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SYNTHESIS OF AZULENO[1,2-b]PYRROLE AND AZULENO[1,2-b]FURAN

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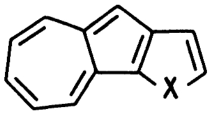
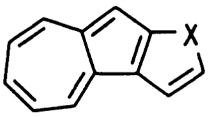
New heterocyclic compounds, methyl 1,2-dihydroazuleno[1,2-b]-pyrrole-9-carboxylate, its [1,2-c] isomer, and the furan analogues are synthesized by the reaction of 3-methoxycarbonyl-2H-cyclohepta-[b]furan-2-one with morpholino enamines of N-ethoxycarbonyl-3-oxo-pyrrolidine or 3-oxotetrahydrofuran. By the dehydrogenation of the resulting [1,2-b] isomers followed by demethoxycarbonylation, azuleno-[1,2-b]pyrrole and azuleno[1,2-b]furan are obtained, respectively.

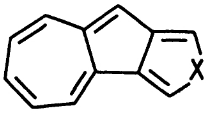
Among three possible isomers of azulenopyrroles (1a-3a) and azulenofurans (1b-3b), respectively, only 2-phenyl derivatives of azuleno[2,1-b]pyrrole (2a) and azuleno[2,1-b]furan (2b) are known.[1)] In this communication, we wish to report the synthesis of new azulenopyrroles, azuleno[1,2-b]- and azuleno[1,2-c]pyrrole, and the furan analogues by the application of the new azulene synthesis[2)] using enamines derived from N-ethoxycarbonyl-3-oxopyrrolidine or 3-oxotetrahydrofuran.



