

## Usefulness of Poly(ethylene glycol) in Synthetic Reactions. Part 10. Deamination of Arylamines *via* Dediazonation by Tin-Hydrochloric Acid in Poly(ethylene glycol)-Methylene Dichloride

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Diazotization and reduction with tin powder of representative arylamines (**1a–h**) proceed smoothly in poly(ethylene glycol)-methylene dichloride and were found to be effective for the preparations of hydrocarbons.

Poly(ethylene glycols) (PEGs) are oligomeric diols of general formula HO(CH<sub>2</sub>CH<sub>2</sub>O)<sub>n</sub>H which may be regarded as open-chain crown ethers since they are able to form complexes with alkaline and alkaline-earth cations in protic and aprotic solvents.<sup>2</sup> From preliminary studies, PEG #200 seems to be the most successful candidate for applications to organic synthesis.<sup>3–6</sup>

Santaniello *et al.* have reported the oxidation of benzylic bromides to the corresponding aldehydes by K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> in PEG #400 at 110 °C (yield ~85%),<sup>3a</sup> the substitution of alkyl bromides to the corresponding RX compounds by KX (X = OAc, CN, I, and OPh) in PEG at 110 °C (yields 88~94%),<sup>3a</sup> the reduction of methyl ketones to the corresponding alcohols by NaBH<sub>4</sub> in PEG at 25 °C,<sup>3a</sup> and the reduction of carboxylic esters to the corresponding primary alcohols by NaBH<sub>4</sub> in PEG #400 at 65 °C (10 h).<sup>3b</sup> Sukata has reported an effective ether synthesis from an alcohol and an alkyl chloride by KOH or NaOH in PEG or dialkyl PEG and aqueous MeOH at 30–70 °C.<sup>4</sup>

In our work to find new preparative organic reactions using PEG as a co-solvent, we have investigated several photochemical and dark reactions,<sup>5</sup> *e.g.*, the photochemical nucleophilic substitution reactions of anisole<sup>5a–c</sup> and *o*- and *p*-dimethoxybenzenes<sup>5c–d</sup> by cyanide anions – this reaction was activated by PEG and also assisted by electron-transfer complex formation with dicyanobenzene; catalytic hydrogenation of acetylenic compounds by H<sub>2</sub>-PdCl<sub>2</sub> in PEG-CH<sub>2</sub>Cl<sub>2</sub>;<sup>5e–f</sup> a novel hydrogenation of acetylenes to the corresponding *cis*-olefins by NaBH<sub>4</sub> in PEG-CH<sub>2</sub>Cl<sub>2</sub> catalysed by PdCl<sub>2</sub>;<sup>5g</sup> the effective diazotization of arylamines and Sandmeyer substitution reactions of the resulting diazonium compounds take place with NaNO<sub>2</sub>-HCl in PEG-CH<sub>2</sub>-Cl<sub>2</sub><sup>5h,7–8</sup> and with Cu<sub>2</sub>X<sub>2</sub>, Cu/MX, or K<sub>2</sub>[Cu(CN)<sub>4</sub>·NH<sub>3</sub>] in PEG-CH<sub>2</sub>Cl<sub>2</sub> systems, respectively, providing the first example of the cyano substitution of diazonium salts using the isolated solid K<sub>2</sub>[Cu(CN)<sub>4</sub>·NH<sub>3</sub>] complex. We have found that reduction of diazotized solutions of arylamines by Sn-HCl proceeds smoothly in PEG-CH<sub>2</sub>Cl<sub>2</sub> at 0 °C to room temperature and is effective for the deamination of arylamines.<sup>5h</sup>

Diazonium groups are replaced by hydrogen in the presence of a variety of reducing agents in either aqueous or non-aqueous organic solvents.<sup>6–8</sup> Generally, moderate yields of reduction products are obtained, although some by-products such as aryl ethers and tarry substances always occur.

