Generation and Reactions of Carbene Bearing Unprotected Hydroxy Groups at α-Position

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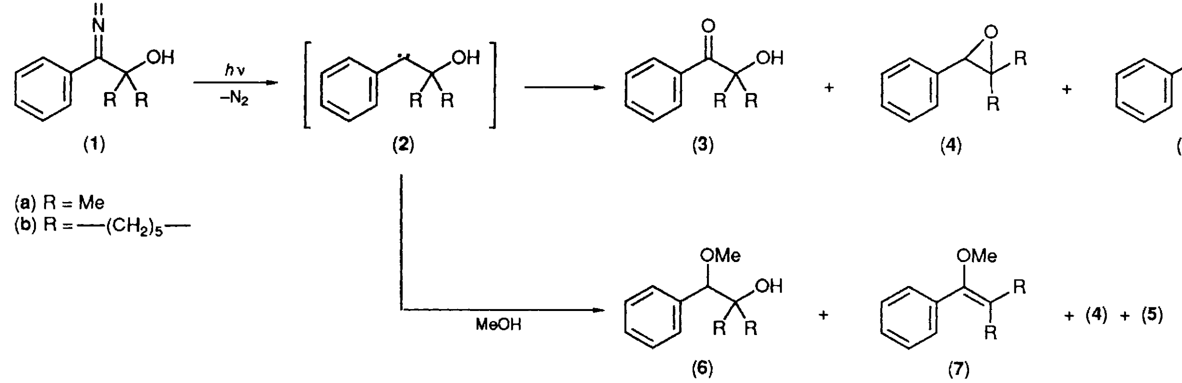
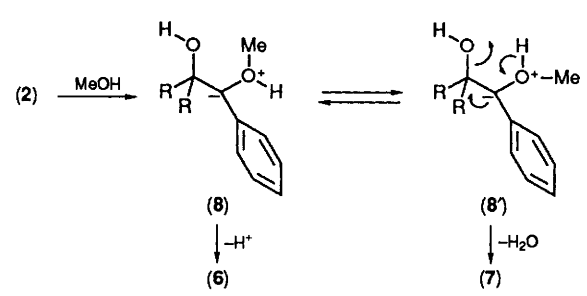
Irradiation of 1,1-dimethyl-2-diazo-2-phenylethanol (**1a**) either in cyclohexane or in hexene produced 1,1-dimethyl-2-oxo-2-phenylethanol (**3a**), 2,2-dimethyl-3-phenyloxirane (**4a**), and 3-phenylbutan-2-one (**5a**), similarly irradiation of (**1a**) in methanol gave 1,1-dimethyl-2-methoxy-2-phenylethanol (**6a**) and 1-methoxy-2-methyl-1-phenylpropene (**7a**) at the expense of (**3a**) and (**5a**), all of which were derived from the carbene (**2a**) generated by elimination of N_2 from (**1a**); the corresponding reaction of (1-hydroxy)cyclohexylphenylcarbene (**2b**) is also described.

Effects of hetero-atom substituents on carbene chemistry have sustained a high level of attention over the past 20 years.[1] The effects of alkoxy substituents especially have been thoroughly studied together with their effects on the migratory aptitude to a carbenic centre and carbenic reactivity.[2] In contrast the effects of hydroxy groups have not been studied to such an extent. This is presumably because unprotected OH groups are usually avoided in carbene chemistry. However, when OH groups are present, interesting and useful chemistry often results.[3] We recently reported[4] the participation of neighbouring groups in carbene chemistry. We generated a carbene-bearing, unprotected hydroxy group at the α-position, and found that the carbene reacted with methanol to give a vinyl ether most probably as a result of the dehydration of an ylidic intermediate.

