

## Remote Intramolecular Functionalization of Arylnitrenium Ions. *ipso*-Substitution and Spiro-lactone Formation

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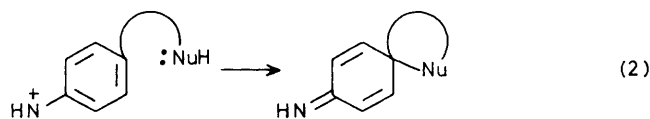
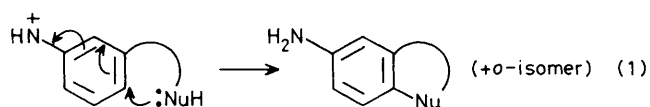
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Acid-catalysed decomposition of (4'-azidophenyl)propanoic and butyric acids leads to *ipso*-attack by the carboxy group *para* to the nitrenium ion and the formation of imines of cyclohexadienone spiro-lactones, which can rearrange to the benz-fused lactones; 4'-azido-2-carboxydiphenyl ether behaves the same way to give spiro-lactone (9).

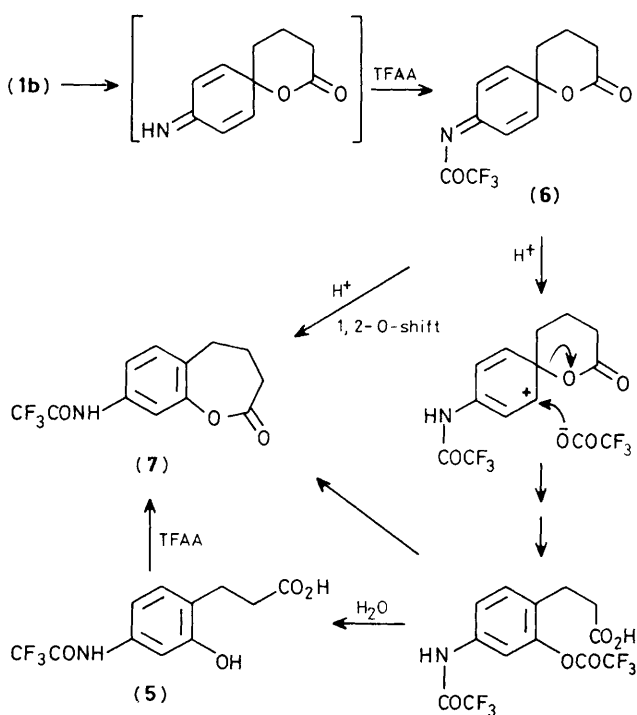
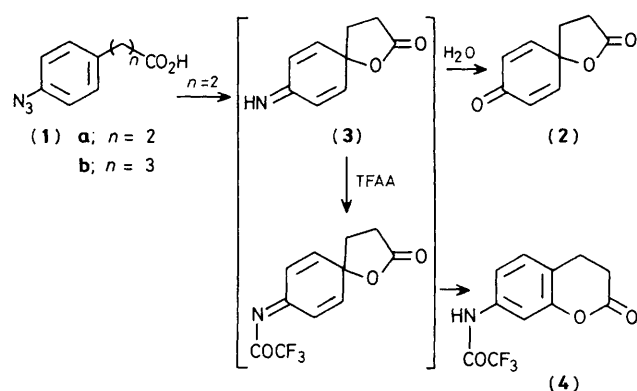
Arylnitrenium ions continue to receive a great deal of attention, mainly owing to their possible intermediacy as the reactive metabolites of mutagenic and carcinogenic amino- and nitro-aromatics,<sup>1</sup> but increasingly also owing to their synthetic applications.<sup>2</sup> We have shown<sup>3</sup> that six-membered rings can be prepared readily by intramolecular C-C bond formation, and five- and six-membered lactones can also be generated by the acid-catalysed decomposition of appropriately *m*-substituted aryl azides (equation 1). More recently, we described the formation of seven-membered rings using this approach.<sup>4</sup> We now report intramolecular nucleophilic trapping *para* to an arylnitrenium function by carboxy groups, leading to *ipso*-substitution and spiro-lactone formation. This greatly enhances the synthetic potential of the reaction (equation 2).

$\beta$ -(4-Azidophenyl)propanoic acid (**1a**), † m.p. 106–107 °C,

† Satisfactory <sup>1</sup>H n.m.r., i.r., mass spectra and elemental analyses were obtained for all new compounds.



