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A FACILE METHOD FOR THE SYNTHESIS OF AZULENO[2,1-b]FURAN AND AZULENO[2,1-b]PYRROLE DERIVATIVES AND THEIR SOME PROPERTIES

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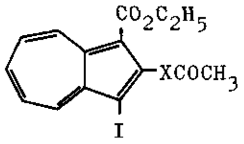
Abstract: Azuleno[2,1-b]-furan and -pyrrole derivatives have been synthesized by the reaction of 2-acetoxy- and 2-acetamido-3-iodoazulene derivatives with cuprous phenylacetylide.

Several papers have appeared on the syntheses of *azulenes fused with heterocycles*, such as furan,[1,2] thiophene,[3] pyrrole,[2] pyrazole,[4] imidazole,[5] thiazole,[6] triazole,[5] pyridine,[7] pyridazine,[8] pyrimidine,[5,9] pyrazine,[5,10] thiapyran,[11] azepine,[11] and quinoxaline.[12] *However, no azuleno[2,1-b]furan or -pyrrole is known to date.* During the course of an investigation on the ethynylation of azulenes,[13] the present authors have found a facile method for the synthesis of azuleno[2,1-b]-*furan and -pyrrole derivatives.*

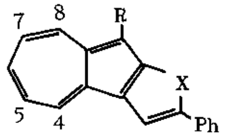
Halogen substituents in azulenes are found to be easily displaced by the phenylethynyl group on treatment with cuprous phenylacetylide.[13b] On the other hand, it is known that the reaction of o-iodo-phenols or -anilines with cuprous phenylacetylide gave benzo[b]furan or indole derivatives.[14] Such the reactions are applied on 3-iodoazulene derivatives (**1a**,**b**).[15]

A mixture of **1a** (2 mM) and cuprous phenylacetylide (3 mM) in pyridine (15 ml) was heated under reflux for 6 h. The product was purified by use of a silica gel column eluted with benzene to give azuleno[2,1-b]furan (**2a**)[16] [dark green needles, mp 132°C] in 69% yield. In a similar manner, **1b** gave azuleno[2,1-b]pyrrole (**2b**) [dark green needles, mp 124°C] in 54% yield. The alkaline hydrolysis of **2a** with 2M potassium hydroxide in ethanol and the subsequent decarboxylation of the resulting carboxylic acid by heating with 100% phosphoric acid[17] gave 2-phenylazuleno-[2,1-b]furan (**3a**) [bluish green needles, mp 182°C] in 40% yield. In the case of **2b**, just heating with 100% phosphoric acid resulted in deethoxycarbonylation to give



1a: X=O

1b: X=NH

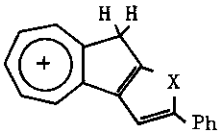


2a: X=O, R=$CO_2C_2H_5$

2b: X=NH, R=$CO_2C_2H_5$

3a: X=O, R=H

3b: X=NH, R=H



4a: X=O

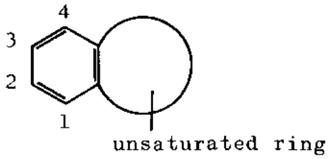
4b: X=NH

Table 1. The spectral data of 2a,b, 3a,b, and 4a,b.

