Open-Chain Nitrogen Compounds. 7.† Synthesis and High-Resolution Nuclear Magnetic Resonance Spectroscopy of 3-(Arylazo)-1,3-oxazolidines and 3-(Arylazo)tetrahydro-1,3-oxazines‡

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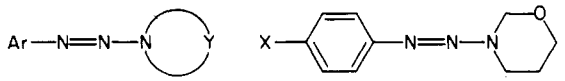
The reaction of arenediazonium ions with a mixture of formaldehyde and ethanolamine affords spontaneously a new series of (arylazo)oxazolidines. Extension of the method to diazonium coupling with formaldehyde/propanolamine mixtures leads to the 4-methyl- and 5-methyloxazolidines or to the arylazoxazines. Diazonium coupling with the acetaldehyde/ethanolamine mixture affords the 2-methyloxazolidine analogues. The method has been extended to the synthesis of some tricyclic heterocycles, oxazolidinobenzotriazines and oxazinobenzotriazines, by incorporating the carbonyl moiety in the ortho position of the arenediazonium ion and coupling with the carbinolamine. The products have been subjected to extensive ^1H and ^{13}C high-resolution NMR analysis. Some complex proton spectra have been fully resolved, and coupling constants have been determined for the spin–spin interactions in the oxazolidine and oxazine heterocycles. The spectra show evidence for rotational isomerism about the triazene N2–N3 bond in some of these heterocycles.

Triazenes of type 1 with an external arylazo group linked to a heterocyclic nitrogen are well-known for many heterocyclic systems.[1] Examples of (arylazo)piperidines,[2] -morpholines,[3] -pyrolidines,[4] and -aziridines[5] have been reported. However, such arylazo heterocycles, in which a NCH_2O moiety is present in the ring, are unknown possibly because of the difficulty of preparation of the parent heterocycles (e.g., oxazolidine and tetrahydro-1,3-oxazine). In this paper we report a convenient general route to the 3-(arylazo)tetrahydro-1,3-oxazines (2) and 3-(arylazo)-1,3-oxazolidines (3) by coupling an arene diazonium ion with a mixture of formaldehyde and a β-carbinolamine. This study is an extension of our previously reported investigation[6] of the formation of (hydroxymethyl)triazenes ($ArN{=}NNRCH_2OH$) during the diazonium coupling reaction with formaldehyde/alkylamine mixtures.



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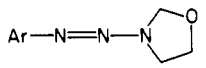
2a, X = Cl
b, X = NO_2
c, X = CN



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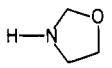

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Although the potential formation of oxazolidines in equilibrium with mixtures of β-amino alcohols and carbonyl compounds has long been recognized,[7,8] the isolation of free 1,3-oxazolidines (with no N substituent) is complicated by their tendency to polymerize. The parent heterocycle 1,3-oxazolidine (4) can be isolated by fractionation of a mixture of ethanolamine and paraformaldehyde[9] but readily polymerizes to a cyclic trimer in the presence of water,[10] presumably via the Schiff base $HOCH_2CH_2N{=}CH_2$.[11] The exact nature of the equilibrium species present in aqueous mixtures of formaldehyde and carbinolamines is not well characterized; the acyclic condensation adduct, e.g., $HO(CH_2)_2NHCH_2OH$, could be an important species competing with the cyclic species (e.g., 4) in reaction with electrophiles, such as the diazonium ion.

We report here that the diazonium coupling reaction with formaldehyde/ethanolamine mixtures leads to a series of new (arylazo)oxazolidines of type 3; the method has been extended to the six-membered heterocycles of type 2 and fused heterocyclic systems 21–23.

Thus, addition of a mixture of formaldehyde (4 equiv) and ethanolamine (1 equiv) to a solution of *p*-cyanobenzenediazonium chloride, followed by neutralization with aqueous sodium bicarbonate, affords a moderate yield of 3-[(*p*-cyanophenyl)azo]-1,3-oxazolidine (7). Absence of OH or NH absorption in the IR spectrum of this product is suggestive of a cyclic structure, which is confirmed by NMR and mass spectral analysis.