1
a: X= NH
b: X= O

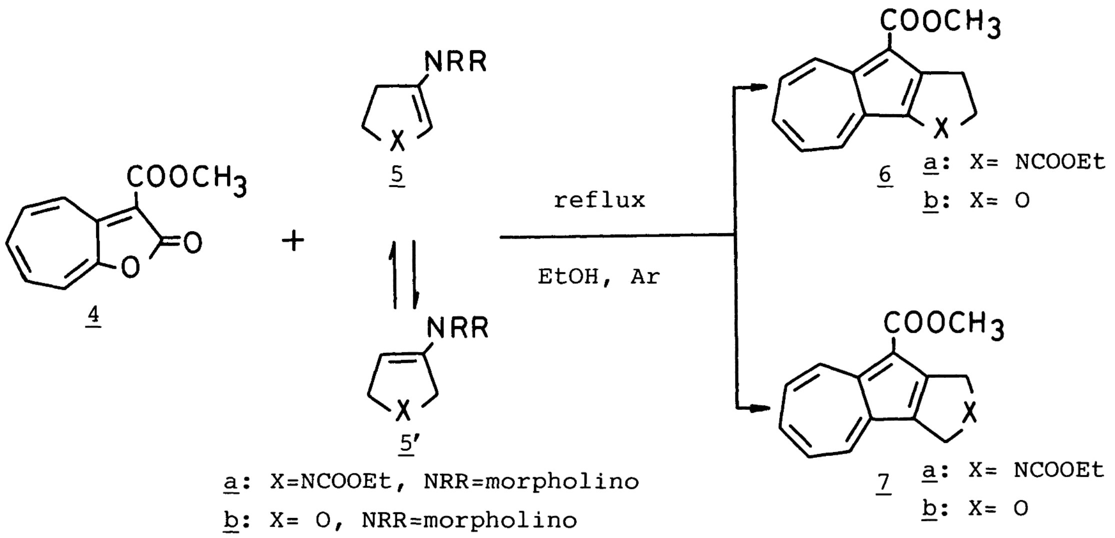


2
a: X= NH
b: X= O



3
a: X= NH
b: X= O

The condensation of N-ethoxycarbonyl-3-oxopyrrolidine or 3-oxotetrahydrofuran with morpholine gave isomeric mixtures of two enamines (5a/5'a and 5b/5'b, respectively). A suspension of 3-methoxycarbonyl-2H-cyclohepta[b]furan-2-one (4)[3)] in anhydrous ethanol containing 3.5 molar equiv. of the morpholino enamines (mixture of 5a and 5'a) was refluxed for 7 days under argon atmosphere. After the reaction mixture was worked up in the ususal way, the products were isolated by chromatography on silica gel using benzene-dichloromethane (1:1) as solvent to give methyl 3-ethoxycarbonyl-1,2-dihydroazuleno[1,2-b]pyrrole-9-carboxylate (6a; green prisms, mp 169.5-171 °C) and methyl 2-ethoxycarbonyl-1,3-dihydroazuleno[1,2-c]pyrrole-9-carboxylate (7a; purple microplates, 193-194.5 °C) in 34 and 37% yields, respectively. In a similar manner, the reaction of 4 with the morpholino enamines of 3-oxotetrahydrofuran (mixture of 5b and 5'b) gave methyl 1,2-dihydroazuleno[1,2-b]furan-9-carboxylate (6b; bluish green prisms, mp 114-114.5 °C) and methyl 1,3-dihydroazuleno[1,2-c]furan-9-carboxylate (7b; purple microneedles, mp 139.5-140 °C) in 59 and 24% yields.



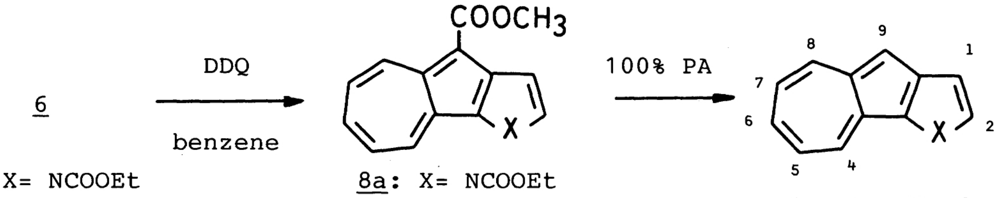
a: X=NCOOEt, NRR=morpholino
b: X= O, NRR=morpholino

6 a: X= NCOOEt
b: X= O

7 a: X= NCOOEt
b: X= O

Dehydrogenation of 6a by treatment with DDQ (2,3-dichloro-5,6-dicyano-p-benzoquinone) gave methyl 3-ethoxycarbonylazuleno[1,2-b]pyrrole-9-carboxylate (8a; dark purple prisms, mp 127-128.5 °C) in a 99% yield. Similar dehydrogenation of 6b gave methyl azuleno[1,2-b]furan-9-carboxylate (8b; bluish green prisms, mp 109-109.5 °C) in an 86% yield.

When the azuleno[1,2-b]pyrrole derivative (8a) was treated with 100% phosphoric acid at 90 °C, only demethoxycarbonylation at 9-position occurred to give ethyl azuleno[1,2-b]pyrrole-3-carboxylate (9; green plates, mp 51-52 °C) in a 95% yield. Further, heating of 9 with 100% phosphoric acid at 180 °C for 50 min resulted in deethoxycarbonylation at 3-position to give azuleno[1,2-b]pyrrole (1a; green microneedles, mp 185-186 °C(dec)) in a 97% yield. On the other hand, treatment of 8b with 100% phosphoric acid at 90-95 °C yielded azuleno[1,2-b]furan (1b; bluish green needles, mp 63-64 °C) in a 46% yield.

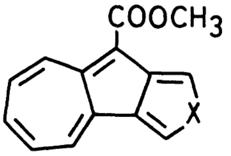


a: X= NCOOEt
b: X= O

8a: X= NCOOEt
8b: X= O

1a: X= NH 9: X= NCOOEt
1b: X= O

Moreover, refluxing of 7a with active manganese dioxide in dry benzene for 24 h resulted in dehydrogenation to give azuleno[1,2-c]pyrrole derivative (10; yellowish brown crystals, 13% yield) having an ortho-quinoid structure. However, dehydrogenation of 7b has not been successful so far.



10
X= NCOOEt

The difference between the vicinal coupling constants, $\Delta J = J_{7,8} - J_{4,5}$, in ^{1}H NMR of azuleno[1,2-b]pyrrole (1a) and azuleno[1,2-b]furan (1b) are 1.4 and 0.8 Hz, respectively, indicating that 7-membered ring exhibits some bond alternation in analogy with azulenothiophene.[4)] The degree of bond alternation decreases in order of azuleno[1,2-b]thiophene,[4)] azuleno[1,2-b]-pyrrole (1a), and azuleno[1,2-b]furan (1b).

Detailed studies in the physical properties and reactivity of these azulenes (1a, 1b and azulenothiophenes[4)]) are now in progress.

