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2-(5-Arylterphenyl-4-yl)quinolines from 2-methylquinoline and 1-(het)aryl-3-phenylprop-2-yn-1-ones in just a one step: a miracle of molecular interplay

Boris A. Trofimov,* Kseniya V. Belyaeva, Lina P. Nikitina, Andrei V. Afonin and Alexander V. Vashchenko

A. E. Favorsky Irkutsk Institute of Chemistry, Siberian Branch of the Russian Academy of Sciences, 664033 Irkutsk, Russian Federation. Fax: +7 3952 419 346; e-mail: boris_trofimov@irioch.irk.ru

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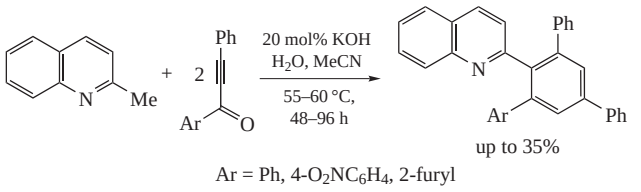
2-Methylquinoline reacts with 1-(het)aryl-3-phenylprop-2-yn-1-ones under mild transition metal-free conditions (55–60 °C, 20 mol% KOH, H_2O, MeCN) to afford 2-{5′-(het)aryl-[1,1′:3′,1′′]terphenyl-4′-yl}quinolines in up to 35% yield. The reaction likely proceeds *via* the intermediate 1,3-dipole followed by the double nucleophilic vinylation of the methyl group with two molecules of ynone and subsequent elimination of (het)arenecarboxylic acid.



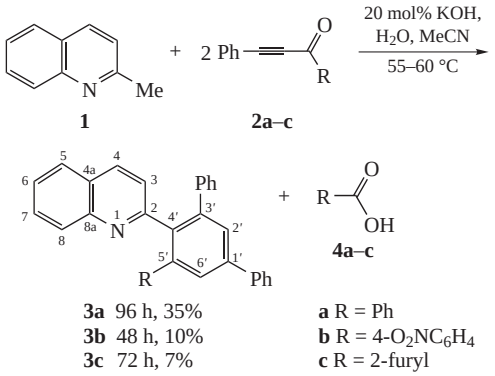
Activation of nitrogen aromatic heterocycles by the zwitterion formation with electron-deficient acetylenes is now dynamically developed. This concept permitted a number of synthetically important functionalizations and reactions of azines and azoles to be implemented. Just to mention a few: annulation of cyano propargylic alcohols with pyridine nucleus,[1] functionalization[2] and ring-opening[3] of pyridines under the action of electron-deficient acetylenes, C^2-vinylation[4,5] and functionalization[6–13] of imidazoles.

Here we disclose one more example of nitrogen heterocycle activation under the action of electron-deficient acetylenes that results in formation of the unexpected molecular structure. Namely, 2-methylquinoline **1** and two molecules of 1-(het)aryl-3-phenylprop-2-yn-1-ones **2a–c** are surprisingly assembled to 2-{5′-(het)aryl[1,1′:3′,1′′]terphenyl-4′-yl}quinolines **3a–c** in 7–35% unoptimized yields (Scheme 1). The reaction proceeds at 55–60 °C in the presence of 20 mol% of KOH, 5 equiv. of H_2O in MeCN for 48–96 h and does not require any transition metal catalysts.† The process was controlled by IR spectroscopy and stopped after disappearance of the absorption bands at 2198–2220 cm^{-1} (the stretching vibrations of the triple bond in ynones **2**).

Oddly, the best result for product **3a** has been obtained at the reactant molar ratio 1:1, while with two molar excess of ynone **2a** relative to quinoline **1**, the process slows down and the conversion of ynone **2** remains 47% (yields of product **3a** are 12% based on acetylene taken and 25% based on acetylene consumed). Quinolines **3** were purified by chromatography. As by-products, the corresponding acids **4a–c** were isolated (see Scheme 1).

