

## Photoinduced Rearrangement of a Steroidal Cyclobutyl Nitrite; Anomalous $\beta$ -Scission of a Cyclobutanoxyl Radical<sup>1</sup>

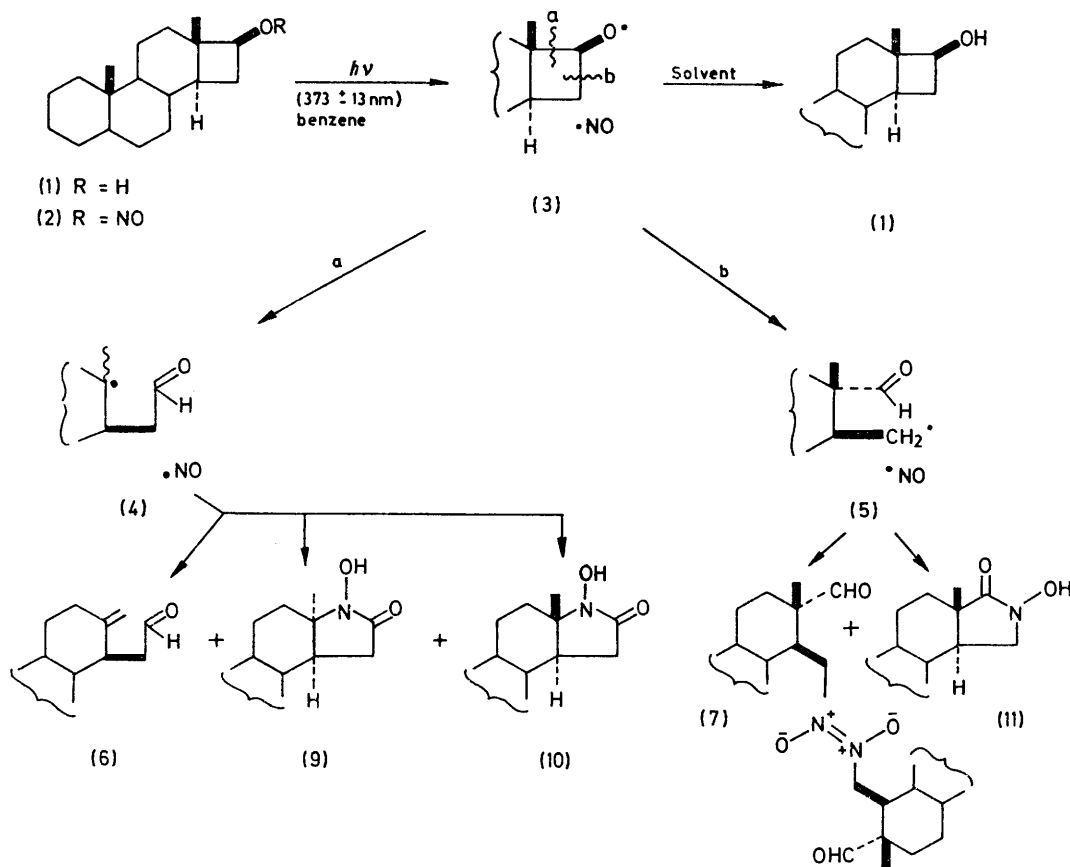
By HIROSHI SUGINOME\* and TSUTOMU UCHIDA

(Department of Chemistry, Faculty of Science, Hokkaido University, Sapporo 060, Japan)

**Summary** An unusually low selectivity in the site of  $\beta$ -scission of a cyclobutanoxyl radical, resulting in the formation of substantial amounts of a less stabilized alkyl radical, was found when D-nor-5 $\alpha$ -androstan-16 $\beta$ -ol nitrite was irradiated with 373 nm monochromatic light.

PHOTOINDUCED rearrangement of steroidal 17 $\beta$ -ol nitrites, cyclopentyl nitrites, leads to cyclic hydroxamic acids *via* exclusive  $\beta$ -scission of the 17 $\beta$ -oxyl radicals to generate tertiary alkyl radicals.<sup>2</sup> We here report the photolysis of a steroidal cyclobutyl nitrite, D-nor-5 $\alpha$ -androstan-16 $\beta$ -ol nitrite. Rearrangement products, resulting from  $\beta$ -scission of the 16 $\beta$ -oxyl radical to generate a less stabilized alkyl radical, were formed in substantial amounts.

