

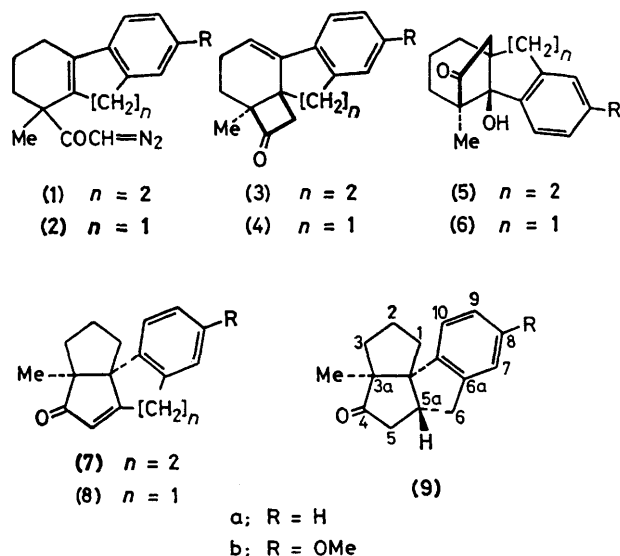
## Acid-catalysed Intramolecular C-Alkylation Rearrangements of $\beta\gamma$ -Unsaturated Diazomethyl Ketones. A Novel Synthetic Entry to Pentaleno-annulated Polycyclic Systems

By GUTTA O. S. V. SATYANARAYANA, PRANAB R. KANJILAL, and USHA R. GHATAK\*

(Department of Organic Chemistry, Indian Association for the Cultivation of Science, Calcutta 700 032, India)

**Summary** A simple new intramolecular C-alkylation–rearrangement reaction of  $\beta\gamma$ -unsaturated  $\alpha'$ -diazo-ketones has been utilized in the incorporation of a functionalized pentalene moiety into a variety of systems.

RECENTLY we have demonstrated<sup>1,2</sup> that intramolecular acid-catalysed cyclisation<sup>3,4</sup> of the rigid polycyclic  $\beta\gamma$ -unsaturated diazomethyl ketones (**1a, b**) and (**2a, b**) leads, in excellent yields, to the corresponding angularly fused cyclobutanones (**3a, b**) and (**4a, b**). Under certain conditions<sup>2</sup> (**1a**) and (**2a**) on acid-induced reactions afford, in excellent yields, the respective rearranged hydroxyketones (**5a**) and (**6a**). Furthermore, (**5a**) undergoes facile rearrangement to the cyclopentenone (**7a**). In view of the recent interest in the linearly and angularly fused biologically active cyclopentane derivatives,<sup>5,6</sup> we report a novel and potentially general synthetic entry to the pentaleno-annulated polycyclic systems such as (**8a**), (**8b**), and (**15**) by a one-step, acid-catalysed intramolecular alkylation rearrangement of the respective  $\beta\gamma$ -unsaturated  $\alpha'$ -diazo-ketones (**2a**), (**2b**), and (**13**), respectively.



The diazo-ketone (**1a**) on short treatment (*ca.* 5 min) with an excess of toluene-*p*-sulphonic acid in boiling benzene produced in quantitative yield a mixture of the cyclobutanone (**3a**) and the rearranged cyclopentenone (**7a**) in a ratio of 55:45 (g.l.c. analysis). In contrast, the tetrahydrofluorene analogue (**2a**) under identical conditions gave exclusively the desired cyclopentenone (**8a**)† (95%) as a low-melting solid after chromatography on silica gel [ $v_{\max}$