The mass spectrum shows a base peak at m/e 102 arising from fragmentation of the Ar–N bond. A significant diagnostic feature of the NMR spectra is the ^{13}C signal of the sp^3 carbon atom at position 2 of the oxazolidine (or oxazine) ring, which is bonded to both N and O atoms; the chemical shift is between 80 and 90 ppm and the presence of a signal in this range indicates condensation of formaldehyde with the carbinolamine to give the five or six-membered heterocycle. Analogous reaction with other diazonium salts affords the corresponding [(*p*-chlorophenyl)azo]- (5) and [(*p*-nitrophenyl)azo]- (6) oxazolidines. The ^1H triplets at δ 4.0 in 6 and δ 3.9 in 7, assigned to the NCH_2C oxazolidine protons, are significantly broadened, as is the ^{13}C signal of the same methylene group (δ 46). The most reasonable explanation for this observation is the restricted rotation around the N2-N3 bond in the triazene due to resonance.

Extension of this method to the reaction of diazonium salts with ethanolamine and acetaldehyde gave the anal-

† Part 6. See ref 12.

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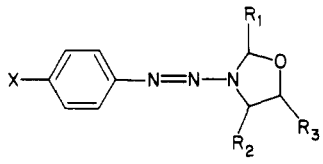
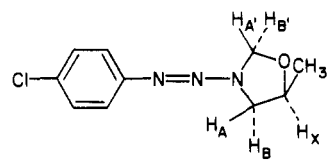
ogous 2-methyloxazolidines **8** and **9**. The reaction products were not as clean as the corresponding formaldehyde products, and column chromatography was necessary to obtain a pure sample of **9**. Further extensions of the synthesis to oxazolidines substituted at positions C-4 and C-5 were achieved by diazonium coupling with a mixture of formaldehyde and either 2-amino-1-propanol or 1-amino-2-propanol, which give the 4-methyl- (**13**, **14**, and **15**) and 5-methyl-3-(arylazo)-1,3-oxazolidines (**10**, **11**, and **12**).





5, X = Cl, $R_1 = R_2 = R_3 = H$
6, X = NO_2, $R_1 = R_2 = R_3 = H$
7, X = CN, $R_1 = R_2 = R_3 = H$
8, X = NO_2, $R_1 = CH_3$, $R_2 = R_3 = H$
9, X = CN, $R_1 = CH_3$, $R_2 = R_3 = H$
10, X = Cl, $R_1 = R_2 = H$, $R_3 = CH_3$
11, X = NO_2, $R_1 = R_2 = H$, $R_3 = CH_3$
12, X = CN, $R_1 = R_2 = H$, $R_3 = CH_3$
13, X = Cl, $R_1 = R_3 = H$, $R_2 = CH_3$
14, X = NO_2, $R_1 = R_3 = H$, $R_2 = CH_3$
15, X = CN, $R_1 = R_3 = H$, $R_2 = CH_3$

