# Tetrazolo[1,5-*a*]quinolines and 1,2,3-Triazolo[1,5-*a*]quinazolines by the Action of Cyanocarbanions on 2-Azidoarylcarbonyl Compounds

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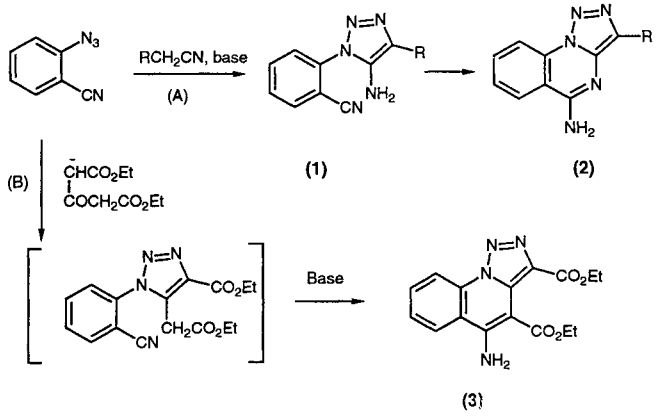
In protic solvents, 2-azidobenzaldehyde undergoes base-catalysed condensation with cyanocarbanions to yield tetrazolo[1,5-*a*]quinolines **5a–g**, whereas in aprotic media 1,2,3-triazolo[1,5-*a*]quinazolines **6a–f** are formed. Triazoloquinazolines **9a–g** are also obtained from 2′-azidoacetophenone and from 2-azidobenzonitrile, whereas with 2-azidobenzoyl chloride hydroxytetrazoloquinolines **13a,b** result. 2,1-Oxazolo[4,3-*c*]tetrazolo[1,5-*a*]quinolines **20a,b** are obtained by the action of selected cyanocarbanions on 2-azidobenzonitrile oxide **15** and a 1,2,3-triazolo[1,5-*a*]quinoline **22** by base-catalysed condensation of 2-azidobenzonitrile with 1,3-diphenylpropan-2-one.

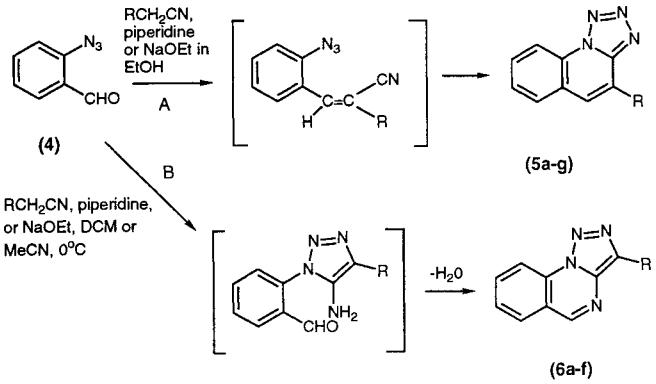
Aryl azides bearing a carbonitrile or carboxylic acid group at the *ortho*-position suffer attack by cyano-stabilised carbanions at the azide function to give, initially, aminotriazoles **1**, which *in situ* ring-close to 1,2,3-triazolo[1,5-*a*]quinazolines **2** (Scheme 1, path A).[1] Recently, we have employed the carbanion derived from diethyl acetonedicarboxylate in these reactions, the triazoles resulting from which undergo base-catalysed intramolecular condensation at the the *ortho*-substituent to give 5-substituted 1,2,3-triazolo[1,5-*a*]quinoline-3,4-dicarboxylates **3** (Scheme 1, path B).[2]




**Scheme 1**

As an extension of this work we now report on the regioselectivity of cyano-stabilised carbanion attack on a series of aryl azides bearing a variety of *ortho*-substituents that possess electrophilic carbon sites and, in particular, 2-azidobenzaldehyde, carbanion attack at which is subject to an unexpected solvent effect.

Treatment of 2-azidobenzaldehyde with an acetonitrile ($RCH_2CN$, R as in Table) in the presence of piperidine, or sodium ethoxide, in ethanol furnished, in each case, a tetrazolo[1,5-*a*]quinoline **5a–g**, formed most probably by initial Knoevenagel condensation at the aldehyde function followed by an intramolecular 1,3-dipolar cycloaddition of the azide function at the pendant cyano group of the sterically favoured cinnamonitrile derivative (Scheme 2, path A).[3] Unlike their intermolecular counterparts,[4] intramolecular 1,3-cycloadditions of azides and nitriles are facile and several examples (including 2-azidocinnamonitriles prepared in a different manner[5]) have been reported.[6] Unexpectedly, however, the piperidine-catalysed condensation of malononitrile with 2-azidobenzaldehyde in dichloromethane at 0 °C yielded not the tetrazolo[1,5-*a*]quinoline **5b** (R = CN) but a structural isomer which from spectroscopic data (IR, $^1H$ and $^{13}C$ NMR) appeared to be the cyano-1,2,3-triazolo[1,5-*a*]quinazoline **6a** (R = CN), i.e. the product from an initial regioselective carbanion attack at the azide function followed by an intramolecular cyclodehydration of the resulting aminotriazole as outlined in Scheme 2, path B).




