A novel and efficient method for the synthesis of dibenzyl diselenides

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A novel and efficient method for the synthesis of dibenzyl diselenides is described. Aromatic aldehydes were reduced *via* selenation with Se/CO/H_2O in DMF under atmospheric pressure to give dibenzyl diselenides in high yields.

Keywords: dibenzyl diselenides

Organoselenium compounds have received considerable attention as useful synthetic reagents and intermediates in organic synthesis. Among these, dibenzyl diselenides are not only versatile intermediates for other organoselenium compounds but are also used in solid phase dispersion of photoconductive materials,[1] inhibition of oxidation of xenobiotics and procarcinogens,[2] and acceleration of vulcanisation of nitrile rubber.[3]

Synthetic routes to dibenzyl diselenides are various. For example, dibenzyl diselenides can be prepared from Grignard reagents,[4] sulfonic esters,[5] and by reaction of sodium hydrogen selenide with N-substituted 1-benzotriazoylbenzyl amines in ethanol.[6] Wang also reported a convenient synthetic method for dibenzyl diselenides with benzyl halides under phase transfer conditions.[7] In addition, carbonyl compounds are potentially attractive starting materials for such syntheses. Both Margolis[8] and Cohen[9] reported that treatment of carbonyl compounds with hydrogen selenide generated from the reaction of Al_2Se_3 and water gave dibenzyl diselenides in the presence of triethylamine. Lewicki[10] reported the synthesis of dibenzyl diselenides from aromatic aldehydes with sodium hydrogen selenide in the presence of amine and sodium borohydride, Huang[11] also reported that aromatic aldehydes reacted with selenium and sodium borohydride to afford dibenzyl diselenides. Sonoda discovered that elemental selenium can be readily reduced by carbon monoxide and water in the presence of organic base to produce hydrogen selenide which was successfully applied to the synthesis of aliphatic diselenides from both aliphatic ketones and aldehydes under high pressure of CO (3.0 MPa), high temperature (120 °C) and long reaction times (24 h).[12]

However, most of the known methods for preparation of diselenides suffer from disadvantages such as using strong reducing agents and highly toxic gases, harsh reaction conditions, low yields, or complicated manipulations.

In our previous work, we developed a new application of the Se/CO/H_2O/DMF system by which aromatic nitro compounds are reduced to the corresponding aromatic amines[13,14] under atmospheric pressure. On this basis, we investigated reactions of aromatic aldehydes with stoichlometric selenium under similar conditions and found that these reactions afforded dibenzyl diselenides in high yields in the presence of base (Eqn 1). Herein we report a novel and efficient synthesis of dibenzyl diselenides by the Se/CO/H_2O/DMF system at atmospheric pressure (reaction (1)).

When **1a** was treated with selenium, carbon monoxide (bubbling) ,water and, NaOAc in DMF solution at 95°C for 7 h, the reductive selenation of **1a** occurred efficiently to give dibenzyl diselenide (**2a**) in 94% yield (entry 1 in Table 1). Under amtospheric pressure we investigated the effect of different bases in DMF, some of the results are shown in Table 1. As is seen in Table 1, the inorganic base NaOAc is the best additive reagent for this reaction (entries 1–11 in Table 1). Other substituted benzaldehydes were also investigated and the results are summarised in Table 2. From Table 2 we can see that diselenide products were obtained in high yields (78–94%) (Table 2, entries 1–8). Increasing steric hindrance on the phenyl rings of the substrates obviously decreased yields of the products, for 4-chlorobenzaldehyde, the yield (53%) was decreased owing to the formation of other by-products (entry 9 in Table 2). However, neither salicylaldehyde nor 4-hydroxybenzaldehyde gave the corresponding diselenide (entries 10 and 11 in Table 2). During the reaction, no monoselenides or alcohols were detected.

