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Regioselective Azidation of 2,4-Dichloroquinolines [1]

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Abstract. Reactions of 2,4-dichloroquinolines (**2a–f**) with sodium azide in DMF lead either regioselectively to 4-azido-2-chloroquinolines (**3a–f**) or with excess of sodium azide and catalysts to 5-azido-tetrazolo[1,5-a]quinolines (**4a–f**). 2,4-Dichloroquinolines (**2g–i**) having electron donating substituents in 3-position react with sodium azide in DMF to a mixture of 4-azido-2-chloroquinolines (**3g–i**) and 5-chloro-tetrazolo[1,5-a]quinolines (**5g–i**). When the reaction of the 2,4-dichloroquinolines (**2a–i**) with sodium azide is carried out in ethanol with addition of methanesulfonic acid, regioselectively 5-chloro-tetrazolo[1,5-a]quinolines (**5a–i**) are obtained. Structural assignments of **3** and **5** have been carried out by ^{13}C-NMR spectra, IR spectra and degradation reactions of the azido- and tetrazolo group to aminoquinolines (**7** and **10**) via iminophosphoranes (**8** and **9**). It could be shown that in 2-azido/tetrazolo-quinolines (**4** and **5**) the tetrazole ring structure is the dominant species.

Some results in the synthesis of azido hetarenes [2] raised the question of regioselectivity during reactions of azide anions with 2,4-dichloroquinolines **2**. 2,4-Dichloroquinolines are known to give nucleophilic substitution both in α- and γ-position [3]. A literature survey on the nucleophilic substitution of 2,4-dichloroquinolines **2** did not show uniform reaction conditions. With alcoholic sodium alkoxide solution most authors report an exchange of both chloro atoms leading to dialkoxy quinolines [4]; in some cases a mixture of 2- and 4-monoalkoxy quinolines were obtained [5]. A recent paper describes the regioselective 2-substitution with solid sodium alkoxide [6]. With amines 2,4-diaminoquinolines, 2-amino-4-chloroquinolines or 4-amino-2-chloroquinolines were obtained [7]. Kinetic studies indicate that the chloro atom in position 4 of 2,4-dichloroquinolines is about two times more reactive towards nucleophiles [3, 8] and predominantly an addition-elimination mechanism is observed [9].

One of our questions was to find out the reaction conditions which should lead regioselectively either to 2-azido-4-chloro- (**5**) or 4-azido-2-chloroquinolines (**3**) or to 2,4-diazidoquinolines (**4**). In order to transform the literature findings to the introduction of azido groups, we studied the reaction of 2,4-dichloroquinolines **2** in various solvents; in dipolar aprotic solvents the additional effect of crown ethers was studied. Another aspect was to explain the influence of substituents in position 3.

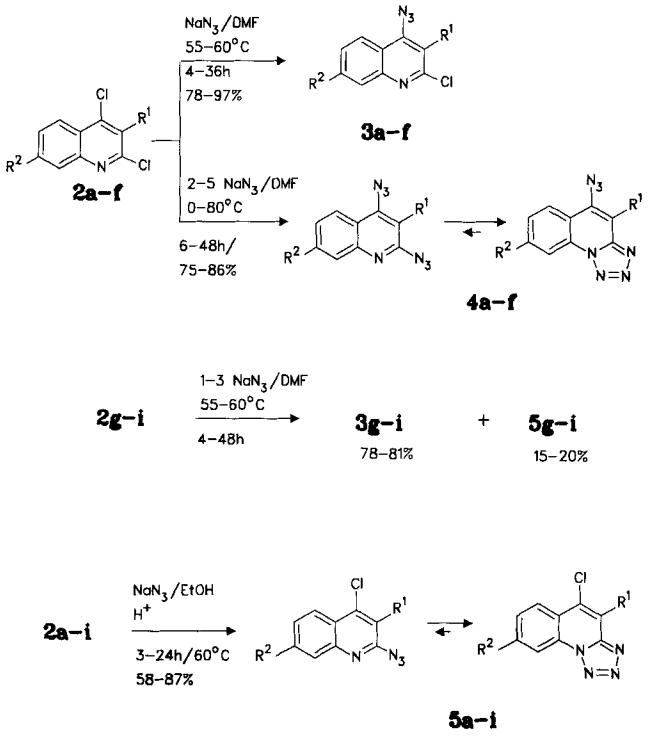
Results and Discussion

To obtain 2,4-dichloroquinolines **2**, 4-hydroxy-2-quinolones **1**, synthesized by literature procedures, were treated with excess of phosphoryl chloride using a method described earlier [2a]. In the case of **1e** having a nitro group in 3-position, triethylamine had to be added as a basic catalyst to destroy hydrogen bonds between the 3-nitro group and the 4-hydroxy group, which retarded the attack of the phosphoryl chloride and caused low yields.