The structures of quinolines **3a**,**b** were established by single crystal X-ray analysis (Figure 1).‡

As follows from the X-ray diffraction data, molecules **3a**,**b** are essentially non-planar. The dihedral angle between the quinoline cycle plane and the C(6)–C(9)C(20)C(21) phenyl ring plane



Scheme 1

† *2-(5′-Phenyl[1,1′:3′,1′′]terphenyl-4′-yl)quinoline* **3a**. A solution of 2-methylquinoline **1** (0.143 g, 1.0 mmol) in MeCN (0.5 ml) and KOH (0.012 g, 20 mol%) were subsequently added to the solution of ynone **2a** (0.206 g, 1.0 mmol) in MeCN (0.5 ml) and H_2O (0.090 g, 5.0 mmol). The mixture was stirred at 55–60 °C for 96 h. The solvent was removed, the subsequent column chromatography afforded quinoline **3a** (0.075 g, 35%) as a white powder, mp 247–249 °C (EtOH). Starting 2-methylquinoline **1** (0.045 g, conversion was 100% as it was taken in a two molar excess, the overflow quantity was returned) and ynone **2a** (0.012 g, conversion was 94%) were recovered. IR (microlayer, ν/cm^{-1}): 1599, 1618 (C=C). ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 7.74 (m, 1H, H-8), 7.72 (s, 1H, H-2′; m, 1H, H-6′; 2H, *o*-H_{Ph} from $C^{3'}$-Ph), 7.70 (d, 1H, H-4, $^3J_{H^3,H^4}$ 8.6 Hz), 7.62 (m, 1H, H-5), 7.53 (m, 1H, H-7), 7.44 (m, 1H, *p*-H_{Ph} from $C^{3'}$-Ph; 1H, *p*-H_{Ph} from $C^{5'}$-Ph), 7.40 (m, 1H, H-6), 7.36 (m, 1H, *p*-H_{Ph} from $C^{1'}$-Ph), 7.16 (m, 2H, *o*-H_{Ph} from $C^{3'}$-Ph; 2H, *o*-H_{Ph} from $C^{5'}$-Ph), 7.06 (m, 2H, *m*-H_{Ph} from $C^{3'}$-Ph; 2H, *m*-H_{Ph} from $C^{1'}$-Ph; 2H, *m*-H_{Ph} from $C^{5'}$-Ph), 7.01 (d, 1H, H-3, $^3J_{H^3,H^4}$ 8.6 Hz). ^{13}C NMR (100.62 MHz, $CDCl_3$) δ: 150.3 (C^2), 147.7 (C^{8a}), 142.7 ($C^{3'}$, $C^{5'}$), 141.5 (*i*-C from $C^{3'}$-Ph; *i*-C from $C^{5'}$-Ph), 141.4 ($C^{4'}$), 140.6 ($C^{1'}$), 137.7 (*i*-C from $C^{1'}$-Ph), 134.8 (C^4), 129.8 (*m*-C from $C^{3'}$-Ph; *m*-C from $C^{5'}$-Ph), 129.3 (C^8), 129.2 (C^7), 129.0 (*m*-C from $C^{1'}$-Ph), 128.6 (*o*-C from $C^{1'}$-Ph), 127.9 (*o*-C from $C^{3'}$-Ph; *o*-C from $C^{5'}$-Ph), 127.8 (C^5), 124.8 (C^3), 127.4 (*p*-C from $C^{1'}$-Ph; *p*-C from $C^{3'}$-Ph; *p*-C from $C^{5'}$-Ph), 126.6 ($C^{2'}$, $C^{6'}$), 126.3 (C^6), 126.1 (C^{4a}). Found (%): C, 91.02; H, 5.17; N, 3.27. Calc. for $C_{33}H_{23}N$ (%): C, 91.42; H, 5.32; N, 3.23.

For the syntheses and characteristics of compounds **3b**,**c**, see Online Supplementary Materials.

