Reaction of chloropyridazin-3(2*H*)-ones with iodide ion. Part II

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Abstract

The reactions of 5-chloro-6-phenyl-,4,5-dichloro-6-phenyl- and 5-chloro-6-(2,4-dichlorophenyl)-2-methylpyridazin-3(2*H*)-ones with 57% aqueous hydrogen iodide or sodium iodide in dimethyl formamide, respectively, are described. Upon treatment of chloro compounds with 57% hydrogen iodide, besides nucleophilic substitution of chloro- by iodo substituent, subsequent hydrodeiodination also occurred. Thus, e.g. 4,5-dichloro-2-methyl-6-phenylpyridazin-3(2*H*)-one gave first 5-chloro-4-iodo-2-methyl-6-phenylpyridazin-3(2*H*)-one and in the next step, 5-chloro-2-methyl-6-phenylpyridazin-3(2*H*)-one. Similarly, treatment of 5-chloro-2-methyl-6-phenylpyridazin-3(2*H*)-one led to the formation of 5-iodo-2-methyl-6-phenylpyridazin-3(2*H*)-one and 2-methyl-6-phenylpyridazin-3(2*H*)-one. The structure of each new product was proved by ^{1}H, ^{13}C and partly by ^{15}N NMR spectroscopy.

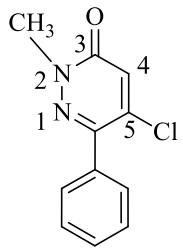
Keywords: 6-Phenyl-halopyridazin-3(2*H*)-ones, regiochemistry, nucleophilic substitution, dehalogenation, ^{15}N NMR

Introduction

Iodopyridazines are important representatives of halopyridazines.[1-3] Their simple and straightforward preparation is based on a nucleophilic halogen displacement reaction. This was carried out by the treatment of chloropyridazine have been treated with 57% hydrogen iodide,[4,5] hydrogen iodide with iodine monochloride[6] or hydrogen iodide with sodium iodide[7] as iodide source.

Some years ago we briefly reported on a similar reaction of 4,5-dichloro-2-methylpyridazin-3(2*H*)-one effected by 57% hydrogen iodide to afford 5-iodo-2-methylpyridazin-3(2*H*)-one,[2,8] the latter compound has been widely utilized for the preparation of fused pyridazines.[8-10, 11b] In a more recent paper, a detailed mechanistic study was also reported[11a]. It was supposed that formation of 5-iodo-2-methylpyridazin-3(2*H*)-one might proceed *via* nucleophilic substitutions of both chlorine atoms in positions 4 and 5 by iodine once, followed by selective mono deiodination reaction. Our DFT calculations suggested that the 5-iodo substituent might preferably facilitate the formation of a more stable anionic intermediate in the 4-hydrodeiodination reaction in comparison with the formation of the respective intermediate in the case of 5-hydrodeiodination. Fully in accord with this explanation, it was found that in case of the 6-nitro derivative, the regiochemistry of the reductive dehalogenation changed, resulting in the formation of a product with a different regioisomeric substitution pattern.

This rather interesting mechanism, and the high synthetic importance of monoiodopyridazinone derivatives prompted us to investigate these transformations further. In this paper, we report on the reactions of 6-phenyl-chloropyridazinones **1**-**3** with 57% hydrogen iodide or sodium iodide in dimethyl formamide (DMF), respectively, under various reaction conditions. The products (both in the crude reaction mixtures and after separation) were characterized by NMR spectroscopy and in pure form also by elemental analysis.