The 2,4-dichloroquinolines **2** having electron donator or acceptor substituents in position 3 were treated with sodium azide in dimethylformamide. Dichloroquinolines **2** with strong acceptor substituents, e.g. nitro- or cyano groups, chloro atoms, phenyl or hydrogen in 3-position, were found to react with equimolar amounts of sodium azide at temperatures of 55–60 °C in good yields to monoazido-chloroquinolines, which were proved to be 4-azido-2-chloroquinolines **3**, a fact which is easily explicable from the data derived from kinetic studies [3, 8], which appear to be in some contradiction to the data found in substitution reactions with alkoxides and amines [4–7].

Increasing the molar amount of sodium azide and the temperature did not show any effect in the reaction of **2a–c** (having hydrogen or phenyl substituents in 3-position). In this case only the monoazides **3a–c** could be isolated. Only when a catalyst such as cryptofix 5 was added to complex the sodium cation, the unsolvatated azide anion was nucleophilic enough to react also in position 2 of the dichloroquinoline **2a–c**. In this case

2,4-diazidoquinolines **4a–c** were obtained, in which the 2-azido group could be shown to exist almost perfectly in the tetrazolo form. The reaction of the 7-methoxy compound **2c** did not show any noticeable difference to the 7-unsubstituted quinoline **2b**.



Scheme 1

2,4-Dichloroquinolines **2d–f** having acceptor substituents in 3-position react with excess of sodium azide without catalysts to give the corresponding diazidoquinolines **4d–f**. Whereas 2,3,4-trichloroquinoline **2f** needs a 3 molar excess of sodium azide at 50 °C to afford the diazide **4f**, 3-cyano- and 3-nitro dichloroquinolines **2d, e** react at these temperatures to colored mixtures of decomposition products. At 0 °C, 2,4-dichloro-3-cyanoquinoline **2d** gave with a 2 molar excess of sodium azide 2,4-diazido-3-cyanoquinoline **4d**, whereas 2,4-dichloro-3-nitroquinoline **2e** and an excess of sodium azide also at lower temperatures produced only green colored mixtures of decomposition products. Changing the solvent to acetonitril or ethanol resulted solely to the formation of the monoazide **3e**.

The synthesis of the 4-azido-2-chloroquinolines **3g–i** having electron donor substituents in position 3 needs an excess of sodium azide, but always the isomeric 2-azido-4-chloroquinolines **5g–i** were formed as by-products. Both isomers could be separated by recrystallization from ethanol. By using acetonitrile as solvent the reaction ratio decreased: after some days only traces of the monoazides could be detected by tlc. Attempts to obtain diazidoquinolines **4** with electron donor substituents in 3-position by raising the temperature and using higher excess of sodium azide or catalysts such as cryptofix 5 failed. A similar hindrance was found in the reaction of 4-chloro-2-quinolones with 3-alkyl substituents [10].

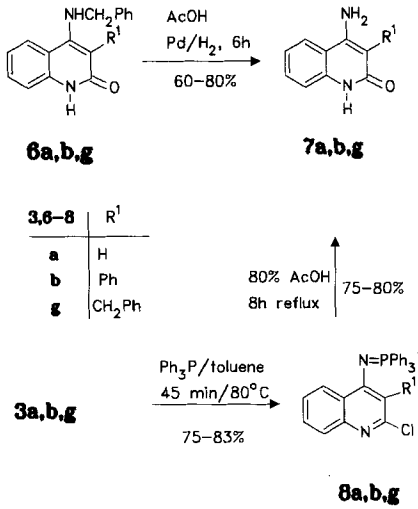
When the solvent system was changed from the dipolar aprotic dimethylformamide to ethanol as a protic, polar solvent, the reaction rates decreased in most cases drastically. After two days reaction time more than 60 % starting material could be detected in the reaction mixture by tlc monitoring, with one exception: 2,3,4-trichloroquinoline **2f** gave a mixture of the two isomeric monoazides **3f** and **5f**.

