

# Reductive fission of azoarenes to aminoarenes by aluminium/hydrazine hydrate

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Various azoarenes undergo reductive fission with hydrazine hydrate in refluxing ethanol to give easily isolable aminoarene(s) using aluminium powder. The reaction is fast and cost effective: yields are excellent ranging from 85–95%; substituents like –OH, –OCH<sub>3</sub>, –COOH, –Cl, –Br are unaffected. The method affords a simple and convenient route to the preparation of substituted aminoarenes.

**Keywords:** azoarenes, reductive fission, hydrazine hydrate, aluminium powder, aminoarenes

Aminoarenes are versatile intermediates in the agrochemical, polymer, pharmaceutical and photographic industries. Many aminoarenes exhibit biological activity. Therefore, the synthesis of aminoarenes is of importance. A variety of reagents has been developed for the preparation of aminoarenes *via* the reduction of nitro compounds which include, nanosized activated Fe/H<sub>2</sub>O,<sup>1</sup> Mn/CuCl<sub>2</sub>,<sup>2</sup> HCOOH/Pd–C,<sup>3</sup> HCOOH/Ni,<sup>4</sup> Sm(0) and 1,1'-dioctyl-4,4'-bipyridyl dibromide,<sup>5</sup> CO/H<sub>2</sub>O catalysed by Ru<sub>3</sub>(CO)<sub>12</sub>,<sup>6</sup> and NaBH<sub>4</sub> and SbCl<sub>3</sub> or BiCl<sub>3</sub>.<sup>7</sup> Aminoarenes can also be obtained by heterogeneous catalytic transfer hydrogenation over cobalt(II) substituted hexagonal mesoporous aluminophosphate molecular sieves,<sup>8</sup> and Bakers' Yeast.<sup>9</sup> Recently, aminoarenes have been obtained by treating nitro compounds with zinc and ammonium salts in the presence of ionic liquids.<sup>10</sup> Most of these methods, however, lack the desired chemoselectivity over other functional groups that are often present in the substrate such as hydroxy, methoxy and halide groups. In addition, reduction of aromatic nitro compounds often stops at an intermediate stage, which affords azoarenes,<sup>11</sup> and azoxyarenes.<sup>12</sup>

On the other hand, the cleavage of N=N multiple bonds of either symmetric or unsymmetric azoarenes permits two functional groups to be introduced into the aromatic nuclei and this is one of the easiest method for the preparation of substituted aminoarenes. As azoarenes are easily accessible, it would be valuable to develop an easier and simpler method for the reduction of –N=N– without affecting the substituents.

Previous reports on the reductive cleavage of azoarenes to aminoarenes have been reviewed.<sup>13</sup> The reduction of azoarenes is usually achieved with HCOONH<sub>4</sub>/10% Pd–C,<sup>14</sup> cyclohexene/5% Pd on asbestos,<sup>15</sup> Cp<sub>2</sub>TiBH<sub>4</sub>,<sup>16</sup> Ni/HCO<sub>2</sub>NH<sub>4</sub> or HCOOH<sup>17</sup> and Zn/HCOOH.<sup>18</sup> More recently, Zn/CH<sub>3</sub>CO<sub>2</sub>NH<sub>4</sub>,<sup>19</sup> nickel-incorporated hexagonal mesoporous aluminophosphate molecular sieves,<sup>20</sup> and PdMCM-41 catalysts,<sup>21</sup> have been reported for the reduction of azoarenes to the corresponding aminoarenes.

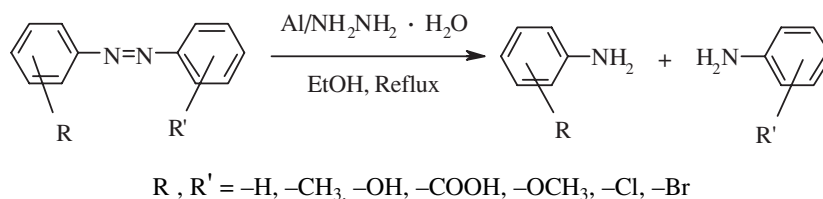
Although some of these procedures are widely used, they still have their own shortcomings based on economic considerations, unavailability of the catalysts used and selectivity.