**Scheme 2**

Unequivocal confirmation of the triazoloquinazoline structure was obtained by single crystal X-ray crystallographic analysis.[7] Subsequently, it was found that 2-azidobenzaldehyde reacts with a variety of arylacetonitriles ($ArCH_2CN$) in dichloromethane or acetonitrile solution at 0 °C in the presence of sodium methoxide to give only triazolo[1,5-*a*]quinazolines **6b–f** (Table). Curiously, under these conditions acetonitriles ($RCH_2CN$, R = PhCO, $CO_2Et$, $PhSO_2$) gave only tarry products.

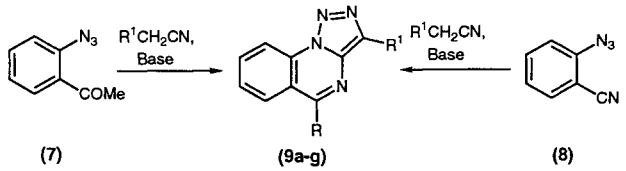
The fused tetrazolo- and triazolo-ring systems are distinguished readily on the basis of their $^1H$ and $^{13}C$ NMR spectra. The chemical shift for H-5 in the tetrazoloquinolines is found upfield ($\delta$ = 8.0–8.7) of the corresponding protons in the triazoloquinazolines, which because of their location at an imine-carbon centre resonate downfield in the range of $\delta$ = 8.9–9.25. In addition, irradiation of H-5 of the tetrazoloquinoline **5g** produced a positive NOE at the 2,6-positions of the dimethoxyphenyl substituent which was not observed on irradiation of the corresponding 5 proton of the triazoloquinazoline **6f**.

A qualitative study, monitored by TLC, of the effect of base and solvent on the reaction of 2-azidobenzaldehyde

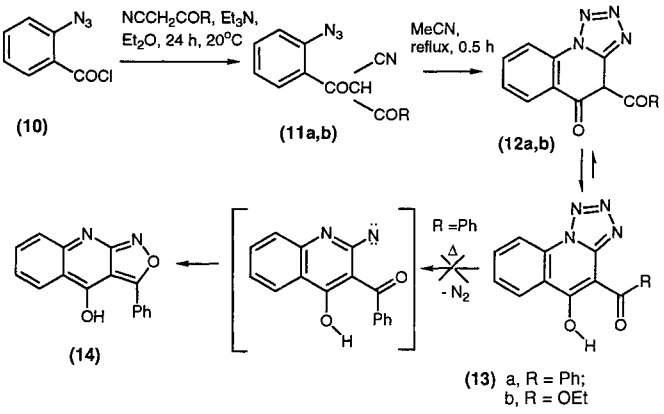
with 3,4-dimethoxyphenylacetonitrile as the cyanocarbanion precursor, indicates that in protic solvents [EtOH, PrOH, $H_2O$, or $HO(CH_2)_2OH$] the tetrazolo[1,5-*a*]quinoline **5g** is formed regardless of the base catalyst used (NaOH, $K_2CO_3$, KOBu-*t*, DBU, or Amberlite resin IR400), whereas in aprotic solvents (MeCN, $CH_2Cl_2$, $CCl_4$, toluene or pyridine) the triazolo[1,5-*a*]quinazoline **6f** results, again regardless of the base (DBU, KOBu-*t*, NaH, Amberlite resin IR400) employed. The reasons for this solvent effect are not yet clear.

As anticipated, protection of the aldehyde function of **4** as the oxime or *N*-methylnitrone followed by reaction with cyanocarbanions [$RCH_2CN$, R = 3,4-$(OMe)_2C_6H_3$, 3,5-$(Cl)_2C_6H_3$] furnished only the triazolo[1,5-*a*]quinazolines **6e,f** in both aprotic and protic solvents with a variety of bases.

Attempts to promote regioselective attack of cyanocarbanions at the carbonyl group of 2'-azidoacetophenone **(7)** failed. In all the cases studied only 5-methyltriazolo[1,5-*a*]quinazolines **9a–e** (Table) were formed. Likewise, with 2-azidobenzonitrile **(8)** 5-aminotriazolo[1,5-*a*]quinazolines **9f–g** (Table) were the sole products regardless of the solvent and base used.