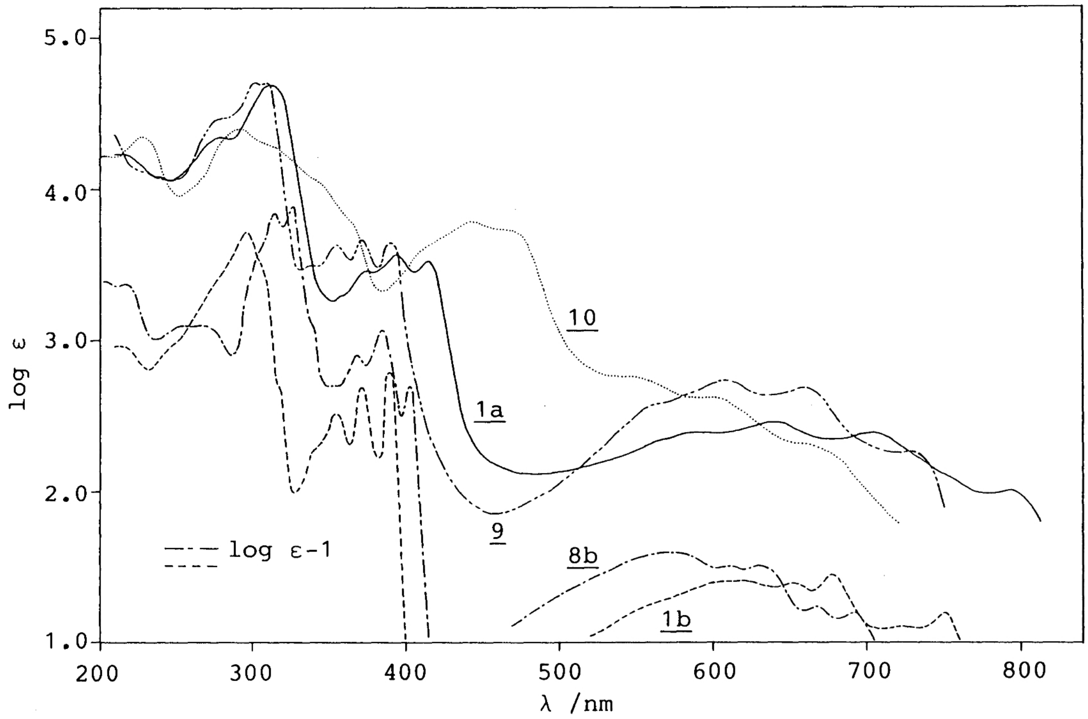


Fig. 1. Electronic spectra of 1a, 1b, 8b, 9, and 10 in MeOH.

Table 1. Spectral data of azulenopyrroles and azulenofurans

^{1}H NMR(90 MHz, $CDCl_3$) δ ppm, J in Hz; ^{13}C NMR($CDCl_3$) δ ppm; UV λ_{max}/nm(log ε)

1a ^{1}H NMR: 6.64(1H, dm, J=2.9, H-1), 6.7-7.4(3H, m, H-5,6,7), 7.26(1H, s, H-9), 7.49(1H, dd, J=2.9, 2.5, H-2), 8.12(1H, dm, J=8.6, H-4), 8.23(1H, dm, J=10.0, H-8), and 8.72(1H, bs, NH)

^{13}C NMR: 99.8, 106.5, 119.5, 120.7, 123.0, 126.0, 129.0, 131.6, 133.6, 135.6, 138.4, and 139.5

UV(MeOH): 279(4.35), 312(4.69), 357(3.29, sh), 376(3.46), 394(3.57), 415(3.52), 590(2.30), 642(2.46), 708(2.39), and 794(2.02)

1b ^{1}H NMR: 6.81(1H, d, J=2.0, H-1), 6.7-7.6(3H, m, H-5,6,7), 7.11(1H, s, H-9), 7.81(1H, d, J=2.0, H-2), 8.22(1H, dm, J=10.1, H-8), and 8.36(1H, dm, J=9.3, H-4)

^{13}C NMR: 103.1, 105.2, 118.8, 120.9, 121.5, 128.3, 135.7, 137.4, 138.8, 139.1, 149.9, and 151.2