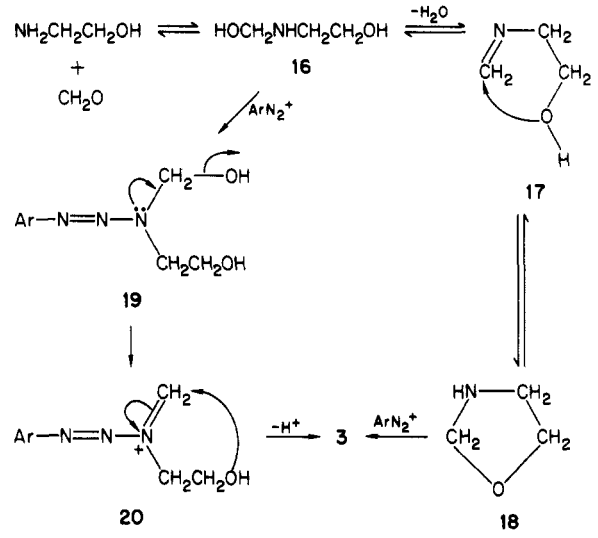
10

The structures of these substituted oxazolidines were verified by high-resolution (360-MHz) NMR spectroscopy. For example the 360-MHz ^1H NMR spectrum of **10** shows several interesting features arising from the introduction of a chiral centre at C-5. The AB pattern of the non-equivalent methylene protons at C-2 (H_A and H_B in the detail of structure **10**) is clearly resolved at 5.39 and 5.51 ppm, with a coupling constant of 5.5 Hz. Equally clear is the ABX pattern of the protons at C-4 and C-5, although H_X is a complex multiplet due to the additional coupling to the protons of the methyl group at C-5; H_X is resolved into the expected quartet when the methyl protons are irradiated. The signal at 3.4 ppm is assigned to H_A due to the larger coupling constant, J_{AX} compared to J_{BX}. The *p*-cyclophenyl analogue **12** in the 5-methyloxazolidine series gives a similarly complex ^1H spectrum, but the ABX signals are more well resolved in the fully coupled situation. The fully analyzed complex ^1H spectra of **10** and **12** provide clear evidence for the heterocyclic structures.

The ^{13}C spectrum of **15** also confirms the oxazolidine structure; all the ^{13}C signals of **15** are sharp, thus showing no evidence of rotational isomerism in this oxazolidine. The methyl substituent at C-4 close to the N-arylazo group may introduce sufficient steric interaction to cause a preference for one rotamer; significantly, the introduction of a methyl substituent at C-2, e.g., in **9**, also results in a ^{13}C spectrum with no broadening of signals. The ^1H NMR spectrum of **9** affords unequivocal evidence for the oxazolidine structure of the product derived from diazonium coupling with a mixture of ethanolamine and acetaldehyde.

The synthetic method for oxazolidines described above is also extendable to saturated six-membered heterocycles; reaction of a diazonium salt with a mixture of formaldehyde and 3-amino-1-propanol affords the 3-(arylazo)tetrahydro-1,3-oxazines **2a–c**. The proton NMR spectra are relatively simple to interpret and are consistent with the oxazine structure. The ^{13}C signals of both NCH_2 groups, and the ^{13}C signal of the C-5 atom (δ 25.0), are significantly broadened, which could arise from rotational isomerism of the type discussed earlier. An alternative explanation for the broadening in this case is that the tetrahydrooxazine ring has a conformational mobility at ambient temperature not present in the more rigid five-membered ring of the oxazolidines.

Scheme I



A likely mechanism for the formation of the *N*-arylazooxazolidines is shown in Scheme I, in which two possible pathways are presented. Condensation of the ethanolamine with formaldehyde leads to the intermediate α,β-carbindiolamine **16**, which can undergo cyclodehydration to the oxazolidine (**18**) via the Schiff base **17**. **18** would readily couple with the diazonium ion to give the observed product **3**; the in situ generation of the oxazolidine (**18**) is appealing because of its simplicity, but there is an alternative route which cannot be readily dismissed. The diolamine **16** could itself be trapped by diazonium coupling to give the 3-(hydroxymethyl)triazene **19**; there is certainly precedence for this reaction in previous studies of (hydroxymethyl)triazene formation.[12] The (hydroxymethyl)triazene **19** might be capable of cyclization via an iminium ion intermediate (**20**) to give **3**; however it has been shown[6] that (hydroxymethyl)triazenes do not undergo this type of transformation unless the hydroxyl group is in a derivatized form. Thus it seems likely that the former mechanism is the preferred one and that the diazonium coupling reaction is serving to trap the otherwise elusive oxazolidine (**18**). A similar mechanism accounts for the formation of the arylazooxazines **2a–c**.

Oxazolidines have attracted pharmacological interest due to their activity as anti-bacterial agents[13] and central nervous system depressants.[14] The new molecules described here are also novel examples of α-oxidized dialkyltriazenes, which have well-characterized anti-tumor properties.[15] Thus the combination of these structural features in one system may have interesting pharmacological consequences; the (arylazo)oxazolidines could undergo ring opening under in vivo conditions and behave as useful pro-drugs for the cytotoxic (hydroxymethyl)triazenes.[15]

Accordingly we have investigated the in vivo and in vitro activity of an oxazolidine and also studied the behavior in solution to see if any ring opening takes place. The [(*p*-cyanophenyl)azo]oxazolidine (**7**) is inactive in vivo on