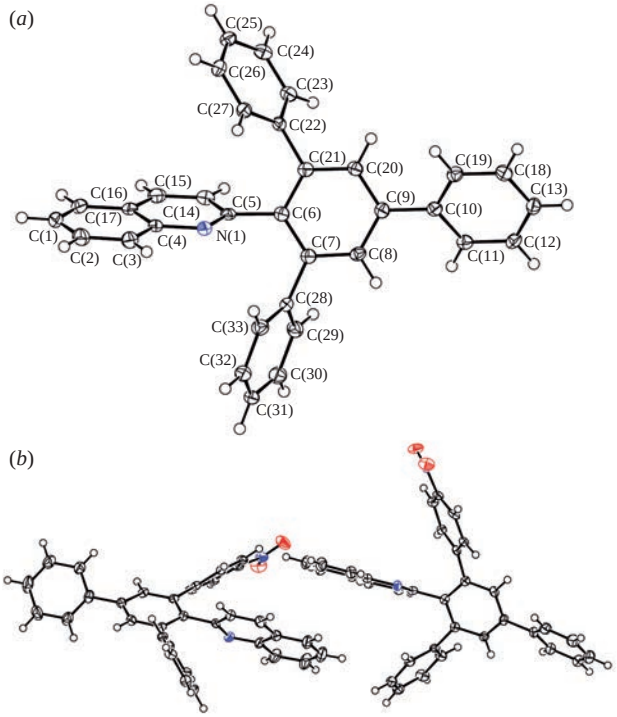
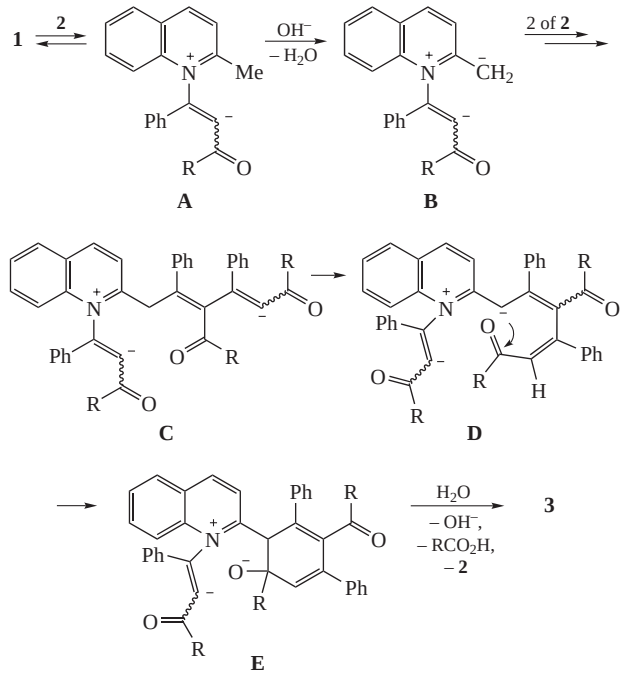


Figure 1 X-ray structure of (*a*) 2-(5′-phenyl[1,1′:3′,1″]terphenyl-4′-yl)-quinoline **3a** and (*b*) 2-(4-nitro-5′-phenyl[1,1′:3′,1″]terphenyl-2′-yl)quinoline **3b**. Thermal ellipsoids set at 50% probability.



Scheme 2

is 68.0 and 56.3° for **3a** and **3b**, respectively. The dihedral angles between the C(6)–C(9)C(20)C(21) phenyl ring plane and the C(10)–C(13)C(18)C(19), C(22)–C(27) and C(28)–C(33) phenyl rings planes are 36.9, 61.9 and 75.6°, respectively, in the molecule of **3a**. The dihedral angles between the C(6)–C(9)C(20)C(21) phenyl ring plane and the C(10)–C(13)C(28)C(29), C(14)–C(19) and C(22)–C(27) phenyl rings planes are 43.3, 50.3 and 57.5°, respectively, in the molecule of **3b**.

The structures of compounds **3b**,**c** were also proved by the ^{13}C NMR spectroscopy, the signals being assigned on the basis of the chemical shifts calculations by the GIAO[14] method at the B3LYP/6-311G(d,p) level with GAUSSIAN 09 program package[15] (see Table S7, Online Supplementary Materials).