### Results and Discussion

Upon diazotization in PEG-CH<sub>2</sub>Cl<sub>2</sub>, the starting material (**1**) (100mm) was consumed completely in 20 min. Three equiv. of the acid (HCl) were necessary (Tables 1–3) for the diazotization in PEG-CH<sub>2</sub>Cl<sub>2</sub><sup>5h</sup> as in the aqueous solutions reported by Kornblum<sup>7c</sup> and Wulfman.<sup>7a</sup>

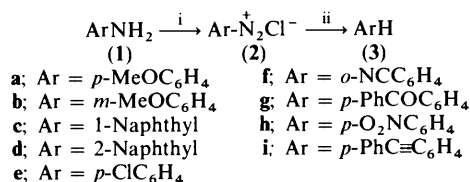
The arylamine (**1**) (1 mmol, 100mm†) mixed with 3M hydrochloric acid (1 cm<sup>3</sup>, 3 mmol) was diazotized by addition of sodium nitrite (1 mmol) dissolved in PEG #200 (2 g, 1m†)-CH<sub>2</sub>Cl<sub>2</sub> at 0 °C. Solid tin powder (1 mmol) was added to the resulting diazotized solution at 0 °C, and the mixture left at room temperature. Samples were withdrawn at intervals and, for the reactions involving PEG, washed with 1M sodium hydroxide. The products were identified by g.l.c. comparison with authentic samples and also by isolation. Optimum reaction conditions (amounts of the reductant and HCl) were studied (Table 1) for (**1e**) and were found to be reductant: 1 equiv.; additional HCl: 0 equiv.

For comparison, experiments in alcoholic solution were carried out in the absence of PEG-CH<sub>2</sub>Cl<sub>2</sub>; reduction reactions with Cu powder and NaBH<sub>4</sub> in PEG-CH<sub>2</sub>Cl<sub>2</sub> were also investigated. Low yields of the hydrocarbons were obtained together with aryl chlorides (**4**) in some cases. The results are shown in Table 2.

Tin powder gave excellent yields of the deamination products (**3**) (see Table 3). No chlorination products were found on g.l.c., whereas classical reduction with copper powder or ethanol gave chlorination products in addition to the reduction products. Excess amounts of Sn and the addition of HCl decreased the yields.

The products were isolated as follows. The reaction mixtures were washed with water, dried (Na<sub>2</sub>SO<sub>4</sub>), and filtered through a short silica gel column (Woelm Activity III, 2 g in glass tubing of 1 cm inside diameter). The products were obtained in good to excellent yields and identified by i.r. spectral comparison with authentic samples.

Conventional Sandmeyer reactions of the diazotized solutions in PEG-CH<sub>2</sub>Cl<sub>2</sub> have been reported.<sup>5h</sup> The chemistry of



**Scheme.** i, NaNO<sub>2</sub>-HCl in PEG-CH<sub>2</sub>Cl<sub>2</sub> at 0 °C. ii, Sn-powder in PEG-CH<sub>2</sub>Cl<sub>2</sub> at 0 °C to room temp.

† Final concentration in a 10 ml solution of PEG (2 g)-CH<sub>2</sub>Cl<sub>2</sub>-water (1 ml).

**Table 1.** Deamination of (1e) with Sn-HCl in PEG-CH<sub>2</sub>Cl<sub>2</sub>

ArNH <sub>2</sub> (1) (100mM)	Diazotization <sup>b</sup> at 0 °C Solvent <sup>a</sup>	Reduction <sup>c</sup>			Yield of products (%) <sup>d</sup>	
		Reductant (equiv.)	HCl (equiv.)	Time (h)	ArH (3)	ArCl (4)
<i>p</i> -ClC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> (1e)	A	A (1.0)	0	3	100	<sup>g</sup>
	A	A (1.0)	3	3	97 [72] <sup>e,f</sup>	
	A	A (5.0)	3	3	86	
	A	A (10.0)	3	3	64	

<sup>a</sup> A: PEG-CH<sub>2</sub>Cl<sub>2</sub>; B: EtOH, 3 equiv. of HCl (3M HCl, 1 ml) was used for the diazotization (Table 2). <sup>b</sup> Each compound (1) was diazotized quantitatively within 20 min. <sup>c</sup> A: Sn powder in the range 0 °C to room temp. Mol. equiv. of the reductants and the additional HCl to (1) are shown; B: refluxed in EtOH (Table 2), C: Cu powder in the range 0 °C to room temp. (Table 2), D: NaBH<sub>4</sub> in the range 0 °C to room temp. (Table 2). <sup>d</sup> G.l.c. yields based on the starting material (1). <sup>e</sup> Isolated yields after work-up. <sup>f</sup> Identified by i.r. spectral measurements. <sup>g</sup> Not detected.