UV(MeOH): 296(4.72), 354(3.52), 371(3.69), 389(3.79), 619(2.41), 652(2.30), 677(2.38), 721(1.96), and 750(2.07)

8a ^{1}H NMR: 1.43(3H, t, J=7.2, $NCOOCH_2C\underline{H}_3$), 3.97(3H, s, $COOC\underline{H}_3$), 4.43(2H, q, J=7.2, NCOOC$\underline{H}_2$CH$_3$), 6.78(1H, d, J=3.6, H-1), 7.2-7.8(3H, m, H-5,6,7), 7.70(1H, d, J=3.6, H-2), 9.56(1H, dm, J=9.6, H-4 or 8), and 9.67(1H, dm, J=9.6, H-8 or 4)

^{13}C NMR: 14.4, 50.8, 63.6, 103.7, 106.5, 126.2, 126.3, 126.7, 127.6, 132.4, 134.8, 136.7, 137.3, 143.0, 143.6, 150.5, and 165.9

UV(MeOH): 213(4.46), 283(4.28), 287(4.24, sh), 320(4.66), 331(4.73), 370(3.80, sh), 387(3.95), 405(3.61, sh), 560(2.62), 598(2.59), and 670(2.07, sh)

8b ^{1}H NMR: 3.97(3H, s, COOC$\underline{H}_3$), 7.05(1H, d, J=2.0, H-1), 7.2-7.8(3H, m, H-5,6,7), 7.89(1H, d, J=2.0, H-2), 8.48(1H, dm, J=9.3, H-4), and 9.69(1H, dm, J=10.1, H-8)

^{13}C NMR: 51.0, 102.3, 106.8, 122.2, 125.8, 126.8, 129.9, 137.2, 137.7, 140.2, 141.8, 149.0, 152.2, and 165.6

UV(MeOH): 216(4.37), 265(4.10), 315(4.84), 327(4.88), 368(3.90), 385(4.07), 403(3.70), 577(2.58), 609(2.50), 629(2.51), 667(2.17), and 693(2.13)

9 ^{1}H NMR: 1.40(3H, t, J=7.2, NCOOCH$_2$C$\underline{H}_3$), 4.44(2H, q, J=7.2, NCOOC$\underline{H}_2$CH$_3$), 6.66(1H, d, J=3.6, H-1), 6.8-7.6(3H, m, H-5,6,7), 7.21(1H, s, H-9), 7.78(1H, d, J=3.6, H-2), 8.25(1H, dm, J=9.6, H-8), and 9.58(1H, dm, J=9.6, H-4)

^{13}C NMR: 14.5, 63.4, 105.2, 105.7, 121.0, 122.2, 123.4, 128.3, 131.5, 133.2, 135.7, 136.8, 140.5, 142.5, and 150.8

UV(MeOH): 235(4.08, sh), 277(4.46, sh), 302(4.71), 310(4.71), 340(3.49, sh), 355(3.64), 372(3.67), 390(3.65), 560(2.57, sh), 608(2.88), 661(2.83), and 730(2.42)

10 ^{1}H NMR: 1.48(3H, t, J=7.3, NCOOCH$_2$C$\underline{H}_3$), 3.94(3H, s, COOC$\underline{H}_3$), 4.50(2H, q, J=7.3, NCOOC$\underline{H}_2$CH$_3$), 6.6-7.0(3H, m, H-5,6,7), 7.47(1H, d, J=1.8, H-1), 7.5-7.7(1H, m, H-4), 7.86(1H, d, J=1.8, H-3), and 8.6-8.9(1H, m, H-8)

^{13}C NMR: 14.4, 51.1, 64.0, 107.3, 109.3, 111.1, 127.5, 129.2, 130.2, 130.5, 132.3, 134.5, 134.7, 141.1, 151.0, 151.2, and 165.9

References

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2) P. W. Yang, M. Yasunami, and K. Takase, Tetrehedron Lett., 1971, 4275; K. Takase and M. Yasunami, Yuki Gosei Kagaku Kyokai Shi, 39, 1172 (1981).
3) The compound was synthesized by the reaction of tropolone tosylate with dimethyl malonate (M. Yasunami and K. Takase, unpublished results).
4) K. Fujimori, T. Fujita, K. Yamane, M. Yasunami, and K. Takase, Chem. Lett., 1983, 1721.
5) Satisfactory elemanetal analyses have been obtained for all new compounds described in this paper.

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