(8) (6%), (9) (4%), (10) (2%), and (11) (5%) (in order of their mobility) were isolated by careful preparative t.l.c. (Scheme). Their structures, with the exception of (8), were clarified by spectroscopic and chemical evidence. Product (6), m.p. 190–191 °C, was shown to be a secoaldehyde by its mass, i.r. and <sup>1</sup>H n.m.r. spectra:  $\tau$  9.31 (3H, s, 19-H), 5.55 and 5.25 (each 1H, br s,  $W_{1/2}$  4.1 Hz, 18-H), and 0.28 (1H, t,  $J$  2.3 Hz, CHO). Another crystalline aldehyd (7), m.p. 197–198 °C (decomp.), was confirmed as a nitros dimer on the basis of its u.v., i.r., and <sup>1</sup>H n.m.r. spectra.  $\tau$  5.53 (2H, dd,  $J$  4.7 and 11.3 Hz, 15-H) and 5.75 (2H, dd,  $J$  6.8 and 11.3 Hz, 15'-H), 0.66 (2H, s, 16-H and 16'-H), and two 6H singlets due to 18-H and 19-H. Product (9), m.p. 234–236 °C, was confirmed as 17-hydroxy-17-aza-5 $\alpha$ ,13 $\alpha$ -



SCHEME

D-Nor-5 $\alpha$ -androstan-16 $\beta$ -ol nitrite (2), m.p. 45–46 °C, prepared in the usual manner from the 16 $\beta$ -ol (1),<sup>3</sup> was irradiated in dry benzene with monochromatic light (373  $\pm$  13 nm or 346  $\pm$  13 nm)<sup>†</sup> for 24 h to afford a mixture of products. Seven products (6) (4%), (7) (4%), (1) (21%),

androstan-16-one; the mass spectrum showed  $M^+$  at  $m/e$  291 (6.4%),  $M^+$  - 13  $\alpha$ -Me at  $m/e$  276 (100%) and  $M^+$  - Me-O at  $m/e$  260 (11.3%); the i.r. spectrum exhibited bands at 3120 (OH) and 1689  $\text{cm}^{-1}$  (C=O) and the <sup>1</sup>H n.m.r. spectrum showed two 3H singlets at  $\tau$  8.83 (18-H) and 9.31 (19-H) and

<sup>†</sup> JASCO CRM-FA grating spectro-irradiator equipped with 2-KW Xe arc was used for this irradiation.

no signal lower than  $\tau$  7.0. Reduction of (8) with zinc and acetic acid<sup>2a</sup> afforded 17-aza-5 $\alpha$ ,13 $\alpha$ -androstane-16-one identical with an authentic specimen.<sup>3</sup> Product (10), m.p. 206–209 °C, was shown to be an isomer of (9) by high resolution mass spectrometry ( $M^+$  291.2204, C<sub>13</sub>H<sub>20</sub>O<sub>2</sub>N). Its low resolution mass spectrum showed  $M^+$  at  $m/e$  291 (0.9%),  $M^+$  – Me at  $m/e$  276 (37.6%), and  $M^+$  – O at  $m/e$  260 (100%). Its i.r. spectrum showed bands at 3070 (OH) and 1699 cm<sup>-1</sup> (hydroxamic C=O) and its <sup>1</sup>H n.m.r. spectrum showed peaks at  $\tau$  9.18 (3H, s, 18-H) and 9.30 (3H, s, 19-H). Product (11), m.p. 218–220 °C, was confirmed as 16-hydroxy-16-aza-5 $\alpha$ -androstane-17-one: the mass spectrum showed an intense molecular ion peak at  $m/e$  291 (60.8%),  $M^+$  – Me at  $m/e$  276 (11.4%),  $M^+$  – O at  $m/e$  275 (7.6%), and  $M^+$  – D-ring as the base peak at  $m/e$  218; the i.r. spectrum showed bands at *ca.* 3400 (br) (OH) and 1680 cm<sup>-1</sup> (hydroxamic C=O); the n.m.r. spectrum showed peaks at  $\tau$  6.32 (2H, br m, 15-H), 9.03 (3H, s, 18-H), and 9.21 (3H, s, 19-H). The aldehyde (6), the hydroxamic acid (9), and its isomer (10), are formed from the tertiary radical (4), and the nitroso dimer (7) and hydroxamic acid (11) are derived from the primary radical (5).

There are several noteworthy features of this study.

(i) Extensive studies<sup>4–6</sup> have confirmed that a high degree of

selectivity is attained in the  $\beta$ -scission of oxyl radicals and the difference in rates of elimination of a primary alkyl radical relative to a tertiary alkyl radical is *ca.* 300; when two scissions resulting in tertiary and primary radicals compete, virtually exclusive formation of the tertiary radical has been observed.<sup>2,5,7</sup> Thus, the low selectivity with regard to the site of  $\beta$ -scission of the oxyl radical (3) observed here is unprecedented<sup>8</sup> and is in contrast to the steroidal 17 $\beta$ -ol nitrite cited above.<sup>2</sup> (ii) Formation of the 16 $\beta$ -ol (1) in substantial amounts and the absence of the 16 $\beta$ -ketone in the products was confirmed by repeated experiments. This is surprising since previous investigators<sup>5</sup> found ring strain to be important in  $\beta$ -scission; photolysis of 5 $\alpha$ -androstane-16 $\beta$ -ol nitrite, a less strained cyclopentyl analogue of the present substrate, afforded less of the parent alcohol (12%) together with the corresponding ketone (8%)<sup>2b</sup> and  $\beta$ -scission of oxyl radicals from substituted cyclopropyl nitrites occurs at the expected sites at temperatures as low as –80 °C.<sup>9</sup>

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