Addition of strong acids such as methanesulfonic acid to ethanol as the solvent reversed the reactivity of the dichloroquinolines **2** probably caused by protonation of the quinoline-nitrogen atom. In this case 2-azido-4-chloroquinolines **5a–i** were obtained in good yields. To obtain the 3-chloro derivative **5f** trifluoroacetic acid could be used as acid catalyst. In the formation of the azides **5** no dependance of electron properties of the substituents in position 3 with the reaction conditions could be observed.

IR-spectra showed, that the 2-azido-4-chloroquinolines **5** did not possess any azide signal but have 3 characteristic tetrazole signals ranging between 1000–1100 cm^{-1} [11]. This fact allows an unequivocal structural assignment of the two isomer monoazides **3** and **5**.

Structural Assignment of the Quinoline Azides by Degradation Reactions

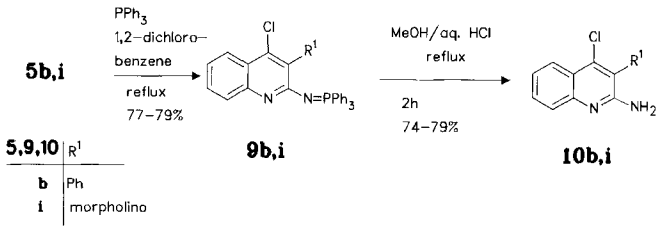
To perform a chemical structural assignment, the monoazides **3** and **5** were converted to aminoquinolones, which have been synthesized too in an independent way. Subsequent amination of the 4-hydroxy-2-quinolones **1** with benzylamine and cleavage of the benzyl group of **6** by catalytic hydrogenation using a method described earlier [10, 12] afforded the 4-amino-2(1H)-quinolones **7**.



Scheme 2

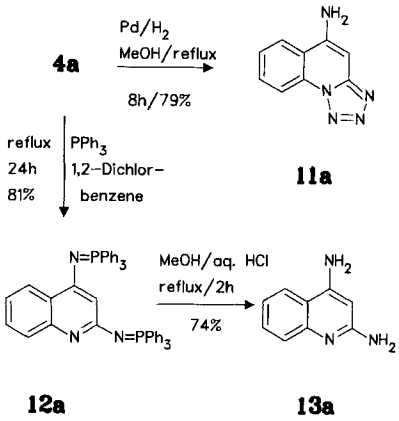
Aminoquinolones **7** could also be obtained when the 4-monoazides **3** were converted to iminophosphoranes **8** by reaction with triphenylphosphane via Staudinger reaction [13, 16b]. Hydrolysis with 80 % aqueous acetic acid produced in one step 4-amino-2(1H)-quinolones **7**. Both reaction paths were performed with hydrogen, phenyl and benzyl as substituents in 3-position (starting from **1a, b, g** or **3a, b, g**, resp.) and no difference in the reaction conditions could be observed. Aminoquinolones **7** obtained in both pathways were identical in all physical and spectroscopic data. The structure of an isomeric 2-amino-4-quinolone could be excluded because the IR spectrum shows significantly an amide carbonyl function at 1655–1665 cm^{-1} [10], whereas 4-quinolones are known to have carbonyl absorptions below 1600 cm^{-1} [14].

2-Azido-4-chloroquinolines **5**, which could be shown to exist mainly in the tautomer tetrazole form (see structural assignment by spectroscopic methods), could be converted in a similar way via the iminophosphoranes **9** and hydrolysis in aqueous hydrochloric acid to the 2-amino-4-chloroquinolines **10**. In this case no hydrolysis of the 4-chloro substituent to a hydroxy- or oxo-group was observed. It was not possible to obtain the 2-aminoquinolines **10** directly from the azido/tetrazoloquinoline **5** by hydrogenation as could shown for other tautomeric azido/tetrazolo hetarenes [15]. This fact indicates that no azido form is present in an equilibrium [16]. No difference in the reactivity of **5** could be found having electron donating or withdrawing substituents in position 3 [17]. Attempts to perform the hydrogenation in acidic medium, where the azido form should be predominant [18], failed. When palladium as catalyst was used, in acetic acid (also with additional trifluoroacetic acid) a mixture of compounds was obtained which could not be separated. Performing the reduction with zinc dust in acetic acid or aqueous hydrochloric acid only starting material was isolated after 24 hours reaction time.



Scheme 3

The catalytic hydrogenation of 5-azido-tetrazolo[1,5-a] quinoline (2,4-diazidoquinoline) **4a** produced selectively 5-amino-tetrazolo[1,5-a]quinoline **11a**, without any attack of the tetrazole ring. These facts are again strong indicators of a predominant tetrazole moiety, which are supported by IR and ^{13}C-NMR spectral data. Similar to the results obtained with the tetrazoloquinolines **5**, the reaction of **4a** with triphenylphosphane produced the bis-iminophosphorane **12a**, which could be hydrolyzed easily in aqueous hydrochloric acid to yield 2,4-diaminoquinoline **13a**.



