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Novel Photochemical Reaction of 2-(2-Alkynyl)acetophenones Initiated by Type II Abstraction

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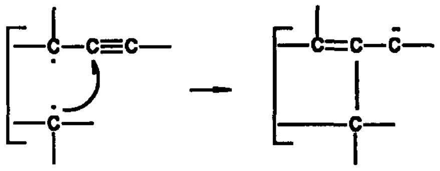
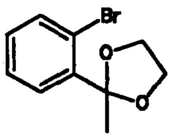
Abstract: Irradiation of **5a** and **5b** in methanol leads to formation of the diastereomeric methoxy alcohols **8a** and **9a**, and **8b** and **9b**, respectively. These reactions can be understood as involving type II abstraction of γ hydrogen, 1,5 cyclization of the resulting biradical **6** to form vinyl carbene **7** (as **1** → **2**), and then carbene insertion into the hydroxyl group of solvent methanol.

We report here a novel photochemical reaction of two *o*-(2-alkynyl)acetophenones that results from closure on the triple bond of the intermediate alkyl propargyl biradicals (*cf.* **1** → **2**) formed on type II hydrogen abstraction.

Reaction[2] of the Grignard reagent from *o*-bromoacetophenone ethylene ketal (**3**), prepared from commercially available *o*-bromoacetophenone, with methoxyallene[3] in the presence of cuprous iodide furnished acetylene **4**. Subsequent methylation in tetrahydrofuran at −78 °C, using butyllithium, hexamethylphosphoramide, and 5 equiv of iodomethane gave a mixture of the ethylene ketals of **5a** and **5b**. These underwent hydrolysis on treatment with oxalic acid adsorbed on silica gel G in dichloromethane[4] to yield a mixture of ketones. This mixture was separated by chromatography over silica gel to furnish the desired substrates, *o*-(2-butynyl)acetophenone (**5a**)[5] and its methyl homolog **5b**.[5]



1 **2**



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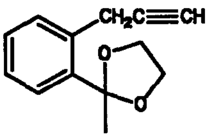

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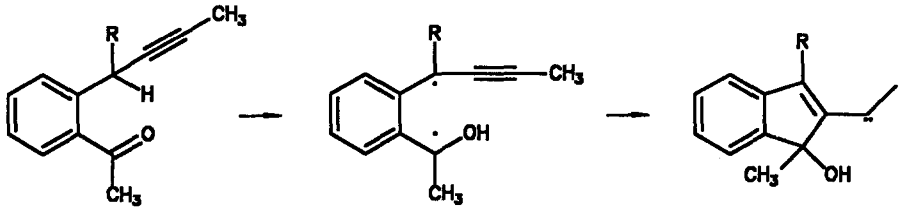
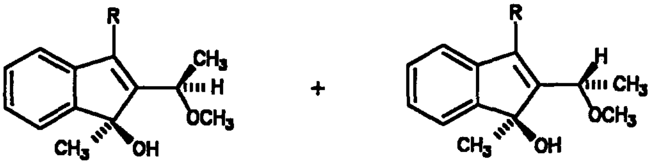
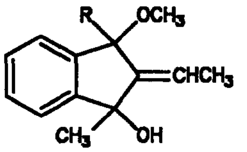
Irradiation of ketones **5a** and **5b** in methanol (λ >340 nm) followed by chromatographic separation and purification gave, respectively, **8a** and **9a**, and **8b** and **9b**, the assigned structures of which are in accord with their spectroscopic properties.[6] These compounds are somewhat unstable and readily rearrange during workup. The products appear from their spectroscopic properties to be various isomers of the allylic rearrangement products **10a** and **10b**. Apart from these side reactions, there was no evidence for other significant products from the irradiations. Type II hydrogen abstraction in **5** leads to alkyl propargyl biradical **6**, and formation of **8** and **9** can be explained through 1,5 closure of **6** to vinyl carbene **7**. Insertion of **7** into the O-H bond of solvent methanol then yields the observed products. There are previous examples of this type of reaction in several other systems that furnish alkyl propargyl biradicals on irradiation,[7] but this is the first observation of the reaction in δ,ϵ-acetylenic ketones. Quantum yields for these products, determined at < 1% conversion and λ ~313 nm, in a merry-go-round apparatus, with the concomitant formation of acetophenone from valerophenone as actinometer,[8] were **8a** (ϕ = 0.0041), **8b** (0.004), **9a** (0.017), **9b** (0.012).