**Table 2.** Reduction of ArNH<sub>2</sub> (1) with the classical reductants

ArNH <sub>2</sub> (1) (100mM)	Diazotization <sup>b</sup> at 0 °C Solvent <sup>a</sup>	Reduction <sup>c</sup>			Yield of products (%) <sup>d</sup>	
		Reductant (equiv.)	HCl (equiv.)	Time (h)	ArH (3)	ArCl (4)
(1a)	B	B	0	4	15	28
(1c)	A	C (1.6)	0	3	35	5
(1e)	B	B	0	5	13	trace
	B	B	0	4	28	7
	A	C (1.6)	0	3	67 [50] <sup>e,f</sup>	21
	A	D (5.0)	0	3	32	<sup>g</sup>

<sup>a-g</sup> See footnotes in Table 1.

**Table 3.** Hydrogenation of diazonium salts by Sn-HCl in PEG-CH<sub>2</sub>Cl<sub>2</sub>

ArNH <sub>2</sub> (1) (100mM)	Diazotization <sup>b</sup> at 0 °C Solvent <sup>a</sup>	Hydrogenolysis <sup>c</sup>			Yield of products (%) <sup>d</sup>		
		Reductant (equiv.)	HCl <sup>e</sup> (equiv.)	Time (h)	ArH (3)	ArCl (4)	Others
(1a)	A	A (1.0)	0	3	87 [76] <sup>e,f</sup>	<sup>g</sup>	
			3	3	74 [48]		
(1b)	A	A (1.0)	0	3	72 [44]	Trace	
			3	3	51 [38]		
(1c)	A	A (1.0)	0	3	51 [50]		
			3	3	100		
(1d)	A	A (1.0)	0	3	97 [72]		
			3	3	96 [54]	Trace	
(1e)	A	A (1.0)	0	3	91 [62]		
			3	3	72 [54]		
(1f)	A	A (1.0)	0	3	57		PhNH <sub>2</sub> 18%
(1g)	A	A (1.0)	0	3	89 [56]		
(1h)	A	A (1.0)	0	3	68 [53]		
(1i)	A	A (1.0)	3	3			

<sup>a-g</sup> See footnotes in Table 1.

cyclic polyethers (crown ethers) has attracted widespread interest because of the rather high selectivity of many reactions of activated anion species and since the properties of poly(ethylene glycol) (PEG) make it an excellent substitute for crown ethers in many reactions,<sup>3,5</sup> its use as a co-solvent has been reported.

The reported simple deamination in this paper was shown to be effective for the electron-rich arylamines such as *p*-anisidine (1a) as well as for those that are electron-poor. Apparently, the co-existent functional groups such as Cl, C=O, MeO, CN, and C≡C do not undergo reduction in this procedure. Only *p*-nitroaniline (1h) gave aniline as a minor product. A primary product, *p*-nitrobenzene, may be reduced under the reaction conditions to give aniline.

## Experimental

PEG #200 (average molecular wt. *M* = 200; Nakarai Chem. Co.) was dried azeotropically with benzene. Methylene dichloride was distilled from CaH<sub>2</sub>. The arylamines (1) were purchased (Wako) with the exception of (1i), which was prepared according to literature methods.<sup>9</sup> The authentic hydrocarbons and aryl chlorides were also purchased with the exception of (4i), which was prepared by literature methods.<sup>10</sup>

Each arylamine (1) (1 mmol, 100mM)\* mixed with dilute aqueous 3M HCl (3 mmol, 1 ml) was placed in a 100 ml flask fitted with a rubber stopper with a balloon connected by an

\* As on p. 1951

injection needle, and diazotized by addition of  $\text{NaNO}_2$  (1 mmol) dissolved in PEG #200 (2 g, 1M\*)- $\text{CH}_2\text{Cl}_2$  at  $0^\circ\text{C}$ . The resulting diazotized solution was added to solid Sn (1 mmol ~ excess) at  $0^\circ\text{C}$ , and the mixture was kept at room temperature. Samples were withdrawn at intervals and washed with 1M NaOH in order to remove the PEG. The products were identified by comparing their g.l.c. retention times and i.r. spectra with those of authentic samples. For isolation, 10 ml of the solutions (the same concentration) were employed and gave similar results to the original experiments. As a comparison, some experiments in aqueous solution were taken without using the PEG- $\text{CH}_2\text{Cl}_2$  system. For reactions in which EtOH was used instead of PEG #200 (2 g)- $\text{CH}_2\text{Cl}_2$ , the other conditions were identical with those for the reactions in PEG. The results are given in Tables 1—3.

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