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The Reaction of Ethyl Azidoformate with Electron Deficient Olefins and the Thermal Ring Opening of the Resulting Aziridines.

Tamejiro Hiyama, Hiroaki Taguchi, and Hitosi Nozaki
Department of Industrial Chemistry, Kyoto University, Yoshida, Kyoto 606

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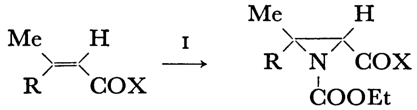
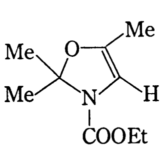
Synopsis. Thermal or photochemical decomposition of ethyl azidoformate in mesityl oxide or in methyl crotonate afforded the corresponding aziridines. Thermal C–C bond cleavage of aziridine-1-carboxylates thus obtained is described.

In continuation of the investigation on the reaction of ethyl azidoformate (I) with carbonyl compounds[1] we have examined the thermal and photochemical decomposition of I in mesityl oxide (IIa) or methyl crotonate (IIb) as a solvent.

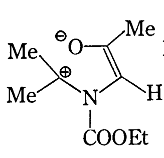


IIa R=X=Me   IIIa R=X=Me
b R=H, M=OMe   b R=H, X=OMe

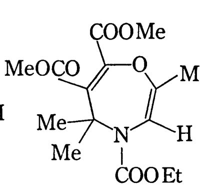
The azide I solutions in IIa or IIb were irradiated with a mercury lamp. When nitrogen evolution had ceased, the solvent was evaporated *in vacuo* and the residue was distilled to afford the adduct IIIa or IIIb. Thermal decomposition of I in IIa or IIb resulted in the improvement of the yields. Both photolysis and thermolysis gave the *trans* isomer of IIIb exclusively.[2,3] In these reactions none of the products arising from carbonyl attack of I on II has been obtained. The reaction discloses a new route to aziridine-2-carboxylic acids, which are useful intermediates in the preparation of β-hydroxyvaline[4] and β-lactams.[5] Photolytic or thermal decomposition of I in methyl acrylate yielded no nitrene adducts but acrylate polymer only.



IV



V



VI

Upon heating in refluxing *p*-xylene aziridine IIIa was isomerized to IV.[6] The intermediary azomethine ylide V[7] was characterized by successful trapping with dimethyl acetylenedicarboxylate, which afforded the cycloadduct VI. The structure VI was confirmed spectrometrically (Experimental). The well-established mode of azomethine ylide cycloaddition[8] should give rise to 2,5-dihydropyrroles, which were absent among products of the present thermolysis. The apparently unusual behavior of V is ascribed to the presence of ethoxycarbonyl group on the nitrogen atom instead of the alkyl or aryl group of the recorded cases.[8,9]

The carbon-carbon double bond in II is thus cleft smoothly in the sequence of reactions.

Experimental[10]

Thermolysis of Ethyl Azidoformate in Mesityl Oxide. Ethyl azidoformate (3.0 g, 26 mmol) in mesityl oxide (15 ml) was added drop by drop to mesityl oxide (45 ml) at 130 °C under a nitrogen atmosphere. After the nitrogen evolution having ceased the excess of mesityl oxide was recovered *in vacuo*. Distillation of the residue afforded ethyl 2-acetyl-3,3-dimethylaziridine-1-carboxylate (IIIa) (2.7 g, 56% yield). Bp 73 °C/3 mmHg; IR (neat): 1725, 1365, 1305, 1260, 1240, 1176, 1096, 800 $\mathrm{cm^{-1}}$; NMR (CCl_4): δ 1.24 (s, 3H), 1.27 (t, J=7 Hz, 3H), 1.34 (s, 3H), 2.14 (s, 3H), 2.75 (s, 1H), 4.07 (q, J=7 Hz, 2H); MS: *m/e* (relative abundance) 185 (M^+, 7), 170 (23), 112 (35), 98 (61), 70 (60), 43 (100); Found: C, 58.5; H, 8.3; N, 7.3%. Calcd for $C_9H_{15}NO_3$: C, 58.4; H, 8.2; N, 7.6%.

Photolysis of I in IIa. The azide I (1.00 g) was dissolved in IIa (10 ml) in a quartz tube. The solution was degassed by bubbling nitrogen gas for *ca.* 2 hr and irradiated with a 200 W high-pressure mercury lamp until nitrogen evolution ceased (2 days). Work-up yielded IIIa (0.64 g, 39% yield).

