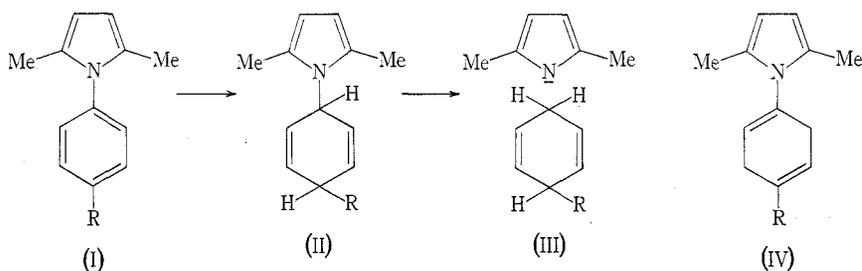


REDUCTION OF 1-ARYLPYRROLES BY METAL-AMMONIA SOLUTIONS

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In the metal-ammonia reduction of benzene rings, the hydrogens ultimately added are found 2,5 to electron-repelling substituents and 1,4 to the charge-stabilizing carboxyl group, the latter being a dominant effect. Carboxyl groups can therefore be used in some cases to force addition of hydrogen to positions occupied by alkyl groups, but the process has disadvantages in some cases because of side reactions.¹ Another electron-stabilizing group is an aromatic ring and its effect can clearly be demonstrated with diphenyl derivatives.² If 1-arylpyrroles (I) were to behave similarly, reduction could lead to 1,4-addition of hydrogen to the benzenoid ring (II), since pyrroles themselves are not reducible,³ and cleavage of the pyrrole as in (III) might then occur because of the stability of the pyrrol anion.



Reduction of 2,5-dimethyl-1-phenylpyrrole (I; R = H) with sodium-ammonia in the presence of ethanol gave a crystalline dihydro derivative. This must be (IV; R = H) since it showed no selective absorption above 210 $m\mu$ and had broad p.m.r. absorption centred at τ 4.25 indicative of 5 protons corresponding to those on the olefinic bonds and the pyrrole, in addition to a multiplet at τ 7.15 (4H, allylic methylenes) and a singlet at τ 7.83 (6H, pyrrole methyls). Acid treatment did not liberate cyclohexenone, so that it does not behave as an enamine; there appears to be no report previously of such an *N*-enylpyrrole.

Further support for the type of reduced structure (IV) was obtained from reduction of the 1-*p*-tolyl analogue (I; R = Me), which gave the dihydro derivative (IV; R = Me). This structure, rather than the alternative (II; R = Me) resulting from 1',4'-addition, follows from p.m.r. absorption at τ 4.27 (3H, multiplet, 1 olefinic

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¹ Birch, A. J., Murray, A. R., and Smith, H., *J. chem. Soc.*, 1951, 1945.

² Birch, A. J., and Subba Rao, G. S. R., unpublished data.

³ O'Brien, S., and Smith, D. C. C., *J. chem. Soc.*, 1960, 4609; and references therein.

and 2 pyrrole protons), 4.58 (1H, multiplet, olefinic), 7.22 (4H, broad singlet, allylic methylenes), 7.81 (6H, broad singlet, pyrrole methyls), and 8.27 (3H, broad singlet, allylic methyl), particularly significant being the presence of only two olefinic protons and an allylic methyl group. Additional evidence resulted from reduction of the 1-*p*-anisyl analogue (I; R = OMe) which showed virtually complete retention of methoxyl, in contrast to 4-methoxybenzoic acids or 4-methoxydiphenyls, and the dihydro product (IV; R = OMe) on acid treatment gave rise to the expected unsaturated ketone by hydrolysis of the enol-ether group. Crude reduction products from the 1-phenyl and 1-*p*-tolyl compounds (I; R = H and Me) contained up to 10% of tetrahydro derivatives detected by mass spectrometry, and this proportion increased to 30% in the case of the 1-*p*-anisyl analogue (I; R = OMe).

Reduction of 1-(4'-carboxyphenyl)-2,5-dimethylpyrrole (I; R = CO₂⁻) gave a high yield of 2,5-dimethylpyrrole; the 4'-carboxyphenyl group could therefore be used as a protecting group for a pyrrole NH under some circumstances and could be removed in this way. The intermediate is presumably the 1',4'-dihydro derivative (II; R = CO₂⁻).