compound	ir (KBr): ν cm^{-1}; uv: λ_{max}(MeOH) nm (log ε); nmr (100 MHz, in $CDCl_3$): δ ppm (pattern, J in Hz, assignment)
2a	ir: 1680 (C=O); uv: 213 (4.34), 282 (4.29), 320 (4.78), 335 (4.76), 411 (4.15), 430 (4.13), 550 (2.89), 572 (2.90); nmr: 1.55 (t, J=7.0, CH_3), 4.53 (q, J=7.0, CH_2), 7.25 (s, H-3), 7.3-7.5 (m, H-5,7,3'~5'), 7.62 (br t, J=9.0, H-6), 7.87 (dm, J=8.0, H-2',6'), 8.46 (br d, J=9.0, H-4), 9.65 (br d, J=9.1, H-8).
2b	ir: 3490 (NH), 1680 (C=O); uv: 216 (4.38), 295 (4.33), 345 (4.83), 451 (4.03), 560 (2.79); nmr: 1.49 (t, J=7.0, CH_3), 4.48 (q, J=7.0, CH_2), 7.12 (d, J=1.8, H-3), 7.2-7.6 (m, H-5~7,3'~5'), 7.68 (dm, J=8, H-2',6'), 8.50 (br d, J=9.5, H-4), 9.05 (br s, NH), 9.45 (br d, J=10.0, H-8).
3a	uv: 256 (4.22), 321 (4.77), 331 (4.78), 365 (4.08), 387 (4.30), 407 (4.42), 580 (2.63), 612 (2.65), 640sh, 720sh; nmr: 7.16 (br t, J=9.0, H-7), 7.21 (br t, J=9.0, H-5), 7.19 (s, H-3), 7.3-7.5 (m, H-3'~5'), 7.39 (s, H-9), 7.56 (br t, J=9.5, H-6), 7.88 (dm, J=8.0, H-2',6'), 8.33 (br d, J=9.1, H-8), 8.42 (br d, J=9.0, H-4).
3b	ir: 3410 (NH); uv: 229 (4.05), 332 (4.84), 344 (4.87), 385 (3.87), 404 (4.03), 425 (3.95), 581 (2.55), 635 (2.52), 720sh; nmr: 7.03 (br t, J=9.0, H-5,7), 7.24 (d, J=1.8, H-3), 7.5-7.3 (m, H-6,3'~5'), 7.42 (s, H-9), 7.66 (dm, J=8.0, H-2',6'), 8.20 (br d, J=10.0, H-8), 8.36 (br d, J=8.6, H-4), 8.50 (br s, NH).
4a	nmr (CF_3CO_2H): 4.37 (s, H-9), 7.19 (s, H-3), 7.36-7.52 (m, H-3'~5'), 7.73-7.88 (m, H-2',6'), 8.37-8.84 (m, H-4~8).
4b	nmr (CF_3CO_2H): 4.16 (s, H-9), 6.95 (d, J=1.5, H-3), 7.3-7.5 (m, H-3'~5'), 7.54-7.69 (m, H-2',6'), 7.9-8.3 (m, H-5~8), 8.43 (br t, J=10.0, H-4).

2-phenylazuleno[2,1-b]pyrrole (**3b**) [green prisms, mp 254°C] in 90% yield. The structures were established on the basis of the spectral data (Table 1). The compounds, **3a**,**b**, are stable to light, a prolonged heating, or acid or alkali. In trifluoroacetic acid, **3a**,**b** exist in azulenium ions (**4a**,**b**), but not cations protonated at the hetero atoms: this is confirmed by the nmr spectra (Table 1).

It is known that the vicinal nmr coupling constants of benzene rings fused to additional unsaturated rings reflect the aromatic character of the latter ring, that is, the qualitative trend toward divergence of the coupling constants, ΔJ (= $J_{1,2}$ - $J_{2,3}$), is in accord with the degree of bond alternation arising from the expected perturbation and loss of π-symmetry in the benzene ring increasing aromatic character in the second ring.[18] An analogous divergence of the coupling constants is also observed in the azulene ring fused to unsaturated rings. As can be seen from the data of Table 2, a large divergence of the vicinal coupling constants of benz[a]azulene, ΔJ=2.7 Hz, indicates a high degree of bond alternation in the azulene ring, reflecting a great aromatic character of the benzene ring. Similarly, **3b** shows a large divergence of 1.4 Hz, reflecting a significant aromaticity in the pyrrole ring. In contrast, no divergence of coupling constant is observed in **3a**, indicating nonaromatic character of the furan ring. The divergences of 0.6 Hz for azuleno[1,2-d]tropone and 1.2 Hz for azuleno[2,1-d]tropolone are also observed.[19]



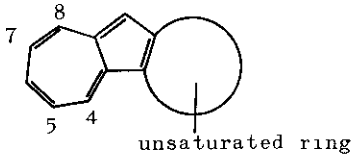


Table 2. The divergences of the vicinal coupling constants, $\Delta J = J_{7,8} - J_{4,5}$, in the azulenes fused to unsaturated ring.

azulene	$J_{7,8}$	$J_{4,5}$	ΔJ(Hz)	ref.
benz[a]azulene	10.9	8.2	2.7	18
azuleno[1,2-d]tropone	9.0	8.4	0.6	19
azuleno[2,1-d]tropolone	10.0	8.8	1.2	19
azuleno[2,1-d]pyrrole (**3b**)	10.0	8.6	1.4	this work
azuleno[2,1-b]furan (**3a**)	9.1	9.0	0.1	this work

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