Thermolysis of I in Methyl Crotonate (IIb). Ethyl azidoformate (0.45 g, 3.9 mmol) was decomposed in methyl crotonate (9 ml) at 120 °C. Distillatory work-up gave ethyl 2-methoxycarbonyl-3-methylaziridine-1-carboxylate (IIIb) (0.53 g, 72% yield). Bp 71 °C/3 mmHg; IR (neat): 1752, 1732, 1445, 1332, 1300, 1217, 1194, 795 $\mathrm{cm^{-1}}$; NMR (CCl_4): δ 1.23 (t, 3H), 1.32 (d, J=3 Hz, 3H), 2.70 (s, 1H), 2.73 (q, J=3 Hz, 1H), 3.74 (s, 3H), 4.11 (q, 2H); MS: *m/e* (relative abundance) 187 (M^+, 13), 155 (20), 114 (38), 83 (55), 59 (100); Found: C, 51.1; H, 7.1; N, 7.5%. Calcd for $C_8H_{13}NO_4$: C, 51.3; H, 7.0; N, 7.5%.

Photochemical procedure performed similarly as described for IIIa gave IIIb in 70% yield.

Thermal Isomerization of IIIa. The aziridine IIIa (198 mg, 1.1 mmol) was dissolved in *p*-xylene (10 ml) and the solution heated to reflux for 2 hr under a nitrogen atmosphere. Concentration *in vacuo*, followed by preparative tlc of the residue (silica gel, benzene, R_f 0.6), gave 3-ethoxycarbonyl-2,2,5-trimethyl-4-oxazoline (IV) (86 mg, 43% yield). Bp 90 °C (bath temp.)/3 mmHg; IR (neat): 1700, 1635, 1420, 1215, 1070, 844, 750, 672 $\mathrm{cm^{-1}}$; NMR (CCl_4): δ 1.25 (t, 3H), 1.63 (s, 6H), 1.76 (d, J=1.2 Hz, 3H), 4.07 (q, 2H), 5.80 (q, J=1.2 Hz, 1H); MS: *m/e* (relative abundance) 185 (M^+, 15), 174 (16), 112 (20), 73 (100), 70 (57); Found: C, 58.1; H, 8.1; N, 7.4%. Calcd for $C_9H_{15}NO_3$: C, 58.4; H, 8.2; N, 7.6%.

Reaction of IIIa with Dimethyl Acetylenedicarboxylate. A mixture of IIIa (525 mg, 2.84 mmol) and dimethyl acetylenedicarboxylate (412 mg, 2.90 mmol) was dissolved in *p*-xylene (2 ml) and the solution heated to reflux for 15 hr. Work-up and the subsequent preparative tlc (silica gel, benzene, R_f 0.2) gave 4-ethoxycarbonyl-6,7-dimethoxycarbonyl-2,5,5-trimethyl-4,5-dihydro-1,4-oxazepine (VI) (832 mg, 89% yield). Bp 150 °C (bath temp.)/0.1 mmHg; IR (neat): 1720, 1649, 1436, 1378, 1336, 1237, 1112 $\mathrm{cm^{-1}}$; NMR (CCl_4): δ 1.25 (t, 3H), 1.52 (s, 3H), 1.58 (d, J=1.2 Hz, 3H), 1.60 (s, 3H), 3.74 (s, 3H), 3.75 (s, 3H), 4.04 (q, 2H), 4.70 (q, J=1.2 Hz, 1H); MS: *m/e* (relative abundance) 327 (M^+, 5), 312 (13), 270 (4), 238 (14), 198 (21), 166 (100), 119 (12), 116 (3), 98 (13); Found: C, 54.8; H, 6.5; N, 4.2%. Calcd for $C_{15}H_{21}NO_7$: C, 55.0; H, 6.5; N, 4.3%.

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9) The aziridine IIIb was recovered unchanged when it was heated in *p*-xylene, but upon heating with dimethyl fumarate, dimethyl maleate, or dimethyl acetylenedicarboxylate, the respective adduct was obtained albeit in low yields. Structural analysis of the adduct could not be attained.

10) IR spectra were taken on a Shimadzu spectrometer IR-27G, MS spectra on a Hitachi RMU-6L spectrometer, NMR spectra on a JEOL C-60H spectrometer. All temperatures are uncorrected.