Scheme 4

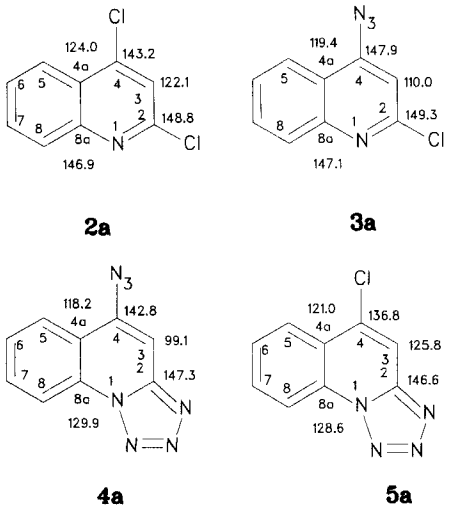
Structural Assignment of the Quinoline Azides by Spectroscopic Methods

In the IR spectra the characteristic azido signal in the region of 2160–2120 cm^{-1} could only be detected in azidoquinolines of type **3** and **4** with an azido group in position 4 of the quinoline nucleus. Monoazides of type **5** and type **11**, having the azido moiety in position 2 with the posibility of an azido/tetrazolo equilibrium, did not show any signal in this region, neither in solid form in potassium bromide pellets nor in solvents as chloroform or trifluoroacetic acid but had three characteristic tetrazole signals in the region between 1000–1100 cm^{-1} [11, 18e].

When ^{13}C-NMR spectral data of azides of type **3**, **4**, and **5** were compared with the data of the 2,4-dichloroquinolines **2**, a significant high field shift of C-8a could be observed. The signal is shifted from 142.4–147.1 ppm to 128.6–133.7 ppm in DMSO. In **4** and **5** no other signal (also in lower intensity) could be detected deriving from an azido tautomer, also using trifluoroacetic acid or chloroform instead of DMSO as the solvent. This effect seems to be general in the quinoline series and allows a simple assignment to either the tetrazole or to the azido form of 2-azido-quinolines.

Experimental

Melting points were obtained on a Gallenkamp Melting Point Apparatus Mod. MFB-595 in open capillary tubes. ^{1}H-NMR-spectra (200 MHz) were obtained on a Varian Gemini 200 instrument, ^{13}C-NMR-spectra (360 MHz) on a Bruker AM 360 instrument. Chemical shifts are reported in ppm from internal tetramethylsilane standard and are given in δ-units. The solvent for NMR was DMSO-d_6 unless otherwise stated. Microanalyses were performed on a Carlo Erba 1106 C,H,N-



Scheme 5

analyzer and are within 0.4 of the calculated percentages. Infrared spectra were taken on a Perkin-Elmer 298 spectrophotometer in potassium bromide pellets. Common reagent-grade chemicals are either commercially available and were used without further purification or prepared by standard literature procedures. All reactions were monitored by thin layer chromatography, carried out on 0.2 mm silica gel F-254 (Merck) plates using uv light (254 and 336 nm) for detection.

4-Hydroxy-2(1H)-quinolones (1a–i)

4-Hydroxy-2(1H)-quinolone (**1a**) is commercially available [19], 4-hydroxy-3-phenylquinolones **1b, c** were prepared from phenylmalonates and anilines according to ref. [20], 3-cyano-4-hydroxy-2-quinolone (**1d**) from isatoic anhydride and cyanoacetate according to ref. [21], 4-hydroxy-3-nitroquinolone (**1e**) according to ref. [2g, 22], 3-chloro-4-hydroxyquinolone (**1f**) from **1a** by chlorination with sulfurylchloride to 3,3-dichloroquinoline-2,4-dione followed by reduction of one chloro atom according to ref. [23], 3-benzyl-4-hydroxy-2-quinolone (**1g**) from benzylmalonate and aniline according to ref. [24], 4-hydroxy-3-methoxy-2-quinolone (**1h**) according to ref. [25] and 4-hydroxy-3-morpholino-2-quinolone (**1i**) according to ref. [26].