Treatment of 2-azidobenzoyl chloride **(10)** with a cyanocarbanion resulted only in *C*-acylation. In boiling acetonitrile, however, the cyanodiketones **11a,b** so formed underwent intramolecular 1,3-dipolar cycloaddition to give tetrazolo[1,5-*a*]quinolines (Scheme 3) which from their $^1H$ NMR spectra in $CDCl_3$ are formulated as the intramolecularly hydrogen bonded 5-hydroxytetrazolo-[1,5-*a*]quinolines **13a,b** rather than as the quinolone tautomers **12a,b**.




**Scheme 3**

Tetrazoloazines are known in some instances to exist in tautomeric equilibria with the azidoazines, and studies suggest that the equilibrium is shifted towards the azide tautomer by electron-withdrawing groups on the azine ring.[8] However, we have found no infrared spectroscopic

**Table.** Tetrazolo[1,5-*a*]quinolines **5**, **13**, 1,2,3-Triazolo[1,5-*a*]quinazolines **6**, **9** and 1,2,3-Triazolo[1,5-*a*]quinoline **22** Prepared

| Product[a] | R | $R^1$ | Basic Catalyst[b] | Yield (%) | mp (°C) | IR (Nujol) $\nu$ ($cm^{-1}$) | $^1H$ NMR ($CDCl_3$/TMS) $\delta$, $J$ (Hz) |
|---|---|---|---|---|---|---|---|
| **5a** | COPh | – | A | 71 | 197[c] | 1658 (CO) | 7.51–8.13 (m, 8H, ArH), 8.77 (d, 1H, ArH), 8.29 (s, 1H, H-5) |
| **5b** | CN | – | A | 85 | 279[c] | 2238 (CN) | 7.9–8.2 (m, 3H, ArH), 8.65 (s, 1H, H-5), 8.78 (m, 1H, ArH)[d] |
| **5c** | $CO_2Et$ | – | A | 79 | 143[c] | 1726 (CO) | 1.51 (t, 3H, $CH_3$), 4.6 (q, 2H, $CH_2$), 7.77 (t, 1H, ArH), 7.99 (t, 1H, ArH), 8.10 (d, 1H, ArH), 8.73 (d, 2H, ArH), 8.75 (s, 1H, H-5) |
| **5d** | $SO_2Ph$ | – | A | 27 | 190[c] | 1330, 1155 ($SO_2$) | 7.24–7.64 (m, 3H, ArH), 7.81 (m, 1H, ArH), 8.04 (m, 1H, ArH), 8.16 (d, 1H, ArH), 8.60 (m, 2H, ArH), 8.70 (d, 1H, ArH), 8.82 (s, 1H, H-5) |
| **5e** | 2-pyridyl | – | B | 94 | 144[c] | – | 7.37–7.42 (m, 1H, ArH), 7.70–7.76 (m, 1H, ArH), 7.85–7.97 (m, 2H, ArH), 8.11 (m, 1H, ArH), 8.71–8.79 (m, 2H, ArH), 9.12 (m, 1H, ArH), 9.05 (s, 1H, H-5) |
| **5f** | Ph | – | B | 95 | 175[c] | – | – |
| **5g** | 3,4-$(OMe)_2C_6H_3$ | – | B | 94 | 173[c] | – | 3.96 (s, 3H, $OCH_3$), 4.20 (s, 3H, $OCH_3$), 7.20 (d, 1H, ArH), 7.68–7.75 (m, 2H, ArH), 7.80–7.85 (m, 2H, ArH), 7.99 (m, 1H, ArH), 8.68 (m, 1H, ArH), 8.02 (s, 1H, H-5)[e] |
| **6a** | CN | – | A | 90 | 144[f] | 2243 (CN) | 7.90 (m, 1H, ArH), 8.15–8.23 (m, 2H, ArH), 8.78 (m, 1H, ArH), 9.25 (s, 1H, H-5)[g] |
| **6b** | 2-pyridyl | – | B | 86 | 171[f] | – | 7.43 (m, 1H, ArH), 7.77 (m, 1H, ArH), 7.90–7.97 (m, 2H, ArH), 8.15 (m, 1H, ArH), 8.75 (m, 1H, ArH), 8.79 (m, 1H, ArH), 9.15 (m, 1H, ArH), 9.08 (s, 1H, H-5) |

