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Short Note

3,6-Dibromopyridazine-4,5-diamine

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Abstract: Dihalogenated derivatives of 1,2,5-chalcogenadiazoles fused with benzene or heterocyclic rings are of interest as starting compounds for photovoltaic materials. The 1,2,5-chalcogenadiazole ring in these heterocycles was most commonly prepared from the corresponding *ortho*-diamine moiety. In this communication, 3,6-dibromopyridazine-4,5-diamine was prepared via the reaction of 4,7-dibromo[1,2,5]thiadiazolo[3,4-*d*]pyridazine with sodium methoxide in THF by heating at reflux for four hours. The structure of the newly synthesized compound was established by means of high resolution mass-spectrometry, ^{1}H, ^{13}C-NMR and IR spectroscopy, and mass-spectrometry.

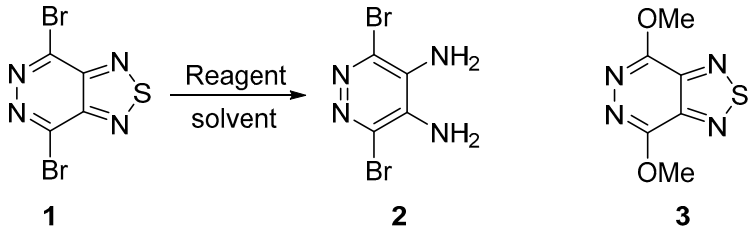
Keywords: 3,6-dibromopyridazine-4,5-diamine; 1,2,5-thiadiazole; sodium methoxide; reduction

1. Introduction

1,2,5-Chalcogenadiazoles fused with benzene or heterocyclic rings are intensively used in the construction of various photovoltaic materials such as organic solar cells (OSCs) and organic light emitting diodes (OLEDs) [1–7]. 4,7-Dibromo-2,1,3-benzothia/selenadiazoles, [1,2,5]thia/selena[3,4-*c*]pyridines are the most convenient precursors for the synthesis of photoactive materials [8]. 1,2,5-Thia(selena, tellura)diazole cycle can be easily formed from the *ortho*-diamine moiety of 3,6-dibromobenzene-1,2-diamine and 2,5-dibromopyridine-3,4-diamine [9]. Recently the synthesis of 4,7-dibromo[1,2,5]thiadiazolo[3,4-*d*]pyridazine **1** has been reported [10] with the formation of the thiadiazole ring in the early steps. Meanwhile, other 4,7-dibromo[1,2,5]chalcogenadiazolo[3,4-*d*]pyridazines are still unknown due to unavailability of 3,6-dibromopyridazine-4,5-diamine precursor. Although the homologous 3,6-dichloropyridazine-4,5-diamine is described in the literature [11], its synthesis is multistage and the yields were not given. Herein, we report the synthesis of 3,6-dibromopyridazine-4,5-diamine **2**.

2. Results and Discussion

Recently, we have shown that 4,7-dibromo[1,2,5]thiadiazolo[3,4-*d*]pyridazine **1** can be safely and efficiently prepared from the commercial diaminomaleonitrile [12]. Herein, we examined the reduction of this compound (Scheme 1).



1 **2** **3**

Scheme 1. Synthesis of 3,6-dibromopyridazine-4,5-diamine **2**.

Sodium borohydride ($NaBH_4$) or lithium aluminum hydride (LAH) were commonly used in the reductive cleavage of the 1,2,5-thiadiazole ring to *ortho*-diamine moiety [13]. We found that the treatment of pyridazine **1** with $NaBH_4$ in EtOH in the presence of catalytic $CoCl_2 \cdot 6H_2O$ or with LAH in THF at reflux led to full decomposition of the starting material. Apparently, pyridazine **1** was found to be very sensitive to strong reducing agents. During our investigation of the nucleophilic substitution in 4,7-dibromo[1,2,5]thiadiazolo[3,4-*d*]pyridazine **1** by alkoxide anions we observed the formation of the new compound as a side product which was proved by mass-spectrometry to be 3,6-dibromopyridazine-4,5-diamine **2**. We showed that the treatment of **1** with sodium methoxide in MeOH led to the formation of bis(methoxy) derivative **3** [12] with a traces of diamine **2** (Entry 3). To develop the synthetic approach to the target compound **2** we investigated this reaction in other solvents. The best yield was achieved after refluxing in THF for 3 h (Entry 4). The use of acetonitrile with higher (Entry 5) boiling point did not improve the yield of the target diamine **2**. The results are summarized in Table 1.