5 **6** **7**



8 **9**



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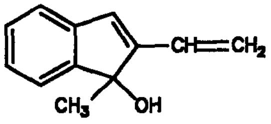

11

a, R = H; b, R = CH_3

Assignment of stereochemistry to **8** and **9** rests on the considerable difference in hydrogen bonding in the two series that is indicated by their IR spectra.[9] Both molecular models and molecular mechanics calculations suggest that intramolecular hydrogen bonding between hydroxyl and methoxyl should be more favorable in **8a,b** than in the diastereomeric **9a,b**. This is largely the consequence of fewer non-bonded interactions in **8a,b** in the conformation of the side chain required for effective hydrogen bonding.[10]

Prolonged irradiation of **5a** in benzene as solvent (λ >340 nm) led to only ~1% reaction and recovery of unreacted starting material. Results were similar at λ >280 nm. We assume that the product detectable in minute amount by analytical gas chromatography is **11**, the expected result of 1,2 hydrogen shift in carbene **7a**. A small amount of **11**, which contains the chromophore of 1-phenyl-1,3-butadiene,[11] should prevent further reaction by competitive absorption of light and quenching of triplet **5a**.[12]

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1. Institut für Organische Chemie, Universität Hamburg.

2. Meijer, J.; Vermeer, P. *Recl. Trav. Chim.* **1974**, *93*, 183.

3. Brandsma, L.; Verkruijsse, H. D. *Synthesis of Acetylenes, Allenes, and Cumulenes*; Elsevier: New York, 1981.

4. Huet, F.; Lechevallier, A.; Pellet, M.; Conia, J. M. *Synthesis* **1978**, 63.

5. This new compound was fully characterized spectroscopically and gave correct elemental analysis or M^+ by high resolution mass spectrometry after purification by chromatography.

6. IR spectra in CCl_4; NMR spectra in $CDCl_3$ at 360 MHz unless indicated otherwise. For **8a**: IR ν 3595, 3429 (m, br), 1111, 1083 cm^{-1}; NMR δ 7.20-7.48 (m, 4 H), 6.49 (s, 1 H), 4.36 (q, J = 6.3 Hz, 1 H), 3.41 (s, 3 H), 1.84 (br s, 1 H), 1.74 (s, 3 H), 1.51 (d, J = 6.3 Hz, 3 H); MS *m/z* 204.1153 (M^+; calcd for $C_{13}H_{16}O_2$, 204.1151). For **9a**: IR ν 3594, 3516 (w, br), 1111, 1087 cm^{-1}; NMR δ 7.20-7.48 (m, 4 H), 6.51 (s, 1 H), 4.25 (q, J = 6.5 Hz, 1 H), 3.35 (s, 3 H), 1.84 (br s, 1 H), 1.62 (s, 3 H), 1.48 (d, J= 6.5 Hz, 3 H). For **8b**: mp 128-130 °C (ether/hexane); IR ν 3593, 3405 (m, br), 1109, 1092 cm^{-1}; NMR (C_6D_6) δ 7.37 (d, J = 7.2 Hz, 1 H), 7.24 (ddd, J = 7.2, 7.2, 1.1 Hz, 1 H), 7.17 (ddd, J = 7.2, 7.2, 1.1 Hz, 1 H), 7.08 (d, J = 7.2 Hz, 1 H), 4.31 (q, J = 6.6 Hz, 1 H), 3.13 (s, 3 H), 2.10 (s, 3 H), 1.54 (d, J = 6.6 Hz, 3 H), 1.52 (s, 3 H), 1.17 (br s, 1 H); MS *m/z* 218.1309 (M^+; calcd for $C_{14}H_{18}O_2$, 218.1307). For **9b**: mp 200-202 °C (ether/hexane); IR ν 3594, 3522 (w, br), 1111, 1095 cm^{-1}; NMR (C_6D_6) δ 7.34 (d, J = 7.0 Hz, 1 H),