General Procedure for the Synthesis of 2,4-Dichloroquinolines (2a–i)

A solution of the corresponding 4-hydroxy-2(1H)-quinolone (**1a–i** (70 mmoles) in 100 ml of phosphorylchloride was heated under reflux for 30 min. To prepare 2,4-Dichloro-3-nitroquinoline (**2e**) the addition of dry triethylamine (10 ml) is necessary. Then the excess of phosphorylchloride was removed i. vac. and the residue was poured into ice-water. The solution was brought up to pH 6 with sodium hydroxide and filtered by suction.

2,4-Dichloroquinolines **2a–f** and **2h** are identical with known compounds [2a, 5a, 22, 28–30].

3-Benzyl-2,4-dichloroquinoline (**2g**)

Yield: 15.65 g, 89 %, m.p. 72–73 °C (ethanol). **2g** is described in ref. [32], but without any data; IR: 3020 w, 3030 w, 1570 s, 1480 s cm^{-1}.

$C_{16}H_{11}Cl_2N$	Calcd.: C 66.69	H 3.85	N 4.86
(288.2)	Found: C 66.94	H 4.01	N 4.75

2,4-Dichloro-3-morpholinoquinoline (**2i**)

Yield: 13.27 g (77 %), m.p. 121 °C (ethanol); IR: 2970 m, 2850 m, 1560 m, 1480 m cm^{-1}.

$C_{13}H_{12}Cl_2N_2O$	Calcd.: C 55.1	H 4.27	N 9.89
(283.2)	Found: C 55.19	H 4.31	N 9.93

General Procedure for the Synthesis of 4-Azido-2-chloroquinolines (3a–i)

Method A (for **3a–f**): A solution of the appropriate 2,4-dichloroquinoline (**2a–f**) (5 mmoles) and sodium azide (5 mmoles) in 30 ml of dimethylformamide was stirred at 55 °C for the time given in table 1. Then the reaction mixture was poured into 150 ml of ice-water and the product was collected by filtration.

Method B (for **3g–i**): Sodium azide (15 mmoles) was added to a solution of the appropriate 2,4-dichloroquinoline (**2g–i**) (5 mmoles) in 30 ml of dimethylformamide. After stirring the reaction mixture at 60 °C for the time given in table 1, the mixture was poured into 150 ml of ice-water and the precipitated product collected by filtration. The azides **3g–i** are obtained as a mixture together with the tetrazoles **5g–i**, and are separated by recrystallization: 1.0 g of the mixture is recrystallized in 30 ml of ethanol to obtain the 4-azidocompounds **3g–i** as precipitate. The mother liquor contains the tetrazole **5g–i** (for their work-up see method B of these compounds).

General Procedure for the Synthesis of 5-Azido-tetrazolo [1,5-a]quinolines (4a–d, f)

Method A: A suspension of the appropriate 2,4-dichloroquinoline (**2a–c**) (5 mmoles), sodium azide (25 mmoles) and cryptofix 5 (0.1 g) in 30 ml of dimethylformamide was stirred at 80 °C for the time given in table 2. Then the reaction mixture was poured into 150 ml of ice-water and after 12 h the product was filtered by suction.

Method B: A suspension of 3-cyano-2,4-dichloroquinoline **2d** (1.0 g, 4.5 mmoles), sodium azide (0.58 g, 9.0 mmoles) and cryptofix 5 (0.1 g) in 30 ml of dimethylformamide was stirred at 0 °C. After 12 h the reaction mixture was poured into 150 ml of ice-water and the product was collected by filtration.

Method C: Sodium azide (0.84 g, 12.9 mmoles) was added to a solution of 2,3,4-trichloroquinoline (**2f**) (1.0 g, 4.3 mmoles) in 30 ml of dimethylformamide. After stirring the reaction mixture for 24 h at 50 °C the mixture was poured into ice-water (150 ml) and the product was filtered by suction.

General Procedure for the Synthesis of 5-Chloro-tetrazolo [1,5-a]quinolines (5a–i)

Method A: To a suspension of the corresponding 2,4-dichloroquinoline (**2a–i**) (5 mmoles) and sodium azide (5 mmoles) in 30 ml of ethanol, 1 ml of methanesulfonic acid (in the case of **2f** 1 ml of trifluoroacetic acid) was added. After stirring the reaction mixture at 60 °C for the time given in table 3, the solution was allowed to cool to room temperature. The resulting precipitate was washed with water, filtered by suction and dried.