The results show that the nitrogen atom bonding the rings is incapable of transmitting the anionic charge between the rings, and the 1-arylpyrrole system does not in this respect behave like a diphenyl.

Experimental

Melting points were determined on a Kofler block, and are uncorrected. Proton magnetic resonance spectra were recorded at 60 Mc/s for c. 12% solutions in deuteriochloroform containing tetramethylsilane as internal reference on a Varian A60 or a Perkin-Elmer R10 machine. Mass spectra were measured on an AEI MS9 instrument at 70 eV. Liquid ammonia was distilled from sodium immediately prior to use.

1-Arylpyrroles were prepared after Lions *et al.*,⁴ and these and their reduction products were stored in a refrigerator under nitrogen.

Reduction of 1-Aryl-2,5-dimethylpyrroles

2,5-Dimethyl-1-phenylpyrrole (3.42 g) in hot methanol (8 ml) was added to liquid ammonia (150 ml). After the addition of sodium (2.6 g) in small pieces, the reaction was diluted with water (50 ml) and the product (3.14 g) collected by filtration. Crystallization from methanol gave 1-(cyclohexa-1',4'-dienyl)-2,5-dimethylpyrrole (IV; R = H), m.p. 60–62°, ν_{\max} (Nujol) 1690, 1650, and 1520 cm⁻¹, showing no absorption above 210 m μ (Found: C, 83.7; H, 8.9; mol. wt., *m/e* 173. C₁₂H₁₅N requires C, 83.2; H, 8.7%; mol. wt., 173). Substitution of ether for methanol in the reduction afforded the same product.

Similar reduction of 2,5-dimethyl-1-*p*-tolylpyrrole in ethanol-ammonia gave an oil, extracted with ether, which crystallized on refrigeration. Recrystallization from ethanol yielded 1-(4'-methylecyclohexa-1',4'-dienyl)-2,5-dimethylpyrrole (IV; R = Me), m.p. 36–37°, ν_{\max} (Nujol) 1700, 1665, and 1515 cm⁻¹ (Found: C, 82.7; H, 9.2; N, 7.9; mol. wt., *m/e* 187. C₁₃H₁₇N requires C, 83.4; H, 9.2; N, 7.5%; mol. wt., 187).

Reduction of 1-*p*-anisyl-2,5-dimethylpyrrole gave a viscous oil, ν_{\max} (liquid film) 1670 and 1520 cm⁻¹, shown by mass spectrometry to be a mixture of tetrahydro derivative (30%) (Found: mol. wt., *m/e* 205. C₁₃H₁₉NO requires mol. wt. 205) and dihydro derivative (IV; R = OMe) (Found: mol. wt., *m/e* 203. C₁₃H₁₇NO requires mol. wt. 203). The latter had p.m.r. resonances at τ 4.30 (3H, multiplet, 2'-olefinic and pyrrole protons), 5.40 (1H, broad singlet, 5'-olefinic

⁴ Hazlewood, S. J., Hughes, G. K., Lions, F., Baldick, K. J., Cornforth, J. W., Graves, J. N., Maunsell, J. J., Wilkinson, T., Birch, A. J., Harradence, R. H., Gilchrist, S. S., Monaghan, F. H., and Wright, L. E. A., *J. Proc. R. Soc. N.S.W.*, 1937, **71**, 92.

proton), 6.50 (3H, singlet, methoxyl), 7.13 (4H, multiplet, allylic methylenes), and 7.90 (6H, broad singlet, pyrrole methyls). Reaction of the mixture with acid under nitrogen gave unstable material with ketonic reactions; the amorphous semicarbazone gave the expected molecular ions for unsaturated and saturated ketone derivatives (Found: mol. wt., *m/e* 246, 248. $C_{13}H_{18}N_4O$, $C_{13}H_{20}N_4O$ require mol. wt. 246, 248).

Reduction of 1-(4'-carboxyphenyl)-2,5-dimethylpyrrole (13.7 g), m.p. 210–211° (lit.⁴ m.p. 196–198°), yielded a non-acidic oil, which was distilled under nitrogen, b.p. 72–73°/15 mm, and identified by p.m.r. spectroscopy as 2,5-dimethylpyrrole (4.9 g), n_D^{25} 1.5035 (lit.⁵ n_D^{20} 1.5036).

Acknowledgment

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⁵ "Dictionary of Organic Compounds." Vol. 2, p. 1218. (Eyre & Spottiswoode: London 1965.)