(CHCl<sub>3</sub>) 1695 and 1630 cm<sup>-1</sup>;  $\lambda_{\max}$ (EtOH) 228 nm (log  $\epsilon$  4.2); <sup>1</sup>H n.m.r.  $\delta$  (CCl<sub>4</sub>) 1.06 (s, 3H, CMe), 1.33–2.33 (m, 6H), 3.76 (br. s, 2H, COCH=CCH<sub>2</sub>Ar), 5.90 (br. s, 1H, COCH=C), and 7.16 (s, 4H, ArH); *m/e* 224 (*M*<sup>+</sup>)]. The methoxytetrahydrofluorene diazo-ketone (**2b**) under similar conditions produced a mixture of three compounds, according to g.l.c. analysis, from which pure cyclopentenone (**8b**) (50%) was easily isolated as a viscous liquid by chromatography on silica gel with ether–petroleum (2:1) as eluant [ $v_{\max}$  (CHCl<sub>3</sub>) 1700 and 1640 cm<sup>-1</sup>;  $\lambda_{\max}$  (EtOH) 230 nm (log  $\epsilon$  4.22); <sup>1</sup>H n.m.r.  $\delta$  (CCl<sub>4</sub>) 1.01 (s, 3H, CMe), 1.10–2.33 (m, 6H), 3.76 (br. s, 5H, ArOMe and COCH=CCH<sub>2</sub>Ar), 5.86 (br. s, 1H, COCH=C), 6.75 (m, 2H, 7-H and 9-H), and 7.03 (d, *J*<sub>9,10</sub> 8 Hz, 1H, 10-H)]. Catalytic hydrogenation (10% Pd–C, EtOH) of the unsaturated ketones (**8a**) and (**8b**) gave the corresponding saturated oily ketones (**9a**) and (**9b**) in quantitative yields. G.l.c. and <sup>1</sup>H n.m.r. properties of these ketones indicated their stereohomogeneities. The tentatively assigned stereochemistry at the newly generated asymmetric centre shown in (**9a**) and (**9b**) is based upon the expected hydrogenation from the sterically least-hindered face.

SCHEME 1

The facile transformations of the diazo-ketones (**2a**) and (**2b**) evidently proceed<sup>2</sup> *via* the cations (ii) through a Wagner–Meerwein shift as shown in Scheme 1. Recently, acid-catalysed rearrangements of cyclobutane intermediates have been productively utilised<sup>6,7</sup> for the synthesis of cyclopentane-annulated systems. The alkylation–rearrangement reaction was also extended to the bicyclic diazo-ketone (**13**). The semi-solid acid (**12**), prepared from the known keto-ester (**10**)<sup>8</sup> through reduction (W-2 Raney Nickel–

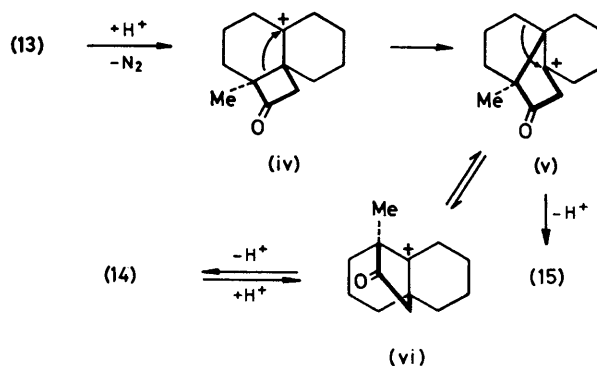
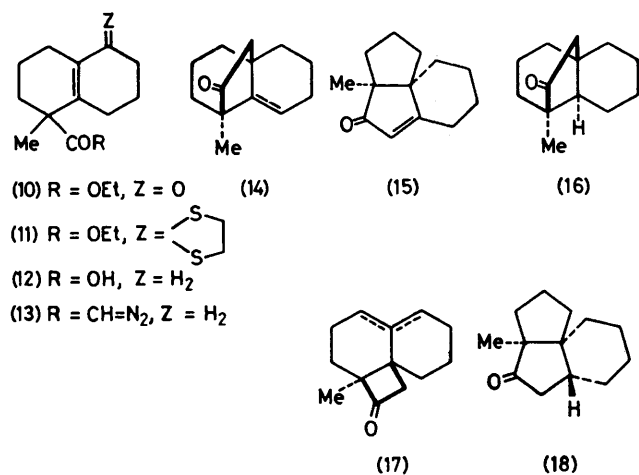
† All new compounds gave i.r., <sup>1</sup>H n.m.r. (60 MHz), mass and, in some cases <sup>13</sup>C n.m.r., spectra in accordance with the structures shown. G.l.c. analyses were performed with a Hewlett-Packard Model 5731 employing a column of 10% UCW-982 and SE-52 at 180–190 °C. Satisfactory combustion analyses were obtained for all compounds. Petroleum refers to the fraction of b.p. 60–80 °C.