Moreover earlier procedures include tedious workup and expensive catalysts like, Raney Ni, 5% Pd on asbestos and 10% Pd–C. Dehalogenation was observed with HCOONH<sub>4</sub>/10% Pd–C and benzidine rearrangement cannot be ruled out with Raney Ni/HCOOH since the reaction proceeds *via* a hydrazobenzene intermediate.

It is to be noted that systems such as NH<sub>2</sub>NH<sub>2</sub>/10% Pd–C<sup>22</sup> and NH<sub>2</sub>NH<sub>2</sub>/Raney–Ni<sup>23</sup> have been reported to convert azobenzene into hydrazobenzene. It is also worth noting that, Wang and Zhang<sup>24</sup> have recently reported the partial reduction of azoarenes using hydrazine hydrate as reductant to form hydrazoarenes in refluxing ethanol after 20 min–3 h without catalyst.

We have been exploring easier and simpler methods for the preparation of arylamines using inexpensive and readily available aluminium metal under various reaction conditions.<sup>25–27</sup> In this paper and in continuation of our work on the use of hydrazine hydrate in functional group transformations,<sup>28</sup> it was found that, 99–100% hydrazine hydrate in presence of aluminium powder at reflux in ethanol is an exceedingly convenient, simple and highly selective system for the reductive fission of azoarenes to aminoarenes as shown in Scheme 1. The reaction proceeds smoothly without affecting substituents like –OH, –OCH<sub>3</sub>, –COOH, –Cl, –Br.

In a typical experiment, 10 mmol of azobenzene in ethanol is treated with 80 mmol hydrazine hydrate (99–100%) (see CAUTION) and 10 mg atom aluminium powder. The contents were refluxed and after completion of the reaction, the product was found to be aniline. Encouraged by this result, the potential of this reaction was tested for the reductive fission of a variety of azoarenes in order to verify the suitability of this method. Different substituted azoarenes were prepared by standard procedures and subjected to reaction with hydrazine hydrate. The results are summarised in Table 1. From this it is clear that different substituted azoarenes can be readily converted into the respective aminoarenes under the above reaction conditions in excellent yields within 25 min. The product formation from the respective azoarenes to aminoarenes with hydrazine hydrate has been followed by TLC (a single spot



Scheme 1

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**Table 1** Reduction of azoarenes into aminoarenes by aluminium/hydrazine hydrate<sup>a</sup>

Entry	R	Substrate	R'	R	Product <sup>b</sup>	R'	yield <sup>c</sup> (%) 1, 2	M.p/B.p./°C
1	-H	-H	-H	-H	-H	-H	95, –	178 <sup>d</sup>
2	2-CH <sub>3</sub>	2'-CH <sub>3</sub>	2-CH <sub>3</sub>	2'-CH <sub>3</sub>	2-CH <sub>3</sub>	2'-CH <sub>3</sub>	94, –	194 <sup>d</sup>
3	3-CH <sub>3</sub>	3'-CH <sub>3</sub>	3-CH <sub>3</sub>	3'-CH <sub>3</sub>	3-CH <sub>3</sub>	3'-CH <sub>3</sub>	95, –	197 <sup>d</sup>
4	3-OCH <sub>3</sub>	3'-OCH <sub>3</sub>	3-OCH <sub>3</sub>	3'-OCH <sub>3</sub>	3-OCH <sub>3</sub>	3'-OCH <sub>3</sub>	94, –	78/2 torr
5	2-OH	2'-OH	2-OH	2'-OH	2-OH	2'-OH	90, –	176
6	2-Br	2'-Br	2-Br	2'-Br	2-Br	2'-Br	92, –	30
7	2-Cl	2'-Cl	2-Cl	2'-Cl	2-Cl	2'-Cl	92, –	202 <sup>d</sup>
8	2-OH	-H	2-OH	-H	2-OH	-H	92, 94	176, 178 <sup>d</sup>
9	2-COOH	4'-N(CH <sub>3</sub> ) <sub>2</sub>	2-COOH	4'-N(CH <sub>3</sub> ) <sub>2</sub>	2-COOH	4'-N(CH <sub>3</sub> ) <sub>2</sub>	85, 92	147, 38 (34–38) <sup>29</sup>
10	4-COOH	-H	4-COOH	-H	4-COOH	-H	87, 95	188, 178 <sup>d</sup>
11	4-NH <sub>2</sub>	-H	4-NH <sub>2</sub>	-H	4-NH <sub>2</sub>	-H	93, 94	146, 178 <sup>d</sup>