**Table.** (continued)

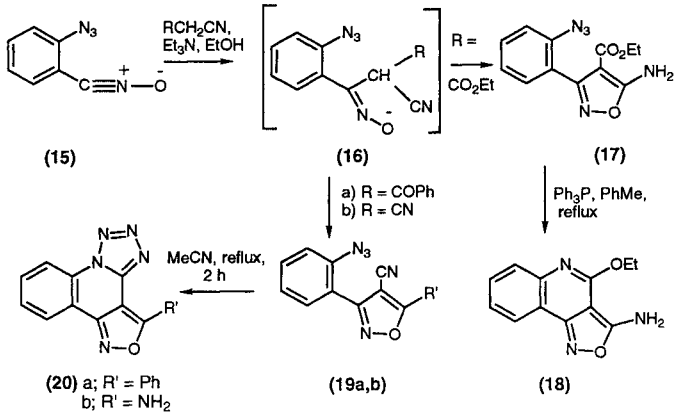
| Product[a] | R | $R^1$ | Basic Catalyst[b] | Yield (%) | mp (°C) | IR (Nujol) $\nu$ ($cm^{-1}$) | $^1H$ NMR ($CDCl_3$/TMS) $\delta$, $J$ (Hz) |
|---|---|---|---|---|---|---|---|
| **6c** | 3,4-$F_2C_6H_3$ | – | B | 95 | 258[h,i] | – | 7.30 (m, 1H, ArH), 7.79 (m, 1H, ArH), 8.02–8.10 (m, 2H, ArH), 8.22–8.30 (m, 1H, ArH), 8.33–8.40 (m, 1H, ArH), 8.72 (d, 1H, ArH), 9.05 (s, 1H, H-5) |
| **6d** | 1-naphthyl | – | B | 80 | 223[h] | – | 7.52–7.57 (m, 2H, ArH), 7.62–7.67 (m, 1H, ArH), 7.78–7.83 (m, 1H, ArH), 7.93–8.12 (m, 5H, ArH), 8.55–8.57 (m, 1H, ArH), 8.82 (d, 1H, ArH), 9.04 (s, 1H, H-5) |
| **6e** | 3,5-$Cl_2C_6H_3$ | – | B | 78 | 232[h] | – | 7.43 (dd, 1H, ArH), 7.60 (d, 1H, ArH), 7.75–7.83 (m, 2H, ArH), 8.78 (d, 1H, ArH), 9.05 (s, 1H, H-5) |
| **6f** | 3,4-$(OMe)_2C_6H_3$ | – | B | 84 | 208[h] | – | 3.96 (s, 3H, $OCH_3$), 4.40 (s, 3H, $OCH_3$), 7.01 (d, 1H, ArH), 7.73 (m, 1H, ArH), 7.96–8.09 (m, 4H, ArH), 8.70 (d, 1H, ArH), 8.96 (s, 1H, H-5)[j] |
| **9a** | Ph | Me | C | 38 | 197[h] | – | 2.95 (s, 3H, $CH_3$), 7.00–8.80 (m, 9H, ArH) |
| **9b** | CN | Me | C | 25 | 243[h] | 2243 (CN) | 3.03 (s, 3H, $CH_3$), 7.96 (m, 1H, ArH), 8.23 (m, 1H, ArH), 8.51 (d, 1H, ArH), 8.69 (d, 1H, ArH) |
| **9c** | $CO_2Et$ | Me | C | 17 | 200[h] | 1730 (CO) | 1.48 (t, 3H, $CH_3$), 3.05 (s, 3H, $CH_3$), 4.56 (q, 2H, $CH_2$), 7.77 (m, 1H, ArH), 8.03 (m, 1H, ArH), 8.19 (m, 1H, ArH), 8.76 (m, 1H, ArH) |
| **9d** | 1-naphthyl | Me | C | 30 | 211[h] | – | 2.87 (s, 3H, $CH_3$), 7.51–8.67 (m, 11H, ArH) |
| | | | D | 61 | 212[l] | | |
| **9e** | 3,5-$Cl_2C_6H_3$ | Me | D | 54 | 181[l] | – | 2.94 (s, 1H, $CH_3$), 7.48 (dd, 1H, ArH), 7.56 (1H, d, ArH), 7.74 (m, 2H, ArH), 7.99 (m, 1H, ArH), 8.12 (d, 1H, ArH), 8.73 (d, 1H, ArH) |
| **9f** | 3,5-$Cl_2C_6H_3$ | $NH_2$ | D | 49 | 284–288[l,m] | 3451, 3333, 3218 ($NH_2$) | 3.37 (br s, 2H, $NH_2$), 7.51–7.55 (m, 1H, ArH), 7.72–7.81 (m, 2H, ArH), 8.00–8.11 (m, 2H, ArH), 8.39–8.49 (m, 2H, ArH) |
| **9g** | 1-naphthyl | $NH_2$ | D | 78 | 230[l] | 3402, 3301, 3218 ($NH_2$) | – |
| | | | C | 70 | | | |
| **13a** | Ph | – | – | 18 | 219[f] | 3435, (OH), 1618 (CO) | 7.50–7.55 (m, 2H, ArH), 7.65–7.70 (m, 1H, ArH), 7.77 (d, 1H, ArH), 7.79–7.81 (m, 2H, ArH), 8.01–8.08 (m, 1H, ArH), 8.56–8.59 (m, 1H, ArH), 8.63–8.65 (m, 1H, ArH), 15.93 (br s, OH) |
| **13b** | OEt | – | – | 68 | 118[f] | 1752, 1715 (CO) | 1.56 (t, 3H, $CH_3$), 4.46 (q, 2H, $CH_2$), 7.74 (m, 1H, ArH), 7.98 (m, 1H, ArH), 8.44 (m, 1H, ArH), 8.62 (d, 1H, ArH), 9.49 (br s, 1H, OH) |
| **22** | – | – | – | 55 | 216[k,n] | 3350 (OH) | 6.35 (s, 1H, OH), 6.90–7.23 (m, 10H, ArH), 7.61 (m, 1H, ArH), 7.78 (m, 1H, ArH), 8.22 (d, 1H, ArH), 8.80 (d, 1H, ArH) |