Table 1. Reaction of 4,7-dibromo[1,2,5]thiadiazolo[3,4-*d*]pyridazine **1** with reducing agents.

Entry	Solvent	Reagent	Temperature, °C	Time, h	Yield, %	
					2	**3**
1	EtOH	$NaBH_4CoCl_2 \cdot 6H_2O$ (cat.)	**78**	3	0	0
2	THF	LAH	66	3	0	0
3	MeOH	MeONa	64	5	traces	70
4	THF	MeONa	66	4	60	0
5	MeCN	MeONa	81	4	55	0

The structure of diamine **2** was strictly confirmed by means of high resolution mass-spectrometry, ^1H, ^{13}C-NMR and IR spectroscopy, and mass-spectrometry.

In conclusion, unexpected synthesis of 3,6-dibromopyridazine-4,5-diamine **2** from the corresponding fused 1,2,5-thiadiazole derivative **1** was discovered. This method may open new possibilities for reductive cleavage of the 1,2,5-thiadiazole ring fused with electron-accepting rings and containing functional derivatives.

3. Experimental Section

3.1. General Information

4,7-Dibromo[1,2,5]thiadiazolo[3,4-*d*]pyridazine **1** was prepared according to the published method [12]. Melting point was determined on a Kofler hot-stage apparatus and is uncorrected. ^1H and ^{13}C-NMR spectra were taken with a Bruker AM-300 machine (Bruker AXS Handheld Inc., Kennewick, WA, USA) (at frequencies of 300.1 and 75.5 MHz, respectively) in acetone-d_6 solution, with TMS as the standard. MS spectrum (EI, 70 eV) was obtained with a Finnigan MAT INCOS 50 instrument (Hazlet, NJ, USA). IR spectrum was measured with a Specord M-80 instrument (Carl Zeiss, Jena, Germany) in KBr pellet. High-resolution MS spectrum was measured on a Bruker micrOTOF II instrument (Bruker Daltonik Gmbh, Bremen, Germany) using electrospray ionization (ESI). The measurement was performed in a positive ion mode (interface capillary voltage −4500 V) or in a negative ion mode

(3200 V); mass range was from m/z 50 to m/z 3000 Da; external or internal calibration was done with Electrospray Calibrant Solution (Fluka). Syringe injection was used for solutions in acetonitrile, methanol, or water (flow rate 3 L·min^{-1}). Nitrogen was applied as a dry gas; interface temperature was set at 180 °C.

3.2. Synthesis of 3,6-Dibromopyridazine-4,5-diamine **2**

4,7-Dibromo[1,2,5]thiadiazolo[3,4-*d*]pyridazine **1** (40 mg, 0.13 mmol) was added to a solution of MeONa (18 mg, 0.32 mmol) in dry THF (3 mL) with stirring. The reaction mixture was stirred under reflux for 4 h. On completion (monitored by TLC), the mixture was poured into water and extracted with EtOAc (3 × 100 mL). The combined organic layers were washed with brine, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was subjected to column chromatography on silica gel (Silica gel Merck 60, eluent: EtOAc–CH_2Cl_2, 1:5, v/v). Yield 22 mg (60%), white solid, mp > 250 °C, R_f = 0.5 (CH_2Cl_2/EtOAc, 2:1, v/v). IR spectrum, ν, cm^{-1}: 3426, 3329, 3258, 3195, 3124, 1655, 1639, 1619, 1543, 1516, 1349, 1285, 1086, 907, 678, 669, 600. ^{1}H-NMR (ppm): δ 5.60 (s, 4H). ^{13}C-NMR (ppm): δ 136.0, 139.8. HRMS (ESI-TOF), m/z: calcd for $C_4H_5{}^{79}Br_2N_4$ $[M + H]^+$, 266.8875, found, 266.8869. MS (EI, 70eV), m/z (I, %): 270 ($[M + 2]^+$, 48), 269 ($[M + 1]^+$, 30), 268 (M^+, 98), 267 ($[M - 1]^+$, 50), 108 (20), 81 (85), 53 (100).

Supplementary Materials: The following are available online, ^{1}H, ^{13}C-NMR, IR and mass-spectra for the compound **2** are available online.

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Conflicts of Interest: The authors declare no conflict of interest.

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