Compound (**1**), a precursor for the desired carbene, was conveniently prepared from the α-hydroxyketones *via* hydrazones. The oxidation of the hydrazones can be carried out with mercury(II) oxide, however, *active* manganese(II) oxide[5] gave a superior result. Irradiation of compound (**1a**) in cyclohexane at 10 °C produced three products that were assigned as compounds (**3a**), (**4a**), and (**5a**) based on their spectroscopic data. The formation of these products is explained in terms of the intervention of carbene (**2a**) generated photochemically from (**1a**). Thus, (**4a**) is formed by intramolecular O–H insertion[6] in (**1**) while (**5a**) arises from 1,2-methyl migration leading to an enol, which is then ketonized.[7] Compound (**3a**), however, is apparently produced as a result of the trapping of (**1**) by dissolved oxygen. This assumption is supported by the fact that (**3a**) is almost completely eliminated when irradiation is carried out in the absence of oxygen. Essentially the same results were obtained when a solution of (**1a**) in hexene was irradiated under similar conditions. The addition of (**2a**) to the double bond of the solvent alkenes is expected to give rise to cyclopropanes although their presence was shown to be <1% by GC–MS analysis. This is not surprising since it is well documented[1] that carbenes having intramolecular reaction channels are often very elusive. Carbene (**1a**) was trapped,





Scheme 1

Table 1. Photolysis[a] of α-hydroxydiazo compounds (**1**).

Diazo compound	Solvent	% Yield[b]				
		(**3**)	(**4**)	(**5**)	(**6**)	(**7**)
(**1a**)	c-C_6H_{12}[c]	3.1	10.4	40.9	—	—
	1-Hexene	1.7	6.7	59.3	—	—
	MeOH	<1	6.0	11.1	40.9	35.5
(**1b**)	c-C_6H_{12}[c]	2.5	12.5	62.1	—	—
	1-Hexene	2.0	7.9	55.7	—	—
	MeOH	<1	<1	17.8	9.2	60.6

[a] Irradiations were carried out on a 10 mM solution of (**1**) in a degassed solvent at 10 °C. Yields of (**3**) increased up to 30% when the irradiations were carried out in non-degassed cyclohexane; [b] Determined by GC. [c] C represents cyclo.

however, when a seemingly more reactive trapping reagent, *e.g.* methanol, was used as solvent. Thus, irradiation of (**1**) in methanol afforded compounds (**6a**) and (**7a**) at the expense of the intramolecular reaction products (**4a** and **5a**). Compound (**6a**) presumably forms by the insertion of (**2a**) into the solvent O–H bond. However, compound (**7a**) may be formed by the dehydration of the initial O–H insertion product (**6a**). Surprisingly, this possibility was eliminated because (**7a**) is formed in the initial stage of the reaction and (**6a**) does not undergo dehydration even after prolonged irradiation under similar reaction conditions. These observations clearly indicate that compound (**7a**) is not derived from (**6a**) by its subsequent (photo)dehydration but is the primary product of reaction of carbene with methanol.

Similar results were obtained for (**2b**) generated photolytically from (**1b**). Thus, irradiation either in cyclohexane or in hexene produced (**5b**) as a major product as a result of alkyl migration and ketonization together with a small amount of (**4b**) (due to intramolecular OH insertion). Photolysis in methanol gave (**6b**) together with (**7b**), the latter being the major product.

What is the mechanism for the formation of (**7**)? The mechanism for O–H insertion of carbene is relevant. At least three plausible reaction pathways are conceivable: (a) one-step insertion into the O–H bond, (b) protonation of the carbene to give a carbocation, and (c) electrophilic attack of the carbene at oxygen, followed by proton transfer. Mechanism (a) does not offer any intermediates that could form (**7b**) rather than the O–H insertion product. Intervention of the carbocation in the O–H insertion reaction, however, is more important than previously thought, although no reasonable mechanism can be proposed for the formation of (**7**) *via* the carbocation intermediate. Thus, the O–H insertion must take place *via* an ylidic intermediate. Scheme 1 shows the proposed mechanism that explains the formation of both (**6**) and (**7**) simultaneously *via* ylide. Electrophilic attack of the carbene at oxygen results in the formation of compounds (**8**), which usually undergo rapid proton transfer leading to the O–H insertion product. In this special ylidic structure the hydroxy group on the α-carbenic centre is situated so as to interact with the oxonium proton as in the ylide conformer (**8'**), elimination of water producing (**7**) may well compete with the proton transfer leading to the ether.

The present work was supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture of Japan.

Received, 18th April 1990; Com. 0/01736A

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