explanation, in terms of magnesium chelation, which leads to modification of the geometry and reactivity of the substrate, has been proposed.[1,2] We report an examination of the dimethyl xanthophanic enol (I; without magnesium) system which shows clearly how dependent the nature and composition of the products are upon the magnesium methoxide level.

Tables 1 and 2 record the composition of crystalline material formed after 20 hr. from differing initial molar proportions of base at 20° (compiled by fractional crystallisation and quantative thin-layer analysis of mixed crops). Table 1 illustrates the relative insensitivity towards sodium methoxide concentration, the major product after the first mole is neutralised being the Michael–aldol product (II) with a trace of its coumarin (III).

The more intricate response (Table 2) towards initial magnesium methoxide concentration may be explained as follows. At the 0·5 : 1 mol. level, magnesium is bound as the chelate from (I) or as (VII) and xanthophanic enol is recovered on work-up. With a 1 : 1 ratio, and the availability of methoxide ion, the pyrone is opened and ultimate irreversible base-catalysed cyclisation to the isophthalate (III) is the major course, probably *via* species such as (VIIIa or b). As the initial magnesium methoxide concentration moves through the range 1 : 1 to 2·5 : 1 there is declining formation of (III), which eventually disappears. Products (IVa, b; R=H) and (IVb; R=Me) which increase and then disappear in roughly this range also appear to be produced by reactions connected with the aldol pathway.

Accompanying the decline of (III) is the emergence of a new compound, shown to be an isomer (V) of xanthophanic enol. The yellow compound m.p. 149—150° ($C_{16}H_{16}O_8$, *M* 336·0843 ± 15) had ν_{max} (mull) 1757 (2-acyl pyrone), 1727 (pyrone ester), 1653 (chelated ester), and 1612 cm.$^{-1}$ (pyrone and conj. C=C). It absorbed at shorter wavelength than (I) and had λ_{max} (acid ethanol) 258 (6,800) and 372 (14,000) nm. The n.m.r. spectrum showed resonances at τ 7·63 (3H, enolised acetyl), 7·25 (3H, pyrone methyl), 6·05, 6·08 (6H, two CO_2Me), 1·27 (1H, pyrone 4-hydrogen), −4·33 (1H, chelated hydroxyl), 2·30, 2·20 (2H, AB quartet, *J* 16 Hz, *E*-olefin[3]). Treatment with an excess of magnesium methoxide converted (V) into the known compound[1] (VI).

As the initial concentrations of magnesium methoxide are increased, more substrate becomes blocked with two stable chelate rings (IXa).

TABLE 1

Products from dimethyl xanthophanic enol and sodium methoxide

Mole ratio base : ester	1 : 1	2 : 1	3 : 1	6 : 1	12 : 1	24 : 1
Xanthophanic enol (I) ..	99[a]	35—40	20—25	<1	<1	<1
Isophthalate (II)	<1	60—65	75—80	99	99	99
Isophthalate (III)	—	trace	trace	trace	trace	trace
Crystalline material % ..	94	47	58	51	56	67