EtOH) of the respective thioacetal (**11**) ( $\text{HSCH}_2\text{CH}_2\text{SH}$ ,  $\text{BF}_3\text{-Et}_2\text{O}$ ) followed by hydrolysis ( $\text{HOCH}_2\text{CH}_2\text{OH}$ , 10% aqueous KOH), was converted into the diazo-ketone (**13**) via the standard<sup>2</sup> acid chloride,  $\text{CH}_2\text{N}_2\text{-Et}_2\text{O}$  procedure. The reaction of a dilute solution of (**13**) in dry nitromethane with aqueous  $\text{HBF}_4$  (48%) and quenching with ice-water after 1–2 min afforded a colourless liquid [b.p. 105–115 °C (0.5 mmHg);  $\nu_{\text{max}}$ (neat) 1740 and 1690  $\text{cm}^{-1}$ ] (85%) with a camphoraceous odour, consisting mainly (ca. 94%) of two isomeric ketones (**14**) and (**15**) in a ca. 85:15 ratio besides two other components (g.l.c. analysis). The structure of (**14**) has been confirmed by catalytic hydrogenation (10% Pd-C, EtOH) of this mixture and identification of the major product as (**16**) by g.l.c. comparison with an authentic

11:74:4:11 corresponding to (**14**), (**15**), and two other compounds, respectively. The i.r. spectrum of this mixture exhibited, in addition to the strong C=O bands at 1740 and 1690  $\text{cm}^{-1}$ , a weak C=O band at 1765  $\text{cm}^{-1}$  revealing the presence of the cyclobutanones (**17**).

The crude mixture of isomeric ketones (**14**) and (**15**) from the cyclisation reactions of (**13**) was converted on treatment with conc.  $\text{H}_2\text{SO}_4$  (1%, v/v) in benzene (0 °C for 1.5 h) into the single  $\alpha\beta$ -unsaturated cyclopentenone (**15**) (80%) [ $\nu_{\text{max}}$  (neat) 1690 and 1610  $\text{cm}^{-1}$ ;  $\lambda_{\text{max}}$  (EtOH) 234 nm (log  $\epsilon$  4.2);  $^1\text{H}$  n.m.r.  $\delta$  ( $\text{CCl}_4$ ) 0.97 (3H, s, CMe), 1.13–2.80 (m, 14H), and 5.73 (m, 1H, COCH=C);  $m/e$  190 ( $M^+$ )] after chromatography on neutral alumina followed by distillation under reduced pressure. Catalytic hydrogenation of (**15**) afforded the cyclopentanone (**18**) [ $\nu_{\text{max}}$  (neat) 1725  $\text{cm}^{-1}$ ] as a colourless liquid, homogeneous by g.l.c. The stereochemistry of (**18**) has been tentatively assigned from the mode of its formation.

We believe the products in the alkylation–rearrangements of the diazoketone (**13**) arise through the cation<sup>9</sup> (iv) via (v) and (vi) as shown in Scheme 2.



SCHEME 2

sample.† The distribution of the various products in the above cyclisation reaction depends upon the concentration and time of reaction. In several experiments we detected (i.r.) considerable amounts of the cyclobutanones (**17**), similar to those observed from (**1a**, **b**) and (**2a**, **b**). The decomposition of the diazoketone (**13**) in dry benzene with an excess of silica gel at room temperature for 30 h gave a four-component mixture (g.l.c.) (74%) in a ratio of ca.

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† Prepared by a regioselective intramolecular oxo-carbenoid insertion of ( $\pm$ )-1 $\beta$ -diazooacetyl-1 $\alpha$ -methyl-9 $\alpha$ ,10 $\beta$ -decalin (P. R. Kanjilal, unpublished results) (cf. U. R. Ghatak and S. Chakrabarty, *J. Am. Chem. Soc.*, 1972, **94**, 4756; *J. Org. Chem.*, 1976, **41**, 1089).

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<sup>8</sup> C. T. Mathew, G. C. Banerjee, and P. C. Dutta, *J. Org. Chem.*, 1965, **30**, 2754.

<sup>9</sup> Cf. D. J. Beames, T. R. Klose, and L. N. Mander, *Aust. J. Chem.*, 1974, **27**, 1269.