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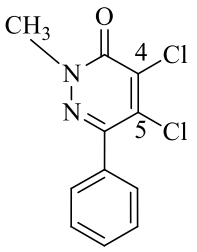

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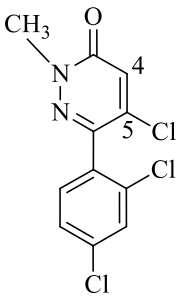

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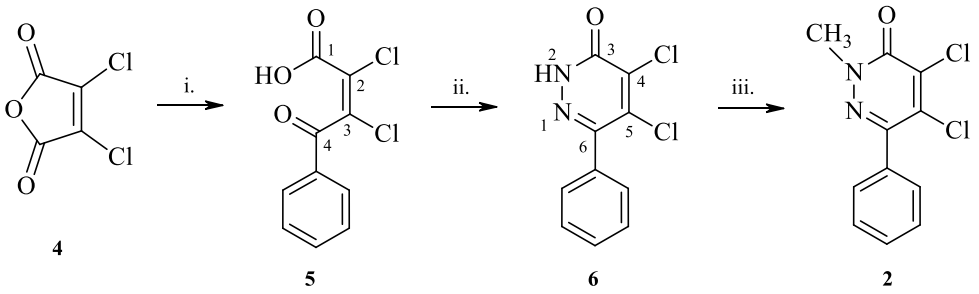
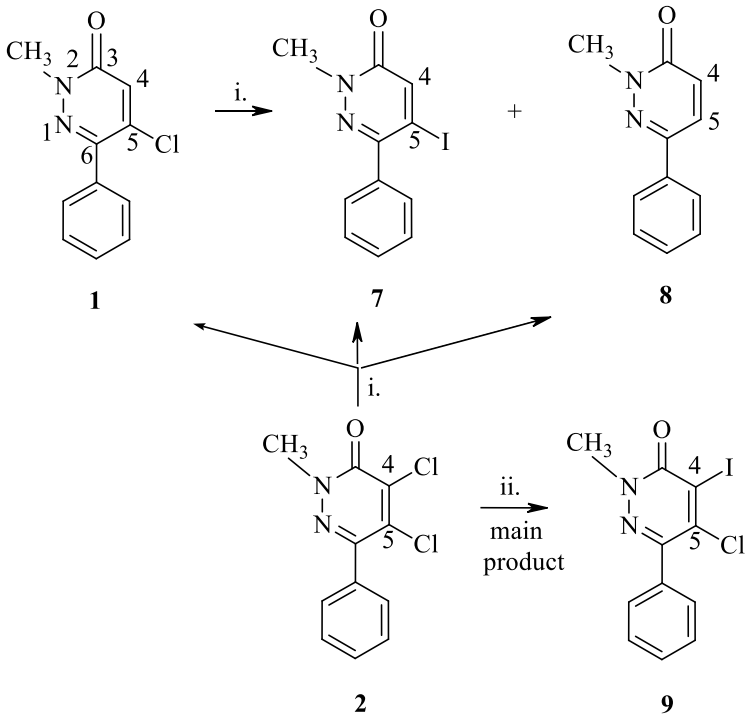
Results and Discussion

The starting 5-chloro-2-methyl-6-phenylpyridazin-3(2*H*)-one **1** and 5-chloro-6-(2,4-dichlorophenyl)-2-methylpyridazin-3(2*H*)-one **3** were prepared according to the literature[12-15] while 4,5-dichloro-2-methyl-6-phenylpyridazin-3(2*H*)-one **2** was obtained by *N*-methylation of 4,5-dichloro-6-phenylpyridazin-3(2*H*)-one **6** with dimethyl sulphate in methanol-water as solvent at room temperature. Compound **6** was reported previously,[16] however, no experimental details or spectral data were given. Thus, it was of interest to prepare this compound by the reaction of *Z*-2,3-dichloro-4-oxo-4-phenylbutenoic acid **5**[17] with hydrazine hydrate in boiling glacial acetic acid (Scheme 1).



Scheme 1. Synthesis of **2**. Reagents and conditions: i. $AlCl_3$, benzene, rt, 15 h (lit 17); ii. 99% N_2H_4 . H_2O, AcOH, reflux, 0.5 h; iii. Me_2SO_4, MeOH, NaOH-H_2O, rt, 24 h.