Table 1 Experimental, Spectral and Analytical Data of 4-Azido-2-chloroquinolines (**3a–i**)

Nr.	R^1	R^2	method: time [h] yield (%)	m.p. [°C] solvent	molecular formula (mol.mass)	Calcd. Found C	H	N	IR Spectral data (cm^{-1}) (N_3-signal)
3a	H	H	A: 4	95–96	$C_9H_5ClN_4$	52.83	2.46	27.31	2120 s
			97	ethanol	(204.6)	52.71	2.67	27.41	
3b	Ph	H	A: 24	104	$C_{15}H_9ClN_4$	64.18	3.23	19.91	2100 s
			88	ethanol	(280.7)	64.59	3.34	20.31	
3c	Ph	OCH_3	A: 24	123	$C_{16}H_{11}ClN_4O$	61.84	3.57	18.01	2120 s
			86	ethanol	(310.7)	62.24	3.87	17.71	
3d	CN	H	A: 36	137[a]	$C_{10}H_4ClN_4$	55.70	1.87	25.91	2190 s,
			91	ethanol	(215.6)	55.92	1.93	25.61	2150 w
3e	NO_2	H	A: 24	137–139	$C_9H_4ClN_5O_2$	43.31	1.62	27.61	2120 s
			88	ethanol	(249.6)	43.46	1.79	28.01	
3f	Cl	H	A: 24	119	$C_9H_4Cl_2N_4$	45.22	1.69	23.41	2110 s
			78	ethanol	(239.1)	45.08	1.78	23.19	
3g	CH_2Ph	H	B: 48	93–94	$C_{16}H_{11}ClN_4$	65.20	3.76	19.00	2100 s
			78	ethanol	(294.7)	64.95	4.00	18.71	
3h	OCH_3	H	B: 6	117	$C_{10}H_7ClN_4O$	51.19	3.01	23.81	2120 s
			77	ethanol	(234.7)	51.15	3.06	23.71	
3i	morpholino	H	B: 48	155	$C_{13}H_{12}ClN_5O$	53.89	4.18	24.17	2120 s
			79	ethanol	(289.7)	54.02	4.27	23.81	

a) **3d** (m.p. 136–138 °C) is described in ref. [27], however with inadequate analytical data (deviation 3–5 %).

Table 2 Experimental, Spectral and Analytical Data of 5-Azido-tetrazolo[1,5-a]quinolines (**4a–d, f**)

Nr.	R^1	R^2	method: time [h] yield (%)	m.p. [°C] solvent	molecular formula (mol.mass)	Calcd. Found C	H	N	IR Spectral data (cm^{-1}) (N_3-signal)
4a	H	H	A: 36	186	$C_9H_5N_7$	51.19	2.39	46.41	2120 s
			75	ethanol	(211.2)	51.35	2.71	46.15	
4b	Ph	H	A: 24	165	$C_{15}H_9N_7$	62.17	3.16	34.13	2120 s
			86	ethanol	(287.3)	62.54	3.11	34.01	
4c	Ph	OCH_3	A: 24	132	$C_{16}H_{11}N_7O$	60.57	3.49	30.91	2110 s
			84	ethanol	(317.3)	60.33	3.42	30.61	
4d	CN	H	B: 12	185[a]	$C_{10}H_4N_8$	50.85	1.70	47.41	2160 s,
			85	ethanol	(236.2)	50.98	1.83	47.19	2110 w
4f	Cl	H	C: 24	181	$C_9H_4ClN_7$	44.01	1.64	39.91	2120 s
			85	ethanol	(245.6)	44.32	1.77	40.31	

a) **4d** (m.p. 190 °C) is described in ref. [27], however with an irreproducible preparation procedure, which in our hands produces **3d**.

Method B: The tetrazoles **5g–i** were obtained as a mixture together with the azides **3g–i** (see method B of these compounds) by the reaction of 2,4-dichloroquinolines **2g–i** with sodium azide in dimethylformamide. Compounds **3** and **5** were separated by recrystallization. After separation of **3g–i** the mother liquor was taken to dryness i. vac. and the residue was recrystallized from the appropriate solvent.

4-Benzylaminoquinolones (6a, b, g)

These compounds were prepared from the corresponding 4-hydroxyquinolones (**1a, b, g**) and benzylamine according to ref. [10, 12].

4-Amino-2(1H)-quinolones (7a, b, g)

Method A: From 4-benzylamino-2-quinolones (**6a, b, g**) by catalytic debenzylation with hydrogen on palladium/charcoal (5 %) in glacial acetic acid according to ref. [10, 12].

