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Green Protocol For The Rapid Generation Of Arylhydroxylamines And Hydrazoarenes In Water



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ABSTRACT

Magnesium mediated vigorous reaction of hydrazinium sulfate in water rapidly generated arylhydroxylamines and arylamines from the corresponding nitro aromatics in excellent yields. Azoarenes and azoxyarenes under the same reaction conditions gave the respective hydrazoarenes. The reactions are very fast, give excellent yields of the product. Substituents such as OH, CH₃, OCH₃, and halogens are unaffected. The method affords an elegant route to the preparation of arylhydroxylamines and hydrazoarenes

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KEYWORDS

Hydrazinium sulfate;
 Magnesium turnings;
 Nitroarenes;
 Azoarenes.

INTRODUCTION

Aryl hydroxylamines have a wide variety of potential applications towards the synthesis of natural products and fine chemicals^[1], and many hydroxylamines^[2] are also known to have a broad spectrum of pharmacological and physiological activities^[3]. Only a few methods are available in the literature for the preparation of arylhydroxylamines, including catalytic transfer hydrogenation and metal-mediated reduction of the corresponding nitro compounds^[4]. Of these, reduction of aromatic nitro compounds

being the most common method, often form side products such as hydrazines, azoarenes and azoxyarenes. In addition, many of these procedures suffer from disadvantages such as: use of high-pressure equipment, flammable hydrogen gas and toxic heavy metals^[5]. Recently, organic reaction in water or aqueous media has attracted great interest in organic synthesis from the view of its environmental concern^[6].

EXPERIMENTAL

Commercially available reagents and solvents

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were used throughout and purified before use. Yields refer to the isolated products after recrystallization. Analytical TLC performed on precoated aluminum plates with Merck silica gel 60 F-254 as the adsorbent. The developed plates were air dried and irradiated with UV light. Melting points were obtained with Buchi B-540 apparatus. GC analyses were performed on a SHIMADZU GC-MS QP 5050A instrument. IR spectra were recorded on NICOLET 400D FT-IR spectrometer. The ^1H NMR spectra were recorded on Bruker 400 MHz spectrometer as CDCl_3 solutions with TMS as internal standard.

RESULTS AND DISCUSSION

In continuation of our successful program on the reduction of nitroarenes and transformations employing hydrazine hydrate^[7], herein we report a rapid, eco-friendly, simple and efficient method for the reduction of different substituted nitroarenes into arylhydroxylamines/aminoarenes by hydrazinium sulfate in presence of magnesium turnings under aqueous medium with striking yields. In addition to the advantage of this reaction under aqueous media, the reduction was completed within 1.5 minutes and the product isolation does not involve organic solvent as shown in SCHEME 1 and the results are summarized in TABLE 1. TLC, IR spectra and GC-MS monitored the course of reaction.

The reduction of azo and azoxyarenes has received a good deal of attention in recent years since reduction of -N-N- bonds is an important reaction in connection with structural determination of azo dyes^[8]. Hydrazoarenes on the other hand, have received little attention due to their tendency towards aerial oxidation, benzidine rearrangement in acidic medium or further reduction into anilines, hence, it is difficult to obtain only hydrazoarenes. Reports are available in the literature for the reduction of azoxy and azoarenes

into hydrazoarenes that includes systems such as Raney-nickel/ NH_2NH_2 , Pd/ NH_2NH_2 ^[9]. Reagents such as Al/KOH in methanol^[10] and a complex of the coenzyme dihydrolipoamide and iron(II) have also been developed for the reductive coupling of nitroarenes^[11].

Recently, we have reported the facile, product-selective reduction of azoxyarenes into azoarenes or hydrazoarenes by Al/ NH_2NH_2 under microwave conditions^[12] and Selective protection of carbonyl compounds as azines and their facile regeneration employing hydrazinium formate^[13]. To extend the utility of the derivatives of hydrazine not polluting the environment, the method described above was tested for the reduction of -N-N- system. Different substituted azo and azoxyarenes were subjected to above reaction conditions and was found that, the system is an exceedingly convenient and selective for the partial reduction of azo/azoxyarenes to hydrazoarenes as shown in SCHEME 2.