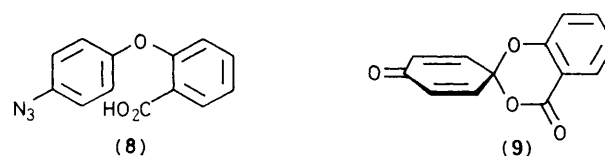
in trifluoroacetic acid (TFA) at 0 °C was treated with trifluoromethanesulphonic acid (TFMSA) (2 drops) and kept at room temp. for 25 h. Aqueous work-up gave spiro-dienone lactone (**2**) (20%),<sup>5</sup> which undoubtedly arises by hydrolysis of imine (**3**). Indeed, when (**1a**) was decomposed as before but treated with trifluoroacetic anhydride (TFAA) before



aqueous work-up, the imine was trapped as indicated by the isolation of 7-trifluoroacetamido-3,4-dihydrocoumarin (4)<sup>†</sup> (15%), m.p. 160–161 °C, isomeric with an authentic sample of 6-trifluoroacetamido-3,4-dihydrocoumarin,<sup>†</sup> m.p. 208–209 °C.<sup>6</sup> No 6-amido isomer was, in fact, detected.<sup>‡</sup>

Decomposition of  $\gamma$ -(4-azidophenyl)butyric acid (1b) with TFA in the presence of TFAA for 3 h gave  $\gamma$ -(2-hydroxy-4-trifluoroacetamidophenyl)butyric acid (5)<sup>†</sup> (44%), m.p. 171–173 °C, and 1-oxaspiro[5.5]undeca-6,9-dien-2-one-8-trifluoroacetimine (6)<sup>†</sup> (13%), m.p. 140–142 °C. When the reaction time was extended to 5 h (5) (34%), (6) (1.5%), and

<sup>‡</sup> A small amount of product was also isolated which had spectral properties corresponding to those expected for *N*-trifluoroacetyl-(3) and which hydrolysed to a compound  $\text{C}_{11}\text{H}_{10}\text{F}_3\text{NO}_4$ , expected from the hydrolysis of the lactone (4). Much tar was also formed.



the seven-membered lactone (7)<sup>†</sup> (6.4%), m.p. 167–169 °C, were isolated. Hydroxy-acid (5) could be converted into the lactone in low yield (10%) by treating with TFAA [thus confirming the orientation of the hydroxy groups in (5)]. Again, no isomeric lactone (which would have resulted from a carbon migration in a spiro-dienone–phenol rearrangement<sup>5,7</sup>) was observed. Thus, the spiro-lactone imine (6) either undergoes only an oxygen shift,<sup>7a,c</sup> followed by ring-opening or, more likely, the protonated imine is attacked by trifluoroacetate to give hydroxyacid (5) on work-up or lactone with TFAA.

That the nitrenium ion did not eliminate a side-chain proton to give a quinonemethene imine followed by addition of the carboxy group to yield the spiro-lactone was supported by the decomposition of  $\alpha,\alpha$ -dimethyl- $\beta$ -(4-azidophenyl)propanoic acid<sup>†</sup> which yielded 4,4-dimethyl-7-trifluoroacetamido-3,4-dihydrocoumarin (24%).<sup>†</sup>

The *ipso*-trapping of arylnitrenium ions has been extended to the synthesis of the parent ring system of geodoxin. 4'-Azido-2-carboxydiphenyl ether (8),<sup>†</sup> m.p. 69 °C, was decomposed with TFMSA in ice-cold dichloromethane to give spiro-lactone (9) (48%).<sup>8</sup> As with (6) it should be possible to trap and protonate the imine to yield depsidones after oxygen migration.

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## References

- M. Pelecanou and M. Novak, *J. Am. Chem. Soc.*, 1985, **107**, 4499; G. R. Underwood and R. B. Kirsch, *J. Chem. Soc., Chem. Commun.*, 1985, 136; *Tetrahedron Lett.*, 1985, **26**, 147; G. R. Underwood and C. M. Davidson, *J. Chem. Soc., Chem. Commun.*, 1985, 555; M. Novak and A. K. Roy, *J. Org. Chem.*, 1985, **50**, 571; M. Demeunck, M. F. Lhomme, and J. Lhomme, *J. Org. Chem.*, 1983, **48**, 1171; S. Galiegue-Zouitina, B. Bailleul, and M. H. Loucheux-Lefebvre, *Carcinogenesis*, 1983, **4**, 249.
- H. Takeuchi, K. Koyama, M. Mitani, R. Ihara, T. Uno, and Y. Okazaki, *J. Chem. Soc., Perkin Trans. 1*, 1985, 677; R. A. Abramovitch and R. Jeyaraman in 'Azides and Nitrenes: Reactivity and Utility,' ed. E. F. V. Scriven, Academic Press, 1984, pp. 297–357.
- R. A. Abramovitch, M. Cooper, S. Iyer, R. Jeyaraman, and J. A. R. Rodrigues, *J. Org. Chem.*, 1982, **47**, 4819.
- R. A. Abramovitch, R. Jeyaraman, and K. Yannakopoulou, *J. Chem. Soc., Chem. Commun.*, 1985, 1107.
- J. S. Davies, C. H. Hassall, and J. A. Schofield, *J. Chem. Soc.*, 1964, 3126.
- R. A. Abramovitch and A. Hawi, unpublished results.
- (a) C. A. Bunton, G. W. Kenner, M. J. T. Robinson, and B. R. Webster, *Tetrahedron*, 1963, **19**, 1001; (b) E. Hecker and E. Meyer, *Angew. Chem., Int. Ed. Engl.*, 1964, **3**, 229; (c) A. I. Scott, P. A. Dodson, F. McCapra, and M. B. Meyers, *J. Am. Chem. Soc.*, 1963, **85**, 3702.
- C. H. Hassall and J. R. Lewis, *J. Chem. Soc.*, 1961, 2312.