[a] Satisfactory microanalyses obtained: C ± 0.5, H ± 0.2, N ± 0.5.
[b] Base: A = piperidine, B = NaOEt, C = Amberlite Resin IR 400, D = KOBu-*t*, E = $Et_3N$.
[c] Crystallized from aq DMF.
[d] $^{13}C$ NMR (DMSO/TMS): $\delta$ = 97.04, 111.77, 113.89, 116.38, 128.84, 130.71, 131.21, 134.72, 143.24, 159.80.
[e] $^{13}C$ NMR (DMSO/TMS): $\delta$ = 55.93, 56.02, 109.47, 111.27, 115.49, 118.88, 119.21, 123.47, 127.82, 128.49, 133.36, 134.65, 136.60, 137.93, 149.15, 153.08.
[f] Crystallized from EtOAc/light petrol.
[g] $^{13}C$ NMR (DMSO/TMS): $\delta$ = 111.81, 112.31, 114.91, 119.29, 129.81, 130.04, 132.41, 136.70, 143.44, 159.82.
[h] Crystallized from EtOH.
[i] HRMS (CI, $NH_3$): *m/z* Calcd for $C_{15}H_{18}F_2N_4$: 283.0795 ($M^+ + 1$); Found 283.0798.
[j] $^{13}C$ NMR (DMSO/TMS): $\delta$ = 56.67, 56.78, 112.07, 112.38, 117.11, 127.08, 128.87, 129.15, 129.67, 130.11, 131.10, 147.92, 149.71, 150.83.
[k] Recorded in DMSO-$d_6$.
[l] Crystallized from toluene.
[m] HRMS (CI, $NH_3$): *m/z* Calcd for $C_{15}H_9Cl_2N_5$: 330.0313 ($M^+ + 1$); Found 330.0307.
[n] With Decomposition.

evidence for the presence of the azido group in the tetrazoloquinolines **5a–g** and **13a,b**. In fact, the benzoyltetrazoloquinoline **13a** is stable at high temperatures and all attempts to induce nitrogen loss from the azide tautomer and thermal rearrangement to the 2,1-oxazolo[3,4-*b*]quinoline **14** (Scheme 3) have failed.

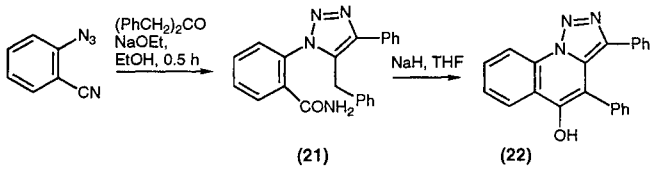
Previously,[9] we have prepared 2,1-oxazolo[4,3-*c*]quinolines by the action of carbanions on 2-azidobenzonitrile oxide **15** followed by an aza-Wittig reaction on the resulting 2,1-oxazole (Scheme 4). For example, with ethyl cyanoacetate as the carbanion precursor, cyclisation of the intermediate oxyanion **16** at the nitrile rather than at the ester function, furnishes the aminoisoxazolo ester **17** which with triphenylphosphine in toluene yields directly the 2,1-oxazolo[4,3-*c*]quinoline **18**. However, with benzoylacetonitrile as the carbanion source, regioselective cyclisation of intermediate (**16**, R = COPh) at the

more reactive ketone function produces the isolable cyanoisoxazole **19a** which in boiling acetonitrile yields the 2,1-oxazolo[4,3-*c*]tetrazolo[1,5-*a*]quinoline **20a** in excellent yield (Scheme 4). Likewise, with malononitrile, the 4-amino-2,1-oxazolo[4,3-*c*]tetrazolo[1,5-*a*]quinoline **(20b)** is obtained.