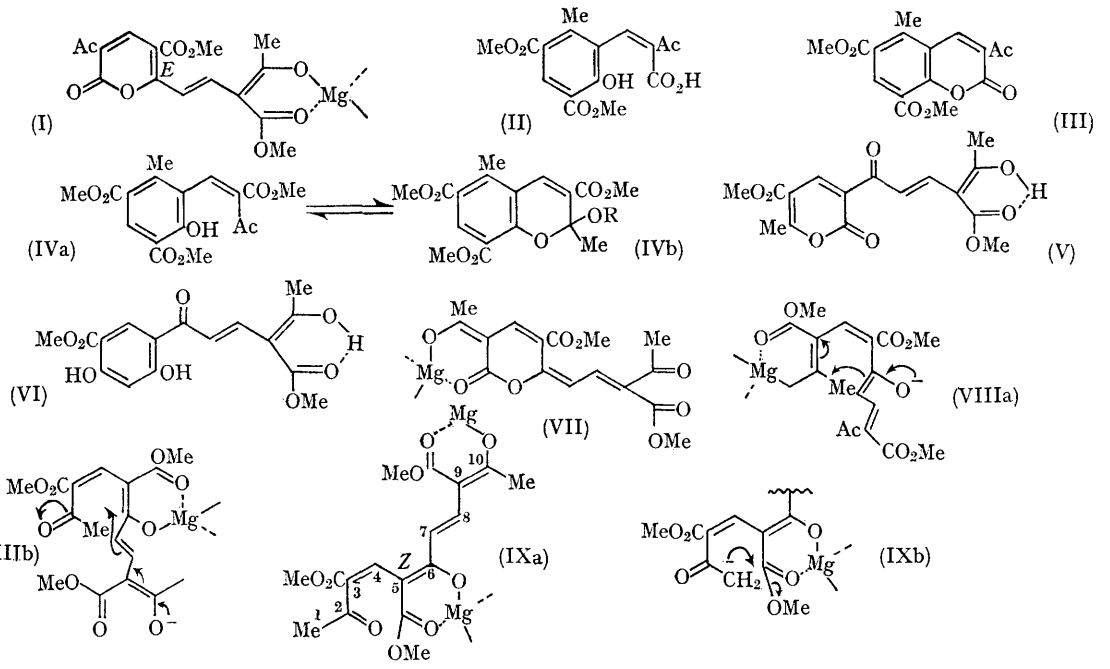
[a] % Based on crystalline product: solvent, methanol–benzene (1 : 9) at 20°.

TABLE 2

Products from dimethyl xanthophanic enol and magnesium methoxide

Mole ratio base : ester	0·5 : 1	0·75 : 1	1 : 1	1·5 : 1	2 : 1	2·5 : 1	3 : 1	6 : 1	12 : 1
Xanthophanic enol (I)	100[a]	95	5—10	<1	nil	nil	nil	nil	nil
Isophthalate (III)	nil	5	80—85	50	35—40	5	nil	nil	nil
Isophthalate (IV; R=H) ..	nil	nil	<5	10—15	10	trace	nil	nil	nil
Isophthalate (IVb; R=Me) ..	nil	nil	trace	trace	trace	nil	nil	nil	nil
Pyrone (V)	nil	nil	<5	35—40	50—55	65—70	35—40	5	nil
Resorcinol (VI)	nil	nil	nil	nil	nil	25—30	60—65	95	100
Crystalline material %	92	78	66	59	48	55	49	68	89

[a] As Table 1.



This preserves the chain from destruction by the Michael–aldol pathway to (III). The 3,4-double bond is envisaged as stereomutatable ($E \rightleftharpoons Z$ mechanism available) but the 5,6-geometry in (IXa) is necessarily fixed Z as opposed to E in (I) and the chain stabilises itself on release from magnesium as (V) rather than reverting to (I).

Increasing the magnesium methoxide : xanthophanic enol ratio still more now allows irreversible disposal of the bischelate by the Claisen condensation (IX) to give the resorcinol type (VI)[1] which ultimately (12 mol. magnesium methoxide) is the only product, isolated in 89% yield.

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[1] L. Crombie, D. E. Games, and M. H. Knight, *Tetrahedron Letters*, 1964, 2313; *Chem. Comm.*, 1966, 355; *J. Chem. Soc.*, 1967, 763, 773.

[2] L. Crombie and A. W. G. James, *Chem. Comm.*, 1966, 357; *cf.* T. Money, J. L. Douglas, and A. I. Scott, *J. Amer. Chem. Soc.*, 1966, **88**, 624.

[3] For specification of geometrical isomers see J. E. Blackwood, C. L. Gladys, K. L. Loening, A. E. Petrarca, and J. E. Rush, *J. Amer. Chem. Soc.*, 1968, **90**, 509.