First, the reactions of 5-chloro-2-methyl-6-phenylpyridazin-3(2*H*)-one **1** with HI were studied (Scheme 2). Heating **1** with 57% hydrogen iodide at 155 °C for 25-160 hours (Table 1) afforded various mixtures of the substitution product 5-iodo-2-methyl-6-phenylpyridazin-3(2*H*)-one **7** and the deiodinated 2-methyl-6-phenylpyridazin-3(2*H*)-one **8** containing small amounts of unreacted starting compound **1** as determined by NMR.



Scheme 2. Treatment of **1** and **2** with HI. Reagents and conditions: i. 57% HI, 155 °C, 25-160 h; ii. 57% HI, 120 °C, 2 h.

Prolonged heating led to higher amounts of the deiodinated product **8** on the account of the primary substitution product **7** in the crude product mixtures (Table 1) indicating that reductive dehalogenation of chloro compound **1** is faster than nucleophilic substitution of chlorine by iodine. The percentage of **8** was always found to be greater than that of **7** in the product mixture.

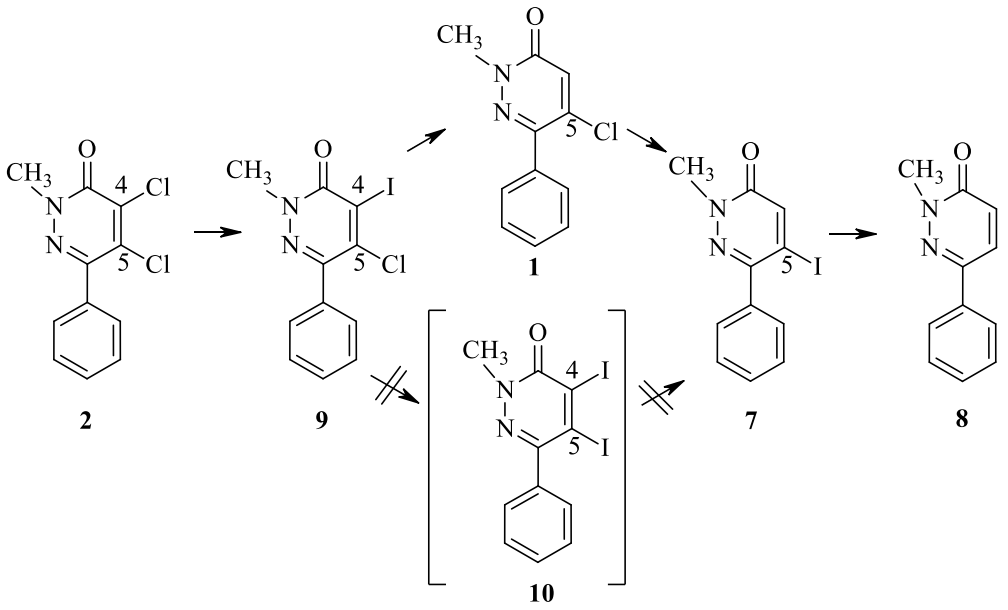
Table 1. Relative ratios of compounds **1** and **7**-**9** in the crude products, versus temperature and reaction time

Starting compounds	Reaction conditions	Products [%]			
		7	**8**	**9**	**1**
1	155 °C, 25h	34	50	-	16
	155 °C, 48h	30	62	-	8
	155 °C, 65h	12	84	-	4
	155 °C, 160h	4	94	-	2
2	120 °C, 2h	-	-	82	18
	140 °C, 2h	12	-	3	85
	155 °C, 2h	11	-	-	89
	155 °C, 25h	36	6	-	58

Flash chromatography of the crude product mixture yielded 2-methyl-6-phenylpyridazin-3(2*H*)-one **8** in pure state and an inseparable mixture of **1** and **7**, since the latter two compounds possess very close R_f values. However, **7** could be characterized by NMR as the data for **1** are available.