Method B: A mixture of the appropriate 2-chloro-4-triphenylphosphoranylideneamino-quinoline (**8a, b, g**) (0.01 mol) in acetic acid (80 %, 30 ml) was heated under reflux for 8 h. After cooling to room temperature, water (20 ml) was added and the solution was extracted with ethylacetate (2 × 25 ml), The aqueous layer, which contains now the aminoquinolone, was evaporated to dryness i. vac. The resulting residue was

Table 3 Experimental, Spectral and Analytical Data of 5-Chloro-tetrazolo[1,5-a]quinolines (**5a–i**)

Nr.	R^1	R^2	method: time [h] yield (%)	m.p. [°C] solvent	molecular formula (mol.mass)	Calcd. Found C	H	N	IR Spectral data (cm^{-1}) tetrazole-signals
5a	H	H	A: 6 68	134 ethanol	$C_9H_5ClN_4$ (204.6)	52.83 53.12	2.46 2.73	27.31 27.16	1020 m, 1040 m, 1090 s
5b	Ph	H	A: 8 76	174 ligroin	$C_{15}H_9ClN_4$ (280.7)	64.18 64.41	3.23 3.28	19.91 19.71	1020 w, 1080 s, 1100 m
5c	Ph	OCH_3	A: 8 74	211 n-butanol	$C_{16}H_{11}ClN_4O$ (310.7)	61.84 61.74	3.57 3.43	18.01 17.91	1030 m, 1050 m, 1085 s
5d	CN	H	A: 8 77	226–227 ethanol	$C_{10}H_4ClN_5$ (229.6)	52.30 52.29	1.76 1.93	30.51 30.71	1020 m, 1040 m, 1075 s
5e	NO_2	H	A: 8 81	204 ethanol	$C_9H_4ClN_5O_2$ (249.6)	43.31 43.12	1.62 1.44	27.61 27.41	1030 m, 1050 m, 1100 s
5f	Cl	H	A: 24 87	195 ligroin	$C_9H_4Cl_2N_4$ (239.1)	45.22 45.46	1.69 1.66	23.41 23.81	1025 m, 1045 m, 1090 m
5g	CH_2Ph	H	A: 24 (73) B: 48 (20)	173 ligroin	$C_{16}H_{11}ClN_4$ (294.7)	65.20 65.51	3.76 4.08	19.0 19.14	1010 m, 1030 m, 1050 s
5h	OCH_3	H	A: 10 (73) B: 6 (16)	129 (ref. [28]: 131–133), ethanol					1020 m, 1075 s, 1095 m
5i	morpholino	H	A: 3 (75) B: 48 (15)	197 ligroin	$C_{13}H_{12}ClN_5O$ (289.7)	53.89 53.93	4.18 4.25	24.11 23.91	1030 m, 1060 s, 1110 m

Table 4 Experimental, Spectral and Analytical Data of 2-Chloro-4-triphenylphosphoranylideneamino-quinolines (**8a, b, g**) and 4-Chloro-2-(triphenylphosphoranylideneamino)-quinolines (**9b, i**)

Nr.	R^1	yield (%)	m.p. [°C] solvent	molecular formula (mol.mass)	Calcd. Found C	H	N	IR Spectral (cm^{-1})
8a	H	84	189 ethanol	$C_{27}H_{20}ClN_2P$ (438.9)	73.89 73.56	4.59 4.46	6.38 6.14	1570 s, 1540 s
8b	Ph	81	214 ethanol	$C_{33}H_{24}ClN_2P$ (515.0)	76.97 76.83	4.70 4.59	5.44 5.29	1530 s, 1490 s
8g	CH_2Ph	83	236 ethanol	$C_{34}H_{26}ClN_2P$ (529.0)	77.19 76.94	4.95 4.83	5.30 5.19	1530 s, 1480 s
9b	Ph	77	184 DMF	$C_{33}H_{25}ClN_2P$ (515.0)	76.96 76.86	4.69 4.73	5.44 5.38	3050 w, 1650 s, 1580 s, 1550 m
9i	morpholino	83	205 DMF	$C_{31}H_{27}ClN_3OP$ (524.0)	71.05 71.12	5.19 5.28	8.02 7.88	3050 w, 2950 w, 2850 w, 1605 m, 1605 m, 1565 m

triturated with diethylether (100 ml) and the precipitate was filtered and recrystallized.

4-Amino-2(1H)-quinolone (**7a**): yield: 83 %, m.p. 315 °C (n-butanol);

4-Amino-3-phenyl-2(1H)-quinolone (**7b**): yield: 76 %, m.p. 210 °C (ethanol);

4-Amino-3-benzyl-2(1H)-quinolone (**7g**): yield 46 %, m.p. 182 °C (ethanol); Analytical and spectral data are identical with the data in ref. [12].