**Scheme 4**

Treatment of 2-azidobenzonitrile with 1,3-diphenylpropan-2-one in the presence of sodium ethoxide yields the expected 1,2,3-triazole accompanied, however, by nitrile hydrolysis to the amide **21**. Cyclisation of the amide to 5-hydroxy-3,4-diphenyl-1,2,3-triazolo[1,5-*a*]quinoline **(22)** can be effected with sodium hydride in boiling THF (Scheme 5).




**Scheme 5**

$^1$H and $^{13}$C NMR spectra were recorded on a Bruker AC 300 FTNMR or Perkin-Elmer R32 spectrometer in $CDCl_3$ solution, (unless stated otherwise) with TMS as internal standard. IR spectra were recorded as Nujol mulls on a Perkin-Elmer 1750 FTIR spectrometer, and mass spectra recorded on a Finnegan 4000 mass spectrometer using CI ($NH_3$) techniques. TLC was performed using Camlab Polygram silica gel N/$uv_{254}$ plates and flash chromatography carried out on Kieselgel 60H silica. Light petrol refers to the boiling range 40–60 °C. Melting points were obtained using an Electrothermal apparatus and are uncorrected.

**CAUTION!** *All azides are potentially explosive and should not be heated as the neat solid or liquid. All reactions involving azides described in this paper were carried out in solution.*

**4-Substituted Tetrazolo[1,5-*a*]quinolines 5a–g: General Procedures:**
Method A, for **5a–d**: To a stirred solution of 2-azidobenzaldehyde **(4)**[10] (1.47 g, 10 mmol) and piperidine (0.2 mL) in EtOH (15 mL) was added the acetonitrile (10 mmol). The solution was stirred for 2 h at r.t., then filtered to give the product as a white solid which was washed with cold EtOH and crystallized from DMF. In the case of R = PhCO, there was evidence [IR: $\nu$ = 2223 (CN), 2133 ($N_3$), 1647 (CO) cm$^{-1}$] for the formation of intermediate cyanoethene (R = COPh) (Scheme 2) which in boiling MeCN (0.5 h) cyclised quantitatively to **5a**.

Method B, for **5e–g**: To a solution of the acetonitrile (8 mmol) and NaOEt (0.55 g, 8 mmol) in EtOH (20 mL) was added dropwise with stirring a solution of 2-azidobenzaldehyde (**4**; 1.18 g, 8 mmol) in EtOH (10 mL). The mixture was stirred at r.t. for 12 h and the solvent removed under reduced pressure to give a solid residue, which was triturated with $H_2O$ and purified by crystallisation as in Method A.

**3-Substituted 1,2,3-Triazolo[1,5-*a*]quinazolines 6a–f; General Procedures:**
Method A, for **6a**: To an ice-cold solution of 2-azidobenzaldehyde (**4**; 1.1 g, 7.48 mmol) and malononitrile (0.51 g, 7.7 mmol) in $CH_2Cl_2$ (15 mL) was added a solution of piperidine (0.2 mL) in $CH_2Cl_2$ (5 mL). The cold solution was stirred for 2 h, filtered and the residue washed with $CH_2Cl_2$ to give **6a** as amber crystals (Table).

Method B, for **6b–f**: To an equimolar amount of 2-azidobenzaldehyde **(4)** and an arylacetonitrile in ice-cold $CH_2Cl_2$ or MeCN was added NaOEt (2 mol equiv). The cold mixture was stirred for 0.5 h whereupon the crude product precipitated as a pale yellow solid. The mixture was filtered and the residue washed with cold EtOH and purified by crystallisation from a suitable solvent (Table).

In a similar manner 2-azidobenzaldoxime (mp 102–103 °C, Lit.[11] mp 103 °C) (from aldehyde **4** and $NH_2OH \cdot HCl$/NaOAc in EtOH) and *C*-(2-azidophenyl)-*N*-methylnitrone[9] were reacted in EtOH/KOBu-*t* with 3,5-dichlorophenylacetonitrile to give **6e** in 81 and 68 %, and with 3,4-dimethoxyphenylacetonitrile to give **6f** in 64 and 78 % yields, respectively.