Table 1 Reductive selenation of benzaldehyde **1a** to dibenzyl diselenide **2a** under various bases

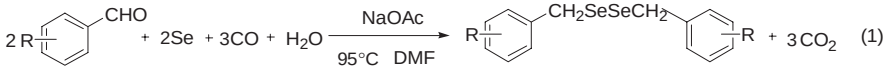
Entry	Base	Yields/%[b]
1	NaOAc	94
2	KOAc	51
3	KOH	73
4	NaOH	84
5	Na_2CO_3	25
6	K_2CO_3	47
7	$NaHCO_3$	53
8	Et_3N	90
9	DBU	76
10	Pydine	92
11	2- Picoline	53

[a]Reaction conditions: benzaldehyde (2.5 mmol); Se (2.5mmol); water 2 ml; temperature 95°C; DMF (20 ml); bubbling CO, 0.1MPa; Reaction time 6 h.

In conclusion, we have found a novel and convenient synthetic method of dibenzyl diselenides. Further study of the actual mechanism for the synthesis of diselenides is in progress in our laboratory.

Typical procedures for synthesis of dibenzyl diselenides

In a 100 ml-three-necked flask was placed aromatic aldehyde (2.5 mmol), selenium powder (95% pure) (2.5 mmol), water (2 ml), NaOAc (2.5mmol) DMF (20 ml), and CO were, introduced into the flask and then the mixture was strongly stirred at 95°C for the given time (traced by TLC). When the reaction was complete, CO bubbling was stopped. The resulting



1 **2**

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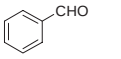
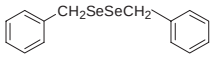
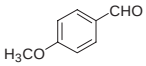
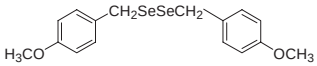
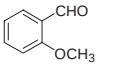
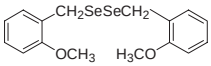
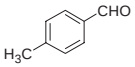
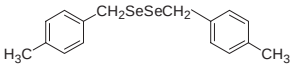
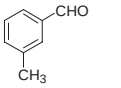
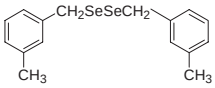
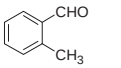
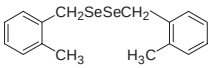
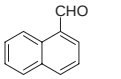
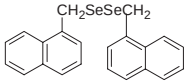
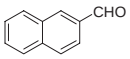
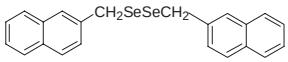
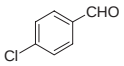
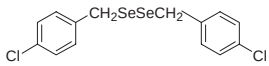
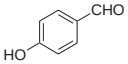
Table 2 Reductive selenation of aromatic aldehyde to diselenides

Entry	Substrate	Product	M.p./°C	Reaction time/h	Yield/%[b]
1			92–93(90–91[15])	6	94
2			72–73 (72[9])	7	84
3			66–67(-[16])	11	83
4			58–59 (61–62[10b])	11	87
5			Yellow liquid	10	78
6			80–81 (86–86.5[7])	8	85
7			102–103 (102[9])	9	88
8			137–138 (134–135)[10b]	9	86
9			73–75(76[9])	9	53
10		No reaction		12	0
11		No reaction		12	0

[a]Reaction conditions: **1a** (2.5 mmol), Se (2.5 mmol), CO (bubbling), 0.1MPa, 95°C, water (2 ml), DMF (20 ml), [b]Isolated yield based on substrate.

solution was stirred at room temperature under air for an additional 0.5 h. addition of water (20 ml), then extraction with diethyl ether (50 ml × 3) gave the crude product, of which purification by column chromatography on silica gel or recrystallisation provided the pure products. All the products were identified by NMR and comparison with the authentic samples.

Data for new compounds

Bis(3-methylbenzyl) diselenide (**5b**). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (m, 2H, CH), 7.22 (m, 6 H, CH), 3.98 (s, 4 H, CH_2), 2.52 (s, 6 H, CH_3); ^{13}C NMR (400 MHz, $CDCl_3$) δ 138.62 and 137.54 (s each, C_q, *i*-C), 129.50, 128.05, 127.56 and 125.82 (s each, CH), 32.38 (s, CH_3), 21.19 (s, CH_2).

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