Assumingly, the 1,3-dipole **A**, reversibly generated from quinoline **1** and ynone **2**, activates the methyl substituent as CH-acid towards nucleophilic addition to ynone **2** (Scheme 2). Consecutive vinylation of one C–H bond by two molecules of ynone **2** leads to intermediate dienic carbanion **C**. The carbanionic center of the latter is neutralized by the proton from the CH_2 group to deliver the intermediate **D**. The CH carbanionic center of the latter undergoes intramolecular nucleophilic addition to carbonyl group with the six-member ring closing. After elimination of molecule of (het)arenecarboxylic acid from intermediate **E** with simultaneous recovery of ynone **2** (reversibly bound with zwitterionic center), quinoline **3** is finally assembled (see Scheme 2).

Low to moderate yields of products **3a–c** (7–35%) despite the almost complete conversion of ynones **2a–c** (94–100%) and 2-methylquinoline **1a** (83–100%) may be related to the oligomerization of reactants and side reactions of the reactive intermediates (*e.g.*, further generation of trienes and longer polyenes like formation of dienic carboanion **C**). The adverse effect of excess ynone **2** on the assembly is probably due to a partial trapping of KOH giving catalytically inactive species (*e.g.* potassium benzoate). Lower yields of **3b** (10%) and **3c** (7%) compared to **3a** (35%) could be explained by higher reactivity of the corresponding ynones **2b** and **2c** *vs.* **2a** towards side oligomerization.

The reaction thus found has obviously a potential for further development employing other substituted 2-methylquinolines and ynones, that corresponds to the modern trend to use acetylenes as universal chemical platform for arriving at the molecular complexity.[16] The scope and limitations of this synthesis are now under investigation. It should be mentioned that poly(het)arylbenzenes are known to be prospective optoelectronic materials and OLEDs.[17–20] They are also used in the synthesis of dendrimers,[21,22] and fullerene fragments.[23,24] Diverse 2-arylquinolines exhibit good fluorescence properties[25] and serve as precursors for photolabile compounds.[26] Therefore, this approach may significantly extend areas of their application, particularly in view of the presence of media-responsive quinoline moiety (potential sensors) in the synthesized molecules (see, *e.g.*, ref. 27).

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‡ *Crystal data for* **3a**. $C_{33}H_{23}N$, 0.77 × 0.5 × 0.24 mm, colorless block-like crystal, orthorhombic, space group *Pbca*, 198 670 reflections in total, maximum θ angle of 26.5°, 4655 independent reflections (completeness 100.0%, R_{int} = 12.06%, R_σ = 2.34%) and 3777 were greater than $2\sigma(F^2)$. The final cell constants are a = 19.4314(12), b = 10.5145(6) and c = = 22.0169(14) Å, Z = 8, V = 4498.3(5) Å^3. The final anisotropic full-matrix least-squares refinement on F^2 with 308 variables converged at R_1 = 3.74%, for the observed data and wR_2 = 8.85% for all data. GOOF = 1.032, largest difference peak/hole 0.23/–0.17 eÅ^{-3}. On the basis of the final model, the calculated density was 1.280 g cm^{-3} and F(000) = 1824 e$^-$.

Crystal data for **3b**. 2($C_{33}H_{22}N_2O_2$), 0.153 × 0.246 × 0.690 mm, white block-like crystal, triclinic, space group $P\bar{1}$, 109 115 reflections in total, maximum θ angle of 27.65°, 11331 independent reflectiions (completeness 98.9%, R_{int} = 13.18%, R_σ = 6.98%) and 7766 (68.54%) were greater than $2\sigma(F^2)$. The final cell constants are a = 12.1392(15), b = 12.6841(15) and c = 17.1616(18) Å, Z = 2, α = 110.717(3)°, β = 90.129(4)°, γ = 96.142(4)°, V = 2455.1(5) Å^3. The final anisotropic full-matrix least-squares refinement on F^2 with 308 variables converged at R_1 = 9.99%, for the observed data and wR_2 = 29.66% for all data. GOOF = 1.084, largest difference peak/hole 0.71/–0.48 eÅ^{-3}. On the basis of the final model, the calculated density was 1.295 g cm^{-3} and F(000) = 1000 e$^-$.

CCDC 1573603 and 1812576 contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre *via* http://www.ccdc.cam.ac.uk.

Online Supplementary Materials

Supplementary data associated with this article can be found in the online version at doi: 10.1016/j.mencom.2018.05.012.

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