**TLC Monitoring of the Effect of Solvent and Base:**
To a stirred solution of 2-azidobenzaldehyde (**4**; 50 mg) and 3,4-dimethoxyphenylacetonitrile (60 mg) in the test solvent at 0 °C was added the base (50 mg). The reactions were monitored over 0.5 h by TLC (silica gel, EtOAc/light petrol) against pure samples of the tetrazoloquinoline **5g** and the triazoloquinazoline **6f**.

**5-Methyl- (9a–e) and 5-Amino- (9f,g) 1,2,3-triazolo[1,5-*a*]quinazolines:**
Method C, for **9a–e**: An equimolar mixture of 2'-azidoacetophenone[12] and the acetonitrile in EtOH was stirred at r.t. for 24 h in the presence of Amberlite IR400 (OH) ion-exchange resin (2 g). The mixture was then heated to boiling and whilst hot filtered rapidly to remove the resin. Evaporation of the ethanolic filtrate under reduced pressure gave the crude product which was purified by flash chromatography (silica gel, EtOAc/light petrol, 1:9, then 1:1).

Method D: To an ice-cold, stirred equimolar (5.5 mmol) solution of 2-azidobenzonitrile[13] or 2'-azidoacetophenone and the acetonitrile in MeCN (15 mL) was added KOBu-*t* (1.1 mmol). The cold solution was stirred for 2 h, then filtered and the crude solid product purified by crystallisation (Table).

**2-Azidobenzoyl Chloride:**
To a stirred suspension of 2-azidobenzoic acid (2.6 g, 18 mmol) in anhyd $Et_2O$ (15 mL) was added dropwise oxalyl chloride (3.4 g, 27 mmol). The mixture was stirred at r.t. for 4 h after which time the solvent and excess of oxalyl chloride were removed at **< 40 °C (Caution)** under reduced pressure. The product was obtained as a pale brown viscous oil which was used directly without further purification.

**Ethyl 2-(Azidobenzoyl)cyanoacetate (11b):**
To a stirred solution of ethyl cyanoacetate (0.46 g, 4.1 mmol) and $Et_3N$ (0.43 g, 4.2 mmol) in sodium dried $Et_2O$ (15 mL) was added dropwise a solution of 2-azidobenzoyl chloride (0.8 g, 4.4 mmol) in anhyd $Et_2O$ (5 mL). The mixture was stirred at r.t. for 24 h and filtered. The filtrate was evaporated to dryness and the residue purified by flash chromatography (silica gel EtOAc/light petrol, 1:2). The product was obtained as a brown oil (0.37 g; 34 %).

IR (neat): $\nu$ = 2233 (CN), 2127 ($N_3$), 1756 (C=O) cm$^{-1}$.

**4-Ethoxycarbonyl-5-hydroxytetrazolo[1,5-*a*]quinoline (13b); Typical Procedure:**
A solution of the cyanoester **11b** (0.3 g, 1.16 mmol) in MeCN was heated under reflux for 24 h. Removal of the solvent under reduced

pressure gave the crude product which was purified by flash chromatography (silica gel, EtOAc/light petrol, 1:1) (Table).

*4-Benzoyl-5-hydroxytetrazolo[1,5-a]quinoline* **(13a)**: This compound was prepared in a similar manner from 2-azidobenzoyl chloride (0.75 g, 4.13 mmol) and benzoylacetonitrile (0.6 g, 4.13 mmol) (Table).

*3-(2-Azidophenyl)-4-cyano-5-phenyl-1,2-oxazole* **(19a)**: This compound was prepared from benzoylacetonitrile (1.11 g, 7.6 mmol) and 2-azidobenzhydroximoyl chloride (15 g, 7.6 mmol) in the presence of $Et_3N$ by the method described previously;[9] yield: 88%; mp 235°C (EtOH).

IR (Nujol): $\nu$ = 2237 (CN), 2151, 2111 ($N_3$).

*5-Amino-3-(2-azidophenyl)-4-cyano-1,2-oxazole* **(19b)**: This compound was obtained similarly from the same hydroximoyl chloride and malononitrile; yield: 77%; mp 290°C (EtOAc/light petrol).

IR (Nujol): $\nu$ = 3353, 3194 ($NH_2$), 2228 (CN), 2123 ($N_3$).

HRMS (CI-$NH_3$): *m/z* calcd for $C_{10}H_6N_6O$: 226.1989; Found 226.1982.

**4-Phenyl-2,1-oxazolo[4,3-*c*]tetrazolo[1,5-*a*]quinoline (20a); Typical Procedure:**

A solution of **19a** (0.25 g, 0.87 mmol) in MeCN (10 mL) was heated under reflux for 2.5 h. The mixture was then cooled in ice-water in order to precipitate the product (0.24 g, 97%) which was crystallised from EtOH, mp 221°C.