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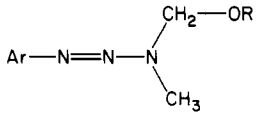
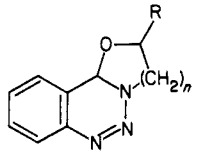
the TLX5 tumor and was also found to be nontoxic to tumor cells in culture using a dose level at which a (hydroxymethyl)triazene produces significant inhibition of cell growth. Furthermore, the oxazolidine was found to be stable in the Me_2SO/phosphate buffer, (pH 7.5) mixture; (hydroxymethyl)triazenes decompose quite rapidly under these conditions.[15] Thus it appears that the (arylazo)oxazolidine does not behave as a "masked" (hydroxymethyl)triazene and is comparable in stability to the α-alkoxymethyltriazene (**24**),[6] which is the nonheterocyclic ether analogue of **3**.

A novel extension of this approach to heterocyclic synthesis is to incorporate the carbonyl moiety at the ortho position of the aryl group in the diazonium ion, which provides the opportunity for an intramolecular reaction leading to tricyclic fused heterocycles. Thus diazotization of *o*-aminobenzaldehyde by a phase-transfer method in aqueous chloroform and coupling the diazonium salt with ethanolamine affords spontaneously the oxazolidinobenzotriazine **21**. Analogous coupling with 1-amino-2-propanol affords the (5-methyloxazolidino)benzotriazine **22** and with 3-amino-1-propanol leads to the oxazinobenzotriazine (**23**).



24



21, R=H, *n*=1
22, R=CH_3, *n*=1
23, R=H, *n*=2

This oxazolidinotriazine **21** is unstable; the initially formed oil crystallizes to give a high melting (mp 198 °C), polymeric compound. Further studies are being undertaken to determine the nature of this process. The 5-methyloxazolidinotriazine **22** and the oxazinobenzotriazine **23** do not undergo the same spontaneous transformation as **21**.

Experimental Section

Melting points were determined on a Kofler hot stage apparatus and are uncorrected. Infrared spectra were recorded with Nujol nulls on Perkin-Elmer 1300 and 299 spectrophotometers, and mass spectra were obtained with a Du Pont CEC-104 medium-resolution spectrometer. ^1H and ^{13}C NMR spectra were recorded with a Nicolet 360-MHz high-resolution spectrometer, using deuteriochloroform as solvent unless otherwise specified. Elemental analyses were carried out by the Canadian Microanalytical Serivce, Vancouver, B.C.

(Arylazo)oxazolidines and -oxazines. General Procedure. The arylamine (26 mmol) was dissolved in hydrochloric acid (8 mL of concentrated HCl + 52 mL of water) and diazotized at 0 °C with sodium nitrite (2.0 g) in water. The diazonium salt solution was then treated with a mixture of the appropriate carbinolamine dissolved in water (20 mL) and 37% aqueous formaldehyde (7.9 g) in the molar ratio 1:4. After being stirred at 0 °C for 0.5 h, the mixture was neutralized slowly with saturated sodium bicarbonate and stirring continued until precipitation of the product was complete. The precipitate was then filtered and recrystallized from the appropriate solvent to give the following products.

3-[(*p*-Chlorophenyl)azo]-1,3-oxazolidine (5): 12%; mp 68–75 °C (ether, white needles): ^1H NMR (60 MHz) 3.9 (2 H, m, NCH_2), 4.1 (2 H, m, CH_2O), 5.25 (s, 2 H, NCH_2O), 7.4 (4 H, arom) ppm; ^{13}C NMR 47.2 (t, J = 145.3 Hz, NCH_2), 67.2 (tt, J = 149.3, 4.1, OCH_2), 82.9 (t, J = 161.6 Hz, NCH_2O), 123.05 (dd, J = 163.3, 5.7 Hz), 129.95 (dd, J = 165.8, 5.2 Hz), 132.9 (t, J = 10.8 Hz), 149.6 (t, J = 7.5 Hz) ppm; this product was initially obtained as an oil after neutralization with $NaHCO_3$. The oil was extracted into methylene chloride and the CH_2Cl_2 extract dried over $MgSO_4$ (anhydrous), filtered, and evaporated to dryness under vacuum. The oily residue was stored in the cold for 7 days, and yellow crystals grew at the bottom of the flask. The crystals were separated from the oil and recrystallized from ether.

