A New and Efficient Method for the Selective Reduction of Nitroarenes: Use of Ammonium Sulphate-Sodium Borohydride

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Various nitro compounds were selectively and rapidly reduced to their corresponding amino compounds in good yield using ammonium sulphate-sodium borohydride, a novel reduction system.

Selective and rapid reduction of nitro compounds is still an area of considerable synthetic interest,[1] particularly when a molecule has several other reducible functionalities. Therefore numerous new reagents[2] have been developed for reduction of aromatic nitro compounds, some of which are incompatible with other substituents on the aromatic ring. Sodium borohydride is a weak reducing agent amongst the borohydride class, and efforts to increase its reactivity using Lewis acids lead to the discovery of hydroboration of olefins[3] and methods for generation of diborane. However, efforts are still continuing for developing convenient methods for the reduction of functional groups using sodium borohydride along with other additives.[4]

We wish to report herein a mild, simple, rapid and selective reduction of nitro compounds to the corresponding amino derivatives using sodium borohydride in presence of ammonium sulphate that complements the collection of existing methods. Interestingly, this present system also reduces with ease a wide variety of nitroso benzenes and 2,1,3-benzooxadiazole-1-oxides directly to the corresponding amino and diamino derivatives respectively in high yield.

Typically, sodium borohydride (20 mmol) was added to a mixture of ammonium sulphate (50 mmol) and aromatic nitro compound (10 mmol) in ethanol. The reaction mixture was stirred at room temperature for 30 min, and then was quenched by addition of water and ether. The product was extracted with ether and purified by column chromatography on silica gel to give the desired amino derivatives (Table). In case of o- and p-nitro benzaldehydes both aldehyde and nitro groups were reduced and the corresponding amino alcohols were obtained. This reduction procedure is fairly general and functional groups such as methyl, methoxy, cyanide, ester, amido and halo in the benzene ring do not have any marked effect on the rate of the reaction.

Table. Reduction of aromatic nitro, nitroso and 2,1,3-benzooxadiazole-1-oxides by $(NH_4)_2SO_4$-$NaBH_4$

Entry	Product[a]	R	Time[b] min	Yield[c] %	Mp °C
1	3a	p-Cl	30	90	68-69
2	3b	p-I	35	80	61-63
3	3c	o-Me	35	80	oil
4	3d	o-HO_2C	60	70	144-48
5	3e	p-MeO	35	85	57-58
6	3f	p-EtO_2C	30	82	88-90
7	3g	p-CH_3CO	20	76	104-06
8	3h	p-CN	32	80	82-83
9	3i	p-HO_2C	120	75	188-89
10	3j	m-CH_2=CH	40	75	oil
11	3k	H	35	80	oil
12	3a	p-Cl	35	86	69-70
13	5a	H	30	86	101-02
14	5b	3-Me	30	87	87-89

[a] Products were identified by the comparison if IR and NMR spectra and melting points with those of authentic samples.
[b] Increasing the time of reaction had no significant effect on the yield and resulted in minor amount of decomposition.
[c] Yields refer to the yield of pure isolated products.

The scope of this general procedure is shown in Table. In most cases the reaction is over within 20-40 mins. However for p-nitro benzoic acid, the reaction completion time was 2 h. In the case of carbonyl substituted aromatic nitro compound, the corresponding aniline was obtained in high yield without any further reduction of carbonyl group (entry 7). Furthermore, aromatic halides showed remarkable selectivity to give the amino product without giving any dehalogenation (entries 1-2). As iodo groups are often cleaved by catalytic hydrogenation and metal-acid reductions, and deiodinated side product or starting material was recovered.[5] The presence of an ortho carboxy group often yield, instead of anilines, 2,1-benzisoxazole-3-ones, but this new system yields 2-amino benzoic acid exclusively in good yield (entry 4). Nitrosobenzene and 2,1,3-benzooxadiazole-1-oxides are reduced by sodium borohydride to form the corresponding azo benzene and dioximes respectively.[7] During our studies we found that the nitroso compound and 2,1,3-benzooxadiazole-1-oxides were reduced with $(NH_4)_2SO_4$-$NaBH_4$ system at ambient temperature to produce the corresponding amines and diamines respectively as the sole product (entry 11-14). In addition, catalytic hydrogenation of 3-nitro styrene using Pd/C in ethanol gives 3-ethylaniline, a reduction of both nitro and vinyl functional groups, while the present system gives 3-amino styrene as the only product (entry 10).

In conclusion, these results demonstrated a rapid, versatile and selective reducing system for a wide variety of nitro compounds in the presence of other functional groups, for e.g. -C≡N, -C=O, -COOEt, -COOH, Cl, I, $CH=CH_2$ etc. Ammonium sulphate also has the advantages of being readily available, inexpensive, stable and non toxic and can be used in conjunction with sodium borohydride. As far as mechanism is concerned it is difficult to postulate any at this stage, but certainly diborane is not formed during the reaction, as functional groups sensitive to this remained intact.[9]

References and Notes

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