Upon heating 4,5-dichloro-2-methyl-6-phenylpyridazin-3(2*H*)-one **2** with 57% hydrogen iodide at different temperatures for various periods of time (Table 1) the reaction temperature was found to influence the composition of the product mixture to a larger extent than the reaction duration (Scheme 4). At a moderately high temperature (120 °C) and for a short reaction time (2h) the substitution of chlorine- by iodine atom in position 4 was predominant, the main product was 5-chloro-4-iodo-2-methyl-6-phenylpyridazin-3(2*H*)-one **9**. It is noted that 5-chloro-4-iodopyridazinones were prepared earlier by Stevenson et al.[18] and Haider et al.[19] starting from 3-chloro-2-iodomalealdehydic acid.[20] At a somewhat higher temperature (140 °C) a dramatic change occurred and the 4-deiodinated 5-chloro-2-methyl-6-phenylpyridazin-3(2*H*)-one **1** was the main product. A further increase of the temperature to 155 °C did not bring about substantial

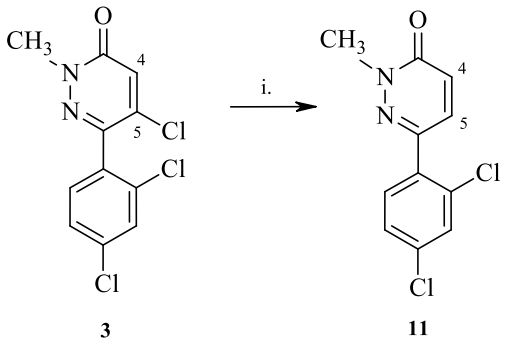
changes but prolonged heating resulted in a considerable increase in the amount of the substitution product 5-iodo-2-methyl-6-phenylpyridazin-3(2*H*)-one **7**. This observation supports the idea, that the 5-chloro-4-iodo derivative **9** might be the first intermediate in the reaction pathway starting from **2**. The higher temperatures and the longer reaction time are favourable for the deiodination of **9** although the main product remains the 5-chloro-2-methyl-6-phenylpyridazin-3(2*H*)-one **1** even after heating at 155 °C for 25 hours. The experiments starting with **1** and **2** (Table 1) indicate that the iodine atom at position 4 exhibits an enhanced tendency toward reduction by hydrodeiodination. While the rate of substitution of the chlorine atom at position 5 in compound **1** is very low deiodination of **7** is faster.



Scheme 3. Proposed pathway for the formation of 2-methyl-6-phenylpyridazin-3(2*H*)-one **8** from 5-halo- or 4,5-dihalo-derivatives.

The reaction sequence proposed for the transformations of chloro substituted phenylpyridazinones **1** and **2** is depicted in Scheme 3. Noticeably, that, in contrast with earlier assumptions, 4,5-diiodo-6-phenylpyridazin-3(2*H*)-one **10** could not be detected, which means that its formation is possible only as a reactive intermediate undergoing very fast conversion to 5-iodo-6-phenylpyridazin-3(2*H*)-one **7**.

As another model compound 5-chloro-6-(2,4-dichlorophenyl)-2-methylpyridazin-3(2*H*)-one (**3**) was heated with hydrogen iodide at 150 °C. After 60 hours 6-(2,4-dichlorophenyl)-2-methylpyridazin-3(2*H*)-one **11** was obtained in a yield of 52% (Scheme 4), other congeners could not be detected in the crude reaction mixture. Thus, under these conditions **3** underwent nucleophilic substitution and subsequent dehalogenation affording **11** while, as expected, the chloro substituents on the phenyl ring did not take part in these reactions.



3 **11**

Scheme 4. Treatment of **3** with HI. Reagent and condition: i. 57% HI, 150 ºC, 60 h.

In an alternative series of the displacement reactions sodium iodide was applied as iodine source. Thus, compounds **1**-**3** were heated with NaI in dimethyl formamide (DMF) at 150 °C for 60 hours. Under these conditions the 5-monochloro compounds **1** and **3**, remained practically unchanged while 4,5-dichloro-6-methyl-2-phenylpyridazin-3(2*H*)-one **2** gave a multicomponent mixture. These results are consistent with our earlier obsevations[11] that, contrary to monochloropyridazinone derivatives, only 4,5-dichloropyridazinones are reactive enough to interact with sodium iodide. The situation with 57% hydrogen iodide is different because under strongly acidic conditions the pyridazinone derivatives are expected to be activated by protonation at the carbonyl oxygen. The preferred *O*-protonation of pyridazinones has been evidenced by experimental and theoretical studies[21] on compounds related to our present model compounds. The enhanced electron-deficiency of the cationic intermediates facilitates the attack of iodide ion making possible the substitution reactions of monochloropyridazinones, too.