3-[(*p*-Nitrophenyl)azo]-1,3-oxazolidine (6): 34%; mp 103 °C (ether/CH_2Cl_2, yellow needles); M^+ 222 (30%), *m/e* 122 (100%); ^1H NMR 4.0 (2 H, t, J = 6.7 Hz, NCH_2), 4.2 (2 H, t, J = 6.7 Hz, CH_2O), 5.3 (2 H, s, NCH_2O), 7.6, 8.3 (4 H, AA'BB' arom) ppm; ^{13}C NMR 46.1 (br, NCH_2), 66.3 (CH_2O), 81.5 (NCH_2O), 120.9, 124.7, 145.3, and 155.0 (arom) ppm.

3-[(*p*-Cyanophenyl)azo]-1,3-oxazolidine (7): 23%; mp 102 °C (ether/CH_2Cl_2, buff flakes); M^+ 202 (15%), *m/e* 102 (100%); ^1H NMR 3.91 (2 H, t, J = 6.5 Hz, NCH_2), 4.20 (2 H, t, J = 6.5 Hz, CH_2O), 5.27 (2 H, s, NCH_2O), 7.5, 7.6 (4 H, AA'BB' arom); ^{13}C NMR 46.1 (br, NCH_2), 66.3 (CH_2O), 81.5 (NCH_2O), 109.0 (C≡N), 119.1, 121.2, 133.0, 153.3 (aromatics) ppm.

3-[(*p*-Chlorophenyl)azo]-5-methyl-1,3-oxazolidine (10): 29%; mp 54–55 °C (ether/pentane, white prisms); ^1H NMR 1.41 (3 H, d, J = 6.2 Hz, CCH_3), 3.42, 3.97 (2 H, J_{AB} = 11.2 Hz, NCH_2), 4.31 (1 H, m, J_{AX} = 8.6, J_{BX} = 5.9 Hz, H_x), 5.15, 5.39 (2 H, J_{AB} = 5.5 Hz, NCH_2O), 7.30, 7.37 (4 H, AA'BB' arom, J_{AB} = 8.7 Hz) ppm; ^{13}C NMR 18.30 (CCH_3), 52.81 (NCH_2), 73.86 ($OCHCH_3$), 81.55 (NCH_2O), 127.87, 128.83, 131.57, 148.68 (arom) ppm.

3-[(*p*-Nitrophenyl)azo]-5-methyl-1,3-oxazolidine (11): 32%; mp 110–112 °C (ether/CH_2Cl_2, yellow prisms); ^1H NMR 1.46 (3 H, t, J = 6.1 Hz, CH_3), 3.47, 4.05 (2 H, br AB, NCH_2), 4.38 (1 H, br, H_x), 5.21, 5.45 (2 H, J_{AB} = 5.9, OCH_2N), 7.51, 8.21 (4 H, AA'BB' arom, J_{AB} = 9.0 Hz) ppm; ^{13}C NMR 18.16, 52.70, 74.09, 81.25, 120.79, 124.68, 145.20, 155.15 ppm.

3-[(*p*-Cyanophenyl)azo]-5-methyl-1,3-oxazolidine (12): 60%; mp 103–104 °C (ether/CH_2Cl_2, white needles); ^1H NMR 1.44 (3 H, d, J = 6.2 Hz, CH_3), 3.45 (1 H, t, J = 9.9 Hz), 4.01 (1 H, dd, J = 10.7, 11.1 Hz) (NCH_2), 4.365 (1 H, tq, J = 6.1, 8.5 Hz, CH_x), 5.18, 5.43 (2 H, AB, J_{AB} = 5.9 Hz, NCH_2O), 7.48, 7.61 (4 H, J_{AB} = 8.5 Hz, AA'BB' arom) ppm; ^{13}C NMR 19.2 (CH_3), 53.8 (br, NCH_2), 75.1 (OCH), 82.3 (br, NCH_2O), 109.8 (C≡N), 120.2, 122.2, 134.0, 154.5 (arom) ppm. anal. C, H, N.