<sup>a</sup> [CAUTION: Hydrazine hydrate is very toxic and corrosive in nature and should be handled with appropriate precautions.]

<sup>b</sup> Characterised by IR spectral analysis and on GC with authentic samples.

<sup>c</sup> Isolated yields. <sup>d</sup> Boiling point at 690 torr.

[Boiling point/melting points were found to coincide with those of authentic commercial samples except for entry 9, 2 where comparison is made with a literature value].

is observed in the cases of symmetric azoarenes and two spots are observed in the cases of unsymmetric azoarenes) or the colour disappearance of the azoarenes which are almost all coloured compounds. The products were characterised by comparison of their melting/boiling points with authentic samples or a literature value and by IR spectral analysis. Aryl amines generally display two stretching bands in the N–H region of the IR spectra. The two bands appear between 3320–3475 cm<sup>-1</sup> because of the coupled vibrations. The high frequency band is due to symmetric vibration and lower frequency band is due to asymmetric vibration. This pattern is noticed in all the arylamines prepared by our procedure.

In conclusion, we have demonstrated for the first time the direct generation of valuable synthons of aniline from the reductive fission of easily accessible azoarenes by hydrazine hydrate with inexpensive catalyst without effecting the reduction of other reducible substituents. The reaction may be considered as simple from practical point of view and has great potential for future applications. The obvious advantages of the proposed method over previous methods are – simplicity, high selectivity, convenience, and high purity of the product.

## Experimental

All azoarenes are either commercially available or prepared according to standard procedures<sup>30</sup> and purified before use. Hydrazine hydrate, other solvents and commercial aminoarenes were purchased from Merck/BDH and were purified/dried (wherever required) prior to use. Yields refer to the isolated yields of the products after purification/separation. GC analysis was performed on a SHIMADZU GC-MS QP 5050A instrument. IR spectra were recorded on NICOLET 400D FT-IR Spectrometer.

**Reduction of azoarenes into aminoarenes: general procedure:** Azobenzene (1.82 g, 10 mmol) in ethanol (20 ml) was efficiently stirred and refluxed with hydrazine hydrate (4 mL, 99–100%, 80 mmol) and aluminium powder (0.27 g, 10 mg atom). After the completion of the reaction (20–25 min), [monitored by TLC (performed on precoated aluminum plates with Merck silica gel 60 F-254 as the adsorbent) using 10% acetone in light petrol as an eluent. The developed plates were air dried and irradiated with UV light or monitored by the disappearance of the colour of the starting material], the reaction

mixture was filtered through a celite pad and washed with solvent. The filtrate was concentrated in *vacuo*, the concentrated residue was taken into ether (20 ml). The contents were washed twice with water (wherever necessary salted out with NaCl), dried over anhydrous sodium sulfate and the solvent distilled off to get the crude product.

The product that contained a mixture of amino carboxylic acid and aniline was treated with sat. NaHCO<sub>3</sub> to separate the amino carboxylic acid from aniline. A mixture of aminophenol and aniline was separated by treating with 20% NaOH, and a mixture of anilines was separated by column chromatography using 60–120 mesh silica gel and 10–20% acetone in light petrol as eluent. The anilines thus obtained were characterised by comparison of their b.p./m.p., with authentic samples (except for Table 1, entry 9, compound 2 where comparison was with the literature) and IR spectral analysis.

