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PHOTOCYCLIZATION OF THE N-BENZOYLENAMINES OF α-TETRALONE TO BENZO(c)PHENANTHRIDINES

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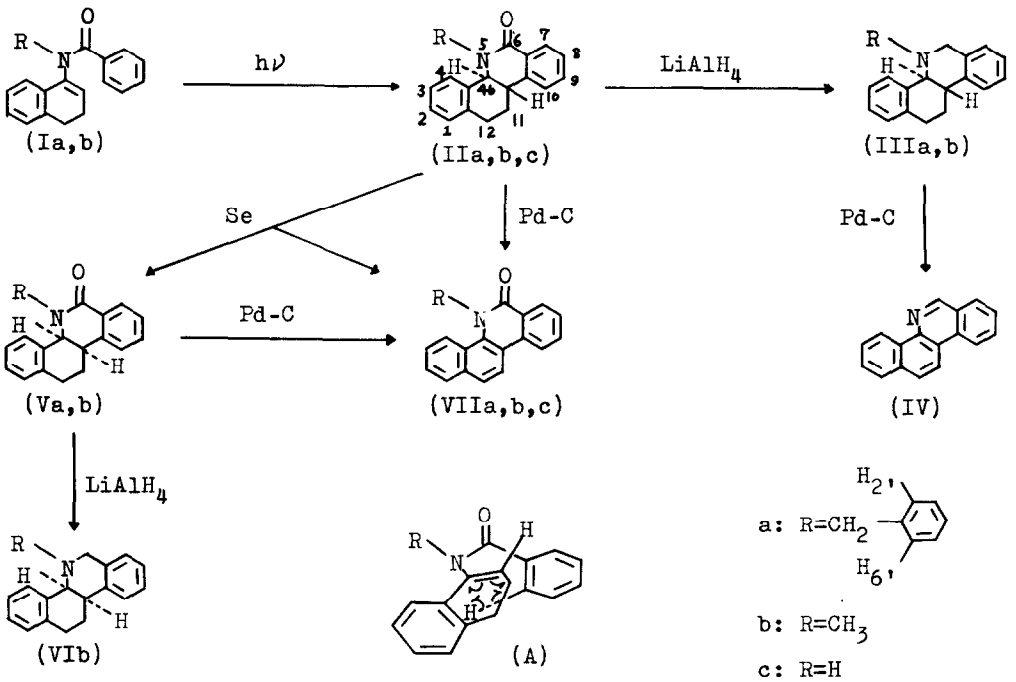
Previously, we reported that in the photochemical reactions of N-benzoylenamines of β-tetralone the photocyclization to the benzo(a)phenanthridines were predominant over the acyl migration (1). Now, we wish to describe an extension of the photocyclization to form the benzo(c)phenanthridines and this would provide a potent preparative route to a group of alkaloids such as chelidonine (2).

A 0.02 M. methanolic solution of the N-benzoylbenzylenamine of α-tetralone in a quartz well was placed under the irradiation from 120 watt low pressure mercury lamp at room temperature for 40 hr. Thin layer chromatography (TLC) of the reaction mixture showed the complete disappearance of the starting enamine and exhibited a single spot due to the photocyclized product besides the one with very low Rf value. Chromatography of the reaction product on alumina readily gave a crystalline compound (IIa), m.p. 123.5-125°C, in 55% yield, which was homogeneous and exhibited IR ν_{max}^{Nujol} (cm^{-1}): 1640, NMR δ ($CDCl_3$): 8.1 (1H, m) and 7.5-6.9 (10H, m) for aromatic H, 6.9-6.6 (2H, m, $C_{2'}$-H, $C_{6'}$-H), 4.85 (1H, d, J=11.5 Hz, C_{4b}-H). Whereas the starting enamine (Ia), m.p. 147-148°C, exhibited IR ν_{max}^{Nujol} (cm^{-1}): 1630. NMR δ ($CDCl_3$): 7.55-7.0 (14H, m, aromatic H), 5.26 (1H, t, J=5 Hz, olefinic H). Similar result was also obtained with the N-benzoylmethylenamine (Ib), m.p. 108.5-109°C, yielding the photocyclized product (IIb), m.p. 164-165°C, in 51% yield, which was homogeneous and exhibited IR ν_{max}^{Nujol} (cm^{-1}): 1645. NMR δ ($CDCl_3$): 8.16 (1H, m) and 7.6-7.15 (7H, m) for aromatic H, 4.8 (1H, d, J= 12 Hz, C_{4b}-H), 3.12 (3H, s, N-CH_3).

Conversion of the N-benzylate (IIa) into the N-methyl derivative (IIb) via debenzylation with sodium in liquid ammonia (3) to the N-norlactam (IIc) followed by methylation established, both products (IIa and IIb) as having the same skeleton.