3-[(*p*-Chlorophenyl)azo]-4-methyl-1,3-oxazolidine (13): 40%; oil; ^1H NMR 1.40 (3 H, d, J = 5.5 Hz, CH_3), 3.65, 3.80, 4.15 (3 H, ABX, $CHCH_2$), 5.1, 5.2 (2 H, AB, J_{AB} = 6 Hz, NCH_2O), 7.35 (4 H, m, arom) ppm.

3-[(*p*-Nitrophenyl)azo]-4-methyl-1,3-oxazolidine (14): 62%; mp 93–95 °C (methylene chloride, yellow needles); ^1H NMR 1.45 (3 H, d, J = 5 Hz, CH_3), 3.75, 3.90, 4.30 (3 H, ABX, $CHCH_2$), 5.15, 5.35 (2 H, AB, J_{AB} = 6 Hz, NCH_2O), 7.5, 8.2 (4 H, AB, J_{AB} = 8 Hz, arom) ppm; ^{13}C NMR 16.93 (br m, CCH_3), 54.48 (d, J = 145 Hz, CH), 73.1 (t, J = 150 Hz, OCH_2), 80.7 (t, J = 165 Hz, NCH_2O), 120.75 (dd, J = 5.1, 170 Hz), 124.75 (dd, J = 3 and 167 Hz), 145.17 (s), 155.39 (s) (arom) ppm.

3-[(*p*-Cyanophenyl)azo]-4-methyl-1,3-oxazolidine (15): 73%; mp 61–62 °C (methylene chloride, buff prisms); ^1H NMR 1.50 (3 H, d, J = 5 Hz, CH_3), 3.70, 3.93, 4.20 (3 H, ABX, $CHCH_2$), 5.2, 5.35 (2 H, AB, J_{AB} = 6 Hz, NCH_2O), 7.50, 7.65 (4 H, AB, J_{AB} = 7 Hz, arom) ppm; ^{13}C NMR 17.6 (q, J = 150 Hz, CCH_3), 54.5 (d, J = 146 Hz, CH), 73.1 (t, J = 150 Hz, OCH_2), 80.75 (t, J = 164 Hz, NCH_2O), 108.75 (s, C≡N), 119.26 (s, arom), 121.13 (dd, J = 166, 5 Hz, arom), 133.0 (dd, J = 165.5, 8.1 Hz, arom), 153.7 (s, arom) ppm. Anal. C, H, N.

3-[(*p*-Chlorophenyl)azo]tetrahydro-1,3-oxazine (2a): 25%; mp 32–34 °C (pentane, yellow plates); ^1H NMR 1.77 (2 H, m CCH_2C), 3.95 (2 H, t, J = 5.5 Hz, OCH_2), 4.03 (2 H, t, J = 6.0 Hz, NCH_2), 5.23 (2 H, s, OCH_2N), 7.17–7.53 (4 H, AA'BB', arom) ppm.

3-[(*p*-Nitrophenyl)azo]tetrahydro-1,3-oxazine (2b): 67%; mp 93–94 °C (ether/CH_2Cl_2, yellow prisms); ^1H NMR 1.84 (2 H, m, CCH_2C), 3.99 (2 H, t, J = 5.3 Hz, NCH_2), 4.14 (2 H, t, J = 5.8 Hz, OCH_2), 5.29 (2 H, s, OCH_2N), 7.57, 8.23 (4 H, AA'BB', J = 7.0 Hz, arom) ppm; ^{13}C NMR 25.00 (br, CCH_2C), 42.27 (br, NCH_2), 67.80 (sh, OCH_2), 83.11 (br, NCH_2O), 121.24, 124.71, 145.67, 154.76 (arom) ppm.

3-[(*p*-Cyanophenyl)azo]tetrahydro-1,3-oxazine (2c): 36%; mp 93 °C (ether, buff plates); ^1H NMR 1.82 (2 H, m, CCH_2C), 3.98 (2 H, t, J = 5.3 Hz, OCH_2), 4.11 (2 H, t, J = 5.8 Hz, NCH_2), 5.27 (2 H, s, OCH_2N), 7.63, 7.54 (4 H, AA'BB', J = 8.6 Hz, arom) ppm; ^{13}C NMR 24.90 (br), 42.29 (br), 67.78 (sh), 82.84 (br), 109.4 (C≡N), 119.2, 121.5, 133.0, 153.1 (arom) ppm. Anal. C, H, N.