Conclusions

By using hydrogen iodide, chloropyridazinones could be converted into iodo derivatives which underwent a reductive deiodination reaction. The regiochemistry of the substitution is independent of the 6-phenyl substituent. Eventual chloro substituents on the phenyl ring were not replaced by iodine. In the case of 4,5-dichloro-6-phenylpyridazinone, the first step is the displacement of the 4-chloro atom by iodine. Our results indicate that dichloropyridazinones could be transformed into monoiodopyridazinones with a predictable regiochemistry. Unfortunately, due to the presence of the phenyl ring, the substitution of the 5-chloro atom is rather slow, and the subsequent reductive deiodination reduction may proceed to completion. This is why the reaction mixtures can be more complex than in case of 6-hydrogen or 6-nitro pyridazinone derivatives studied earlier, and monoiodopyridazinones important from the

synthetic aspects cannot be isolated in pure form. As main products halogen-free pyridazinone derivatives are formed. On the other hand, when using sodium iodide as an iodide ion source, reaction occurred only in the case of a 4,5-dichloropyridazinone but gave a very complex mixture.

Experimental Section

General. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker AM 200 (^{1}H NMR 200 MHz; ^{13}C NMR 50 MHz), a Bruker DRX 500 (^{1}H NMR 500 MHz, ^{13}C NMR 125 MHz) or a Varian MERCURYplus spectrometer (^{1}H NMR 400 MHz; ^{13}C NMR 100 MHz) in the solvents indicated at room temperature, using the ^{2}H signal of the solvent as the lock, and TMS as the internal standard. The assignments of ^{13}C- NMR spectra were supported by DEPT-135 spectra. Chemical shifts are given in ppm and coupling constants (*J*) are given in Hz. The ^{15}N NMR spectrum was recorded on the Bruker DRX 500 instrument (50 MHz, liq. NH_3). Melting points were determined in a Büchi Melting Point B-540 apparatus, and the values given in ^{o}C are uncorrected. IR spectra were recorded in potassium bromide pellets on a Perkin-Elmer 1600 FT-IR spectrophotometer. The elementary analyses (C, H, N) were performed on a Carlo Erba Elemental Analyzer Model 1012 apparatus. For standard flash chromatography, Kieselgel 60 (Aldrich; 0.040-0.063 mm) was used. Thin layer chromatography was performed on commercially available silica plates (Silica gel 60 F_{254}, Merck).
Commercially available solvents were purified by standard procedures prior to use, whereas reagents (Reanal, Budapest, or Sigma-Aldrich Kft., Budapest) were used as received. Solvents were dried and distilled prior to use. Organic extracts were dried over anhydrous sodium sulphate.
The constitution of each new compound was in full agreement with their NMR spectroscopic data. In some cases, ^{1}H-^{13}C heteronuclear chemical shift correlation measurements were also carried out to provide an unambiguous proof for the assignment of the structures.
After transformations of the chloro substituted 2-methyl-6-phenylpyridazin-3(2*H*)-ones the crude product mixtures were analyzed by ^{1}H NMR. The components were identified by using the signals' shifts and their ratios were calculated from the peaks of the *N*-methyl groups and the proton(s) of the pyridazinone rings. Assignation of the signals of each component in the mixtures was confirmed by a careful comparison with those of the isolated and/or synthesized compounds.
All new compounds gave satisfactory elemental analysis.
The following compounds were synthesized by literature procedures cited: 5-chloro-2-methyl-6-phenylpyridazin-3(2*H*)-one **1,**[12-14] 5-chloro-6-(2,4-dichlorophenyl)-2-methylpyridazin-3(2*H*)-one **3**[15] and *Z*-2,3-dichloro-4-oxo-4-phenylbutenoic acid **5**.[17]