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## References

1. L. Wang, L. Pinhua, W. Zongtao, J. Yan, W. Min and Y. Ding, *Synthesis*, 2003, **13**, 2001.
2. H. Sarmah and D.K. Dutta, *J. Chem. Res(S)*, 2003, 236.
3. R.A. Scheuerman and D. Tumelty, *Tetrahedron Lett.*, 2000, **41**, 6531.
4. D.C. Gowda, A.S. Gowda, B. Prakasha, A. Ramesha and S. Gowda, *Synth Commun.*, 2000, **30**, 2889.
5. C. Yu, B. Liu and L. Hu, *J. Org. Chem.*, 2001, **66**, 919.
6. F. Ragaini, S. Cenini and S. Toller, *J. Mol. Cat.*, 2001, **174**, 51.
7. R. Ping-Da, P. Shi-Feng, D. Ting-Wei and W. Shi-Hui, *Synth Commun.*, 1995, **25**, 3799.
8. S.K. Mohapatra, S.U. Sonavane, R.V. Jayaram and P. Selvam, *Tetrahedron Lett.*, 2002, **43**, 8527.
9. W. Baik, J.L. Han, K.C. Lee, N.H. Lee, B.H. Kim and J. Hahn, *Tetrahedron Lett.*, 1994, **35**, 3965.
10. F.A. Khan, J. Dash, C. Sudheer and R.K. Gupta, *Tetrahedron Lett.*, 2003, **44**, 7783.
11. R.O. Hutchins, D.W. Lamson, L. Rua, C. Milewski and B. Maryanoff, *J. Org. Chem.*, 1971, **36**, 803.
12. K. Ohe, S. Uemura, N. Sugitha, H. Masuda, and T. Taga, *J. Org. Chem.*, 1989, **54**, 4169.

- 13 T.L. Gilchrist, in *Comprehensive Organic Synthesis*, ed I. Fleming, Pergamon Press, Oxford 1991, Vol. 8, p. 381.
- 14 G.K. Jnaneshwara, A. Sudalai, and V.H. Deshpande, *J. Chem. Res(S)*, 1998, 160.
- 15 T.L. Ho, and G.A. Olah, *Synthesis*, 1977, 169.
- 16 P. Dosa, I. Kronish, J. McCallum, J. Schwartz, and M.C. Barden, *J. Org. Chem.*, 1996, **61**, 4886.
- 17 D. Channegowda, Shankaregowda and K. Abhiraj, *Ind. J. Chem.*, 2003, **42B**, 1774.
- 18 S. Gowda, K. Abhiraj and D. Channegowda, *Tetrahedron Lett.*, 2002, **43**, 1329.
- 19 G.R. Srinivasa, K. Abhiraj and D. Channegowda, *Ind. J. Chem.*, 2004, **43B**, 192.
- 20 P. Selvam, S.K. Mohapatra, S.U. Sonavane, and R.V. Jayaram, *Tetrahedron Lett.*, 2004, **45**, 2003.
- 21 P. Selvam, S.U. Sonavane, S.K. Mohapatra, and R.V. Jayaram, *Tetrahedron Lett.*, 2004, **45**, 3071.
- 22 P.M.G. Bavin, *Can. J. Chem.*, 1958, **36**, 238.
- 23 S. Hornsby and W.L. Peacock, *Chem. Ind.*, 1958, **27**, 858.
- 24 Y.L. Wang and C.R. Zhang, *Synth. Commun.*, 2004, **33**, 4205.
- 25 D. Nagaraja and M.A. Pasha, *Tetrahedron Lett.*, 1999, **40**, 7855.
- 26 M.A. Pasha and V.P. Jayashankara, *J. Chem. Res(S)*, 2004, **4**, 282.
- 27 M.A. Pasha and V.P. Jayashankara, *Ultrason. Sonochem.*, 2004, (04J21- In Press).
- 28 M.A. Pasha and H.M. Nanjundaswamy, *Synth. Commun.*, in press.
- 29 Lancaster, Newgate, White Lund, Lancashire LA3 3BN, England, 2002-3, 761.
- 30 A.I. Vogel, A. Watling and J. Watling, *J. Chem. Educ.*, 1958, **35**, 40.