3-(Arylazo)-2-methyl-1,3-oxazolidines. The procedure described above was modified slightly. The diazonium salt solution

was treated with a 1:1 mixture of ethanolamine and acetaldehyde in aqueous solution to afford the following products.

3-[(*p*-Nitrophenyl)azo]-2-methyl-1,3-oxazolidine (8): 28%; mp 75–78 °C (ether/petroleum ether, yellow prisms); ^{1}H NMR 1.68 (3 H, d, J = 5 Hz, CH_3), 3.8–4.5 (4 H, m, CH_2CH_2), 5.4 (1 H, q, J = 5 Hz, CH), 7.6, 8.3 (4 H, AA'BB', arom, J_{AB} = 9 Hz) ppm.

3-[(*p*-Cyanophenyl)azo]-2-methyl-1,3-oxazolidine (9): 7%; mp 65–67 °C; ^{1}H NMR 1.64 (3 H, d, J = 5.3 Hz, CH_3), 3.78 (1 H, dt, J = 12.2, 7.9 Hz), 3.92 (1 H, m) (NCH_2), 4.07 (1 H, dt, J = 8.7, 7.0 Hz), 4.35 (1 H, ddd, J = 3.35, 7.44, 8.93 Hz) (OCH_2), 5.32 (1 H, q, J = 5.3 Hz, CH), 7.50, 7.62 (4 H, AA'BB', arom, J_{AB} = 8.6 Hz) ppm; ^{13}C NMR 20.55 (CH_3), 46.25 (NCH_2), 65.94 (OCH_2), 89.15 (NCHO), 109.61 ($C{\equiv}N$), 120.28, 122.20, 134.01, 154.91 (arom) ppm. This product was obtained as an oil, which was purified by column chromatography on Hi/Flosil silica gel (60/200 mesh). Elution of the column began with pure naphtha, and the polarity slowly increased with naphtha/chloroform mixtures (up to 30% $CHCl_3$). The fractions of the oxazolidine were combined and evaporated to afford an oil, which crystallized slowly after 2 days. The crystals were separated by washing with cold pentane to give the pure product. Anal. C, H, N.

1,3-Oxazolidino[3,2-*c*]-3,4-dihydrobenzo-1,2,3-triazine (21). 2-Aminobenzaldehyde (0.10 mmol) was dissolved in $CHCl_3$ (30 ml) and the mixture added to a solution of sodium nitrite (0.10 mmol) in water (20 ml). The two-phase mixture was cooled to 0 °C and stirred vigorously, while a solution of concentrated hydrochloric acid (2.5 mL) in water (25 mL) was added dropwise. The resulting mixture was stirred for 1 h, and the two layers were separated; the chloroform layer was extracted with water (20 mL). The combined aqueous fractions, containing the *o*-formylbenzenediazonium salt, were cooled to 0 °C and treated slowly with a cold solution of ethanolamine (0.11 mmol) in water (10 mL) neutralized with hydrochloric acid. The cold aqueous mixture was then rendered basic with a saturated solution of sodium carbonate (20 mL), and the oil which separated was extracted into chloroform. The chloroform extracts were washed with water, dried, and evaporated to afford the **oxazolidinotriazine 21**: 0.36 g (20%); oil; δ ($CDCl_3$) 3.04 (1 H, dd, J = 4.6 and 9.3 Hz), 3.41 (1 H, ddd, J = 3.2, 9.4, 12.5 Hz) (NCH_2), 3.60 (1 H, dd, J = 2.3 and 15 Hz), 4.51 (1 H, ddd, J = 4.7, 12.5, 14.8 Hz) (OCH_2), 6.18 (1 H, s, CH), 7.41 (d, J = 8.0 Hz), 7.52 (t, J = 7.4 Hz), 7.56 (t, J = 7.9 Hz), 7.71 (d, J = 7 Hz) (4 H, arom) ppm; ^{13}C NMR δ ($CDCl_3$) 55.84 (NCH_2), 61.5 (OCH_2), 78.2 (CH), 115.85, 125.5, 126.8, 130.2, 137.9, 156.9 (arom) ppm.