HRMS (CI-$NH_3$): *m/z* Found $(M+1)^+$ 288.0885; Calc. 288.0897.

$C_{16}H_9N_5O$ (287.2): Calcd C 66.9, H 3.2, N 24.4; Found C 67.7, H 3.7, N 24.1.

*4-Amino-2,1-oxazolo[4,3-c]tetrazolo[1,5-a]quinoline* **(20b)**: yield: 50%; mp 264–6°C.

$C_{10}H_6N_6O$ (226.56): Calc. C 53.0, H 2.7, N 37.1; Found C 52.7, H 2.7, N 36.6.

**2-(5-Benzyl-4-phenyl-1,2,3-triazol-1-yl)benzamide (21):**

To a stirred solution of 2-azidobenzonitrile (1 g, 6.94 mmol) and 1,3-diphenylpropan-2-one (1.46 g, 6.95 mmol) in EtOH (30 mL) was added dropwise a solution of Na (0.4 g, 17.4 mmol) in EtOH (10 mL). The mixture was stirred at r.t. for 0.5 h, filtered and the crude product washed with cold EtOH and dried; yield: 1.87 g (76%); mp 194–197°C (EtOH).

$C_{22}H_{18}N_4O$ (354.4): Calcd C 74.55, H 5.1, N 15.9; Found C 74.4, H 5.1, N 16.04.

IR (Nujol): $\nu$ = 3326, 3200 ($NH_2$), 1678 (CO) $cm^{-1}$.

$^1H$ NMR ($CDCl_3$): $\delta$ = 4.12 (s, 2H, $NH_2$), 5.65, 5.87 (2 br s, 1H each, $ArCH_2$), 6.77–7.82 (m, 9H, ArH).

**5-Hydroxy-3,4-diphenyl-1,2,3-triazolo[1,5-*a*]quinoline (22):**

To a stirred suspension of activated NaH[14] in anhyd THF (15 mL) under dry $N_2$ was added dropwise **21** (1 g; 2.82 mmol) in THF (10 mL) and the mixture heated under reflux for 24 h. Removal of the solvent under reduced pressure followed by trituration of the residue with $H_2O$ (20 mL) gave the crude product which was isolated, dried, and purified by flash chromatography (silica gel, EtOAc/light petrol, 1:9 then 1:1) (Table).

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(1) Tennant, G. *J. Chem. Soc. C* **1966**, 2290.
Sutherland, D.R.; Tennant, G. *J. Chem. Soc., Perkin Trans. 1* **1974**, 534.
Westerlund, C. *J. Heterocycl. Chem.* **1980**, *17*, 1765.
(2) Smalley, R.K.; Teguiche, M. *Synthesis* **1990**, 654.
(3) In the case of R = PhCO, a small amount of the cyanoalkene is present, see experimental.
(4) Padwa, A. In *1,3-Dipolar Cycloaddition Chemistry*; Padwa, A., Ed.; Wiley: New York, 1984; Vol. 2, p 277.
Lwowski, W. In *1,3-Dipolar Cycloaddition Chemistry*; Padwa, A., Ed.; Wiley: New York, 1984; Vol. 1, p 559.
(5) Garanti, L.; Zecchi, G. *J. Org. Chem.* **1980**, *45*, 4767.
(6) Smith, P.A.S.; Clegg, J.M.; Hall, J.H. *J. Org. Chem.* **1958**, *23*, 524.
Fusco, R.; Garanti, L.; Zecchi, G. *J. Org. Chem.* **1975**, *40*, 1906.
(7) Porter, T.C. *Ph. D. Thesis*, University of Salford, 1995. Full X-Ray data to be published elsewhere.
(8) Tisler, M. *Synthesis* **1973**, 123.
(9) Purwono, B.; Smalley, R.K.; Porter, T.C. *Synlett* **1992**, 231.
(10) Azadi-Ardakani, M.; Smalley, R.K.; Smith, R.H. *J. Chem. Soc., Perkin Trans. 1* **1983**, 2501.
(11) Bamberger, E.; Demuth, E. *Ber. Dtsch. Chem. Ges.* **1901**, *34*, 1309.
(12) Boyer, J.H.; Straw, D. *J. Am. Chem. Soc.* **1953**, *75*, 2683.
(13) Forster, M.O.; Judd, H.M. *J. Chem. Soc.* **1910**, *97*, 254.
(14) Hubbard, J.L. *Tetrahedron Lett.* **1988**, *29*, 3197.