Characterization of known 5-chloro-2-methyl-6-phenylpyridazin-3(2*H*)-one (1).[12-14] Mp: 140-141 ^{o}C (Mp lit. 135-137 ^{o}C[14]); R_f (chloroform): 0.52; IR (KBr) ν_{max}: 3060, 1666, 1582,

1570, 1492, 1444, 1404, 1382, 1304, 1256, 1088, 1004, 972, 884, 764, 706 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): 7.56 (m, 2H, H-2' and -6'), 7.47 (m, 3H, H-3', -4' and -5'), 7.12 (s, 1H, H-4), 3.83 (s, 3H, NC*H*$_3$); H' are phenyl protons. ^{13}C NMR (125 MHz, $CDCl_3$): 159.1 (C-3), 145.0 (C-6), 139.6 (C-5), 133.6 (C-1'), 129.5 (C-4'), 129.1 (C-3' and -5'), 128.3 (C-2' and -6', C-4), 40.0 (N*C*H$_3$); C' are phenyl carbons; ^{15}N NMR (50 MHz, $CDCl_3$): 341 (N-1), 205 (N-2).

4,5-Dichloro-2-methyl-6-phenylpyridazin-3(2*H*)-one (2)

Step A. 4,5-Dichloro-6-phenylpyridazin-3(2*H*)-one (6).[16] A three-neck, round-bottom flask equipped with a reflux condenser, thermometer and dropping funnel was charged with *Z*-2,3-dichloro-4-oxo-4-phenylbutenoic acid **5**[17] (193.0 mmol), and glacial acetic acid (90 mL). The funnel was charged with 99 % hydrazine monohydrate (24.0 mL, 500.0 mmol). The reaction mixture was heated to 60 °C and hydrazine monohydrate was added dropwise during 15 minutes. Subsequently, the resulting mixture was heated under reflux for 30 minutes. After cooling, the solid precipitate was filtered off and washed first with diethyl ether (50 mL) then with water (50 mL) to yield the crude title compound that was purified by crystallization from ethanol. Yield: white crystals, 29.0 g, 62 %, mp 236-238 °C. R_f (toluene – methanol 4:1): 0.48; IR (KBr) ν_{max}: 3422, 2974, 2914, 1656, 1560, 1232, 1130, 1058, 950, 698, 610, 532 cm^{-1}. ^1H NMR (200 MHz, DMSO-d_6): 7.60-7.45 (m, 5H, phenyl protons), 3.35 (s, 1H, N*H*). ^{13}C NMR (50 MHz, DMSO-d_6): 156.2 (C-3), 144.8 (C-6), 136.9 (C-5), 134.3 (C-4), 134.1 (C-1'), 129.3 (C-4'), 129.1 (C-3' and -5'), 128.1 (C-2' and -6'); C' are phenyl carbons. Anal. Calcd. for $C_{10}H_6Cl_2N_2O$ (241.08): C, 49.82; H, 2.51; N, 11.62. Found: C, 49.66; H, 2.26; N, 11.73.