5-Methyl-1,3-oxazolidino[3,2-*c*]-3,4-dihydrobenzo-1,2,3-triazine (22). Reaction of the *o*-formylbenzenediazonium salt, as for **21**, with 1-amino-2-propanol affords **22** (51%): oil; ^{1}H NMR 1.18 (d, J = 6.0 Hz), 1.38 (d, J = 5.3 Hz) (3 H, CH_3), 3.30–5.00 (3 H, m, $OCHCH_2N$), 5.45, 5.58 (1 H, singlets, CH), 7.25–7.90 (4 H, m, arom) ppm. The doubling of the C-5 methyl and C-2 proton in **22** arises from the diastereoisomerism of this compound.

Tetrahydro-1,3-oxazino[3,2-*c*]-3,4-dihydrobenzo-1,2,3-triazine (23). Reaction of the *o*-formylbenzenediazonium salt, as for **21**, with 3-amino-1-propanol affords **23** (50%): mp 76–78 °C; ^{1}H NMR δ 1.72 (1 H, dq, J = 1.3, 12.3 Hz), 2.33 (1 H, m) (CCH_2C), 3.85 (1 H, dt, J = 3.2, 16.1 Hz), 4.12 (1 H, m) (NCH_2), 4.12 (1 H, m), 4.53 (1 H, dd, J = 4.85, 13.7 Hz) (OCH_2), 5.79 (1 H, s, OCHN), 7.27 (1 H, d, J = 7.1 Hz), 7.44 (1 H, t, J = 7.5 Hz), 7.53 (1 H, t, J = 8.5 Hz), 7.68 (1 H, d, J = 8.1 Hz) (aromatic) ppm. Anal. C, H. N.

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Registry No. **2a**, 96228-94-3; **2b**, 96228-95-4; **2c**, 96228-96-5; **5**, 96228-78-3; **6**, 96228-79-4; **7**, 96228-80-7; **8**, 96228-81-8; **9**, 96228-82-9; **10**, 96228-83-0; **11**, 96228-84-1; **12**, 96228-85-2; **13**, 96228-86-3; **14**, 96228-87-4; **15**, 96228-88-5; **21**, 96228-89-6; *cis*-**22**, 96228-91-0; *trans*-**22**, 96228-92-1; **23**, 96228-93-2; $H_2NCH_2CH_2OH$, 141-43-5; $MeCH(NH_2)CH_2OH$, 78-91-1; $MeCH(OH)CH_2NH_2$, 78-96-6; 2-aminobenzaldehyde, 529-23-7; *o*-formylbenzenediazonium chloride, 96228-90-9; 3-amino-1-propanol, 156-87-6; 4-chlorobenzenamine, 106-47-8; 4-chlorobenzenediazonium chloride, 2028-74-2; 4-nitrobenzenamine, 100-01-6; 4-nitrobenzenediazonium chloride, 100-05-0; 4-aminobenzonitrile, 873-74-5; 4-cyanobenzenediazonium chloride, 25102-85-6; acetaldehyde, 75-07-0; formaldehyde, 50-00-0.

Synthesis of Biaryls from Aryltriazenes

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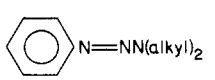
Aryltriazenes react with aromatic solvents in the presence of trifluoroacetic acid to produce biaryls. The mechanism of the reaction involves the formation of arenediazonium trifluoroacetates which lose nitrogen to give mainly aryl radicals.

The aryltriazenes, 1-aryl-3,3-diaklyltriazene (1), have a



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long and interesting background dating to 1875.[1] The early chemical studies of aryltriazenes involved their synthesis, structure, and decomposition with mineral acids.[2-5] Aryltriazene chemistry heightened in the 1940s when Hey[6] et al. and later Rondestvedt[7a] et al. discovered the use of aryltriazenes as diazonium salt equivalents for

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