The reaction proceeded smoothly and is complete within 3-5min, without affecting the substituents like halogens and ether linkage. The product formation from the respective azo and azoxyarenes to hydrazoarenes was followed by thin layer chromatography and GC-MS. The products were characterized by the comparison of their melting points and by the IR spectral analysis and the results are summarized in TABLE 2 and 3.

Typical procedure for the reduction of nitrobenzene, azobenzene and azoxybenzene

Nitrobenzene(1.23g, 10mmol) or azobenzene (1.82g, 10mmol) or azoxybenzene (1.98g, 10mmol) in 1 mL of ethanol(just to dissolve the compound) is taken in 50mL round bottomed flask and was added hydrazinium sulfate (1.56g, 12mmol), magnesium turnings(290mg, 1.2equivalent) followed by 5mL of distilled water. A vigorous reaction ensued

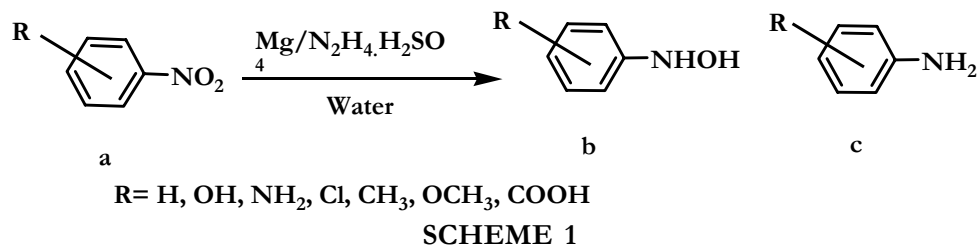
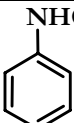

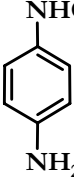
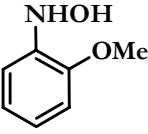
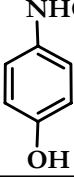
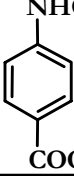
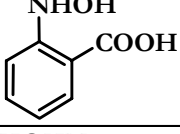
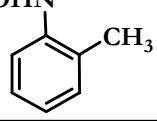
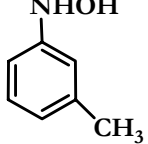

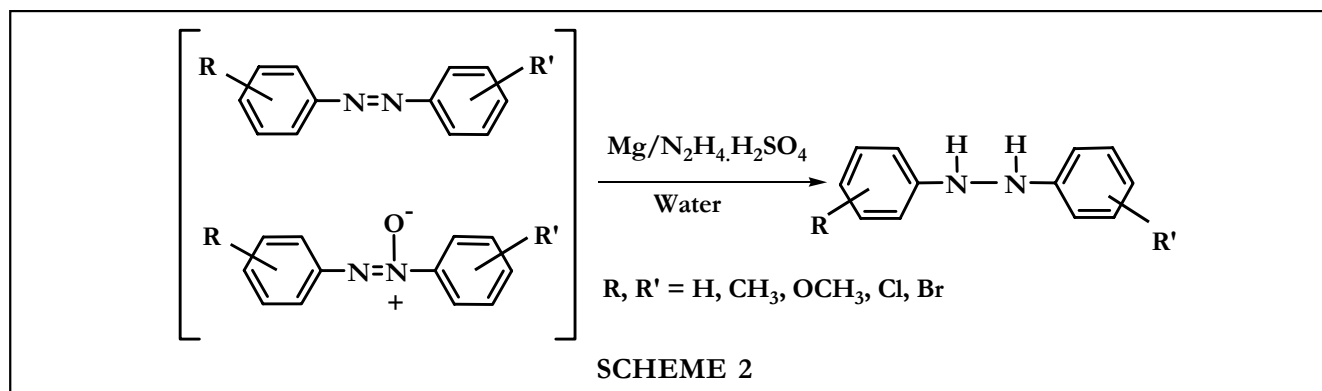


TABLE 1: Reduction of nitroarenes to corresponding arylamines by Mg/NH₂NH₂·H₂SO₄ in water

Entry	A	Reaction Time(min)	Yield (%)	b:c	b	IR (KBr) ν cm ⁻¹ N-OH, N-H
1	Nitrobenzene	1.5	100	96:4		3441,3041
2	p-Nitrochlorobenzene	1.5	92	90:10		3445,3105
3	p-Nitroaniline