Step B. 4,5-Dichloro-2-methyl-6-phenylpyridazin-3(2*H*)-one (2). A two-neck, round-bottom flask equipped with a drying tube and a dropping funnel was charged with 4,5-dichloro-6-phenylpyridazin-3(2*H*)-one **6** (49.8 mmol), methanol (84 mL) and a solution of sodium hydroxide (2.20 g, 55.3 mmol) in water (84 mL). The funnel was charged with 97 % dimethyl-sulphate (5.20 mL, 54.70 mmol). The reaction mixture was cooled to 10 °C and dimethyl sulphate was added dropwise during 20 minutes. Subsequently, the resulting mixture was stirred at ambient temperature for 24 hours. The suspension was evaporated to half volume and extracted with toluene (4x200 mL). The combined organic layers were washed first with 2*M* sodium hydroxide (200 mL) and then with water (2x200 mL). The organic phase was dried, filtered and the solvent was evaporated *in vacuo*. The crude product was purified by flash chromatography followed by recrystallization from acetone. Yield: white crystals, 8.90 g, 70 %, mp 186-187 °C; R_f (toluene – methanol 3:1): 0.69; IR (KBr) ν_{max}: 1662, 1568, 1498, 1444, 1364, 1028, 968, 890, 704 cm^{-1}. ^1H NMR (200 MHz, $CDCl_3$): 7.57-7.46 (m, 5H, phenyl protons), 3.88 (s, 3H, NCH_3). ^{13}C NMR (50 MHz, $CDCl_3$): 156.1 (C-3), 144.8 (C-6), 136.8 (C-5), 135.1 (C-4), 133.8 (C-1'), 129.6 (C-4'), 129.1 (C-3' and -5'), 128.3 (C-2' and -6'), 41.1 (N*C*H$_3$); C' are phenyl carbons. Anal. Calcd. for $C_{11}H_8Cl_2N_2O$ (255.10): C, 51.79; H, 3.16; N, 10.98. Found: C, 51.75; H, 3.07; N, 10.93.

General procedure for the reactions with hydrogen iodide

A round-bottom flask was charged with the 2-methyl-6-phenyl-halopyridazin-3(2*H*)-one derivative **1**, **2** or **3** (1.2 mmol), and 57% HI (3.50 mL). The mixture was heated at the temperature and for the period given in Table 1. After cooling, the mixture was poured onto ice-water (about 45 mL) and was neutralized with K_2CO_3. To the suspension, solid sodium thiosulfate was added at 40 °C, until the suspension turned pale brown followed by extraction with dichloromethane (3x30 mL). The organic phase was dried over $MgSO_4$ and after filtration the solvent was evaporated *in vacuo* to dryness. The crude product was analysed by ^{1}H NMR.

5-Iodo-2-methyl-6-phenylpyridazin-3(2*H*)-one (7). Flash chromatography (eluent: chloroform) of a crude product containing **1**, **7** and **8** yielded, along with pure **8**, a mixture of **1** and **7**. The latter was identified by NMR, using the known spectral data of **1**. R_f (chloroform): 0.52. ^{1}H NMR (200 MHz, $CDCl_3$): 7.73 (s, H-4), 7.57-7.47 (m, phenyl protons), 3.79 (s, NCH_3). ^{13}C NMR (50 MHz, $CDCl_3$): 158.1 (C-3), 148.2 (C-6), 139.8 (C-4), 136.9 (C-1'), 129.3 (C-3' and -5'), 129.1 (C-4'), 128.0 (C-2' and -6'), 105.9 (C-5), 40.0 (N*C*H$_3$); C' are phenyl carbons; ^{15}N NMR (50 MHz, $CDCl_3$): 337 (N-1), 204 (N-2).

2-Methyl-6-phenylpyridazin-3(2*H*)-one (8).[14] An analytical sample was isolated from a crude product by flash chromatography, see above. Mp 111-113 ºC (Mp lit. 112-113 ºC[14]); R_f (chloroform): 0.27; IR (KBr) ν_{max}: 3036, 2930, 1660, 1590, 1574, 1512, 1498, 1442, 1394, 1324, 1276, 1176, 854, 772, 694, 600 cm^{-1}. ^{1}H NMR (200 MHz, $CDCl_3$): 7.71-7.60 (m, 2H, H-2' and -6'), 7.69 (d, *J* = 10, 1H, H-5), 7.45-7.42 (m, 3H, H-3', -4' and -5'), 7.03 (d, *J* = 10, 1H, H-4), 3.89 (s, 3H, NC*H*$_3$); H' are phenyl protons. ^{13}C NMR (50 MHz, $CDCl_3$): 160.1 (C-3), 144.4 (C-6), 134.7 (C-1'), 130.2, 129.7 and 129.4 (C-4, -5 and -4'), 128.9 and 125. 8 (C-2', -3', -5' and -6'), 40.6 (N*C*H$_3$); C' are phenyl carbons. Anal. Calcd. for $C_{11}H_{10}N_2O$ (186.21): C, 70.95; H, 5.41; N, 15.04. Found: C, 70.66; H, 5.50; N, 14.68.