General Procedure for the Synthesis of 2-Chloro-4-triphenylphosphoranylideneaminoquinolines (8a, b, g) and 4-Chloro-2-triphenylphosphoranylideneaminoquinolines (9b, i)

A solution of the appropriate 4-azido-2-chloroquinoline (**3a, b, g**) or 5-chloro-tetrazolo[1,5-a]quinoline (**5b, i**) (20 mmoles) and triphenylphosphane (9.1 g, 40 mmoles) in 50 ml of toluene (in the case of **3**) or 1,2-dichlorobenzene (in the case of **5**) was heated under reflux for the specified time. The solvent was removed i. vac., the residue was triturated with cyclohexane (100 ml) to remove excess triphenylphosphane, and after standing 24 h the product was filtered by suction and recrystallized from the appropriate solvent.

2-Amino-4-chloro-3-phenyl-quinoline (**10b**)

A mixture of 4-chloro-3-phenyl-2-(triphenylphosphoranylideneamino)-quinoline (**9b**) (5.15 g, 10 mmoles) in 0.5 N hydrochloric acid (100 ml) and methanol (20 ml) was heated under reflux for 2 h. After cooling to room temperature the precipitated triphenylphosphaneoxide was removed by filtration and the filtrate was brought up to pH 10 with 2 N sodium hy-

droxide solution. The resulting precipitate was filtered. Yield: 1.9 g (77 %), m.p. 196 °C (ethanol); IR: 3490 s, 3300 m, 3150 m, 1640 s, 1610 m cm^{-1}.

$C_{15}H_{11}ClN_2$	Calcd.:	C 70.73	H 4.35	N 11.00
(254.7)	Found:	C 70.64	H 4.50	N 10.76

2-Amino-4-chloro-3-morpholino-quinoline (**10i**)

4-Chloro-3-morpholino-2-(triphenylphosphoranylideneamino)-quinoline (**9i**) (5.24 g, 10 mmoles) was reacted with HCl using the procedure described for **10b**. Yield: 2.1 g (79 %), m.p. 222 °C (ethanol); IR: 3495 w, 3440 m, 3250–3050 w, 2960 w, 2340 m cm^{-1}.

$C_{13}H_{14}ClN_3O$	Calcd.:	C 59.20	H 5.35	N 15.93
(263.7)	Found:	C 59.10	H 5.36	N 15.72

5-Amino-tetrazolo [1,5-a] quinoline (**11a**)

A solution of 5-azido-tetrazolo[1,5-a]quinoline (**4a**) (2.1 g, 10 mmoles) in 50 ml of methanol was hydrogenated for 8 h in the presence of palladium (10 % on charcoal). After filtration the solvent was removed i. vac. and the residue was crystallized from n-butanol. Yield: 1.4 g (79 %), m.p. 258 °C dec. (n-butanol); IR: 3340 m, 3230 m, 1620 s, 1090 s, 1120 m, 1140 m cm^{-1}.

$C_9H_7N_5$	Calcd.:	C 58.36	H 3.81	N 37.82
(185.2)	Found:	C 58.38	H 4.02	N 37.90

2,4-Di-(triphenylphosphoranylideneamino)-quinoline (**12a**)

From 5-azido-tetrazolo[1,5-a]quinoline **4a** (2.1 g, 10 mmoles) and triphenylphosphane (11.4 g, 50 mmoles) using the general procedure described for **8** and **9**. Yield: 5.4 g (81 %), m.p. 274 °C (dimethylformamide); IR: 3040 w, 1610 s, 1540 m cm^{-1}.

$C_{45}H_{35}N_3P_2$	Calcd.:	C 79.51	H 5.19	N 6.18
(679.7)	Found:	C 79.34	H 5.04	N 5.98

2,4-Diamino-quinoline (**13a**)

2,4-Di-(triphenylphosphoranylideneamino)-quinoline (**12a**) (6.79 g, 10 mmoles) was hydrolyzed with 0.5 N hydrochloric acid (100 ml) and methanol (20 ml) using the procedure described for **10b**. Yield: 1.2 g (76 %), m.p. 312 °C (n-butanol), (lit. m.p. 308 °C [30]) IR: 3480–3230 w, 1650 s, 1590 m cm^{-1}.

$C_9H_9N_3$	Calcd.:	C 67.90	H 5.70	N 26.40
(159.2)	Found:	C 67.76	H 5.64	N 26.13

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