		Ia-b	IIa-c		Va-b	
	R	m.p.	m.p.	NMR(δ), C_{4b}-H	m.p.	NMR(δ), C_{4b}-H
a	CH_2Ph	147~148°	123.5~125°	4.85,d,J=11.5Hz	141~142,5°	4.8,d,J=4.5Hz
b	CH_3	108.5~109°	164~165°	4.8,d,J=12Hz	161~162°	4.75,d,J=4.5Hz
c	H		214~215°	4.6,d,J=12.5Hz		

Then, the skeletal structure of the photoproduct (IIa) was established as follows: lithium aluminum hydride reduction of IIa afforded the tertiary N-benzylamine (IIIa), m.p. 170-171°C, IR ν_{max}^{Nujol} (cm^{-1}): 1600(w), 750, 740, 700. NMR δ ($CDCl_3$): 7.9 (1H, m) and 7.6-6.8 (12H, m) for aromatic H, 4.5-3.1 (4H, complex, CH_2 at C_6, N-CH_2-Ph), 3.97 (1H, d, J=11.5 Hz, C_{4b}-H), which was treated with 10% palladium on charcoal at 250°C for 3 hr. giving benzo(c)phenanthridine (IV), m.p. 135.5-137°C, (lit. 135-135.5°), which was identified with the authentic sample

(4), on comparisons of IR and UV spectra and on the mixed melting point determination of their picrates. Lithium aluminum hydride reduction of IIb underwent smoothly to afford the N-methylamine (IIIb), m.p. 97.5-98.5°C, which was homogeneous and exhibited IRν_{max}^{Nujol}(cm^{-1}): 1600(w), 750. NMR δ ($CDCl_3$): 7.75 (1H, m) and 7.5-7.0 (7H, m) for aromatic H, 4.55 (1H, d, J=16.5 Hz) and 3.85 (1H, d, J=16.5 Hz) for CH_2 at C_6, 4.05 (1H, d, J=11 Hz, C_{4b}-H), 2.25 (3H, s, N-CH_3).

Treatment of the photoproduct (IIb) with selenium at 250°C for 3 hr. afforded two products, the aromatized N-methyllactam (VIIb), m.p. 148-149°C(lit. 98-100°C)(5), in 9% yield and the N-methyllactam (Vb) with the same elemental composition as IIb, m.p. 161-162°C, in 42% yield, which was homogeneous and exhibited IRν_{max}^{Nujol}(cm^{-1}): 1645. NMR δ ($CDCl_3$): 8.05 (1H, m) and 7.5-7.1 (7H, m) for aromatic H, 4.75 (1H, d, J=4.5 Hz, C_{4b}-H), 3.1 (3H, s, N-CH_3). Similarly, the trans-N-benzyllactam (IIa) was treated as above yielding the aromatized N-benzyllactam (VIIa), m.p. 151-153°C(lit. 252°C)(6), in 8% yield and the cis-N-benzyllactam (Va), m.p. 141-142.5°C, in 49% yield, which was homogeneous and exhibited IRν_{max}^{Nujol}(cm^{-1}): 1645. NMR δ ($CDCl_3$): 8.15 (1H, m) and 7.5-6.85 (12H, m) for aromatic H, 5.5 (1H, d, J=15.5 Hz) and 4.35 (1H, d, J=15.5 Hz) for N-CH_2-Ph, 4.8 (1H, d, J=4.5 Hz, C_{4b}-H).

Comparisons of NMR spectra of pairs of isomers (IIa,b and Va,b), particularly the coupling constants between C_{4b}-H and C_{10b}-H, that is, J=11.5 and 12 Hz in IIa and IIb and 4.5 Hz in both Va and Vb, and inspection of the Dreiding models could readily suggest the stereochemistry of the B/C ring junction of these compounds as IIa and IIb, therefore IIc having trans-, while Va and Vb having cis-junctions (7). Furthermore, lithium aluminum hydride reduction of the cis-lactam (Vb) afforded the tertiary cis-amine (VIb), b.p. 150-160°C/1mm. (bath temp.). NMR spectrum of VIb, peaks at 3.65 (1H, d, J=4 Hz, C_{4b}-H), on comparison with that of the corresponding trans-amine (IIIb), provided further support on the stereochemistry of this series of compounds.

As of the structures of VIIa and VIIb, the following spectral data and the reactions including that IIc was dehydrogenated to VIIc, m.p. 314°C(lit. 330°C)(5), IRν_{max}^{Nujol}(cm^{-1}): 3140, 1660, 1612, 758, followed by methylation affording VIIb, established their structures as shown in the chart: VIIa exhibited IRν_{max}^{Nujol}(cm^{-1}): 1655, 1610, 757. UV$\lambda_{max}^{95\%EtOH}$mμ: 242, 266, 275, 314, 322(sh), 352 and VIIb

exhibited IR ν_{max}^{Nujol} (cm^{-1}): 1650, 1610, 755. UV $\lambda_{max}^{95\%EtOH}$ mμ: 241.5, 265.5, 273, 313, 321(sh), 352. NMR δ ($CDCl_3$): 8.6-8.0 (4H, m) and 7.9-7.3 (6H, m) for aromatic H, 3.92 (3H, s, N-CH_3)(8).

As described previously (1), these stereoselective photocyclization to the trans-fused ring systems could be considered to proceed through such an intermediary stage as A as one of possible mechanisms, and these reactions would offer a promizing approach to total syntheses of some benzo(c)phenanthridines in azasteroids and alkaloids, which are now under progress in our laboratory.

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All m.p's and b.p. are uncorrected. Satisfactory analyses were obtained for the compounds described in the paper and the homogeneities of the products were ascertained both on GLC and TLC.

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