7.11 (m, 2 H), 6.99 (d, J = 7.0 Hz, 1 H), 4.16 (q, J = 6.6 Hz, 1 H), 2.98 (s, 3 H), 1.95 (s, 3 H), 1.78 (s, 1 H), 1.53 (s, 3 H), 1.38 (d, J = 6.6 Hz, 3 H); MS m/z 218.1307 (M^+; calcd for $C_{14}H_{18}O_2$, 218.1307).

7. For previous examples, see: Hussain, S.; Agosta, W. C. *Tetrahedron Symposium-in-Print* **1981**, *37*, 3305. Saba, S.; Wolff, S.; Schröder, C.; Margaretha, P.; Agosta, W. C. *J. Am. Chem. Soc.* **1983**, *105*, 6902. Rao, V. B.; Schröder, C.; Margaretha, P.; Wolff, S.; Agosta, W. C. *J. Org. Chem.* **1985**, *50*, 3881. Margaretha, P.; Schröder, C.; Wolff, S.; Agosta, W. C. *J. Fluorine Chem.* **1986**, *30*, 429. Wolff, S.; Agosta, W. C. *J. Am. Chem. Soc.* **1984**, *106*, 2363. Rao, V. B.; Wolff, S.; Agosta, W. C. *J. Am. Chem. Soc.* **1985**, *107*, 521. Agosta, W. C.; Caldwell, R. A.; Jay, J.; Johnson, L. J.; Venepalli, B. R.; Scaiano, J. C.; Singh, M.; Wolff, S. *J. Am. Chem. Soc.* **1987**, *109*, 3050. Rudolph, A.; Margaretha, P.; Agosta, W. C. *Helv. Chim. Acta* **1987**, *70*, 339. Margaretha, P.; Rathjen, H. J.; Wolff, S.; Agosta, W. C. *J. Chem. Soc., Chem. Commun.* **1988**, 841. Margaretha, P.; Rathjen, H.-J.; Agosta, W. C. *Tetrahedron Lett.* **1990**, *31*, 3245.

8. Wagner, P. J. *J. Am. Chem. Soc.* **1967**, *89*, 5898.

9. The IR spectra of **8a,b** have a relatively large, broad band (~3417 cm^{-1}) attributable to hydrogen bonded hydroxyl, while the corresponding absorption (~3519 cm^{-1}) in the spectra of **9a,b** is weaker. *Cf.* Bellamy, L. J. *The Infrared Spectra of Complex Molecules*, 3rd Edition; London: Chapman and Hall, 1975, Chapter 6.

10. Molecular mechanics calculations made use of MMX (version 88.9), a program from Serena Software derived from MM2 (Allinger, N. L.; Yuh, Y. H. *QCPE* **1981**, *13*, 395) and MMI/MMPI (Allinger, N. L. et al. *QCPE* **1976**, *11*, 318). In addition to showing non-bonded interactions, these calculations give a difference in the strength of intramolecular hydrogen bonding of ~1 kcal/mol for hydroxy ethers **8** and **9**.

11. For *trans*-1-phenyl-1,3-butadiene λ_{max} is 280 nm (30,200): Wittig, G.; Schöllkopf, U. *Chem. Ber.* **1954**, *87*, 1318.

12. We are grateful to the National Science Foundation for support of this research.

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