5-Chloro-4-iodo-2-methyl-6-phenylpyridazin-3(2*H*)-one (9). A crude product containing **9** and **1** (molar ratio: 82:18 by NMR) was recrystallized from acetone to afford the title compound as brown crystals (yield: 60%). Mp 221-222 °C; R_f (toluene – methanol 3:1): 0.64; IR (KBr) ν_{max}: 3046, 1650, 1552, 1496, 1442, 1404, 1354, 1282, 1020, 962, 774, 752, 700, 598 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): 7.52-7.45 (m, 5H, phenyl protons), 3.89 (s, 3H, NC*H*$_3$); ^{13}C NMR (125 MHz, $CDCl_3$): 158.3 (C-3), 144.9 (C-5), 144.5 (C-6), 111.5 (C-4), 134.3 (C-1'), 129.6 (C-4'), 129.2 (C-3' and -5'), 128.3 (C-2' and -6'), 41.6 (N*C*H$_3$); C' are phenyl carbons. Anal. Calcd. for $C_{11}H_8ClIN_2O$ (346.55): C, 38.12; H, 2.32; N, 8.08. Found: C, 38.40; H, 2.16; N, 8.04.

6-(2,4-Dichlorophenyl)-2-methylpyridazin-3(2*H*)-one (11). The crude product was purified by flash chromatography, using chloroform – ethyl acetate (95:5) as eluent to produce the title compound as pale yellow crystals (yield: 52 %). Mp 171-172 ºC; R_f (chloroform – ethyl acetate 95:5): 0.27; IR (KBr) ν_{max}: 3446, 3040, 2928, 1698, 1592, 1476, 1374, 1268, 1102, 992, 858, 812, 758 cm^{-1}. ^{1}H NMR (200 MHz, $CDCl_3$): 7.50 (d, *J*=10, 1H, H-5), 7.44 (d, *J* = 2, 1H, H-3'), 7.43 (d, *J* = 8, 1H, H-6'), 7.35 (dd, J_1 = 8, J_2 = 2, 1H, H-5'), 6.97 (d, *J* = 10, 1H, H-4), 3.84 (s, 3H, C*H*$_3$); H' are phenyl protons. ^{13}C NMR (50 MHz, $CDCl_3$): 159.8 (C-3), 143.3 (C-6), 136.9 (C-1'), 133.4 (C-5), 133.1 (C-2', and -4'), 131.7, 129.9, 128.4 and 127.7 (C-4, -3', -5' and -6'),

40.4 (*C*H_3); C' are phenyl carbons. Anal. Calcd. for $C_{11}H_8Cl_2N_2O$ (255.10): C, 51.79; H, 3.16; N, 10.98. Found: C, 51.64; H, 3.03; N, 10.90.

Reactions with sodium iodide

The chloro substituted 2-methyl-6-phenyl-pyridazin-3(2*H*)-one **1**, **2** or **3** (10.0 mmol) was dissolved in DMF (20 mL), sodium iodide (3.0 g, 20.0 mmol) was added and the solution was heated under reflux for 1 hour. Sodium iodide (1.50 g, 10.0 mmol) was again added and the mixture was refluxed for 1 hour. After addition of another 1.50 g portion of sodium iodide the mixture was refluxed for a total of 60 hours. Then DMF was removed *in vacuo*, an aqueous solution (10%) of sodium thiosulfate was added to the residue until the colour of iodine disappeared. The solution was extracted with chloroform (4x30 mL), the combined organic layers were dried, filtered and the solvent was evaporated. The obtained crude product was analysed by ^{1}H NMR. **1** and **3** were found practically unchanged, yields of recovery: 80% and 85%, resp., while starting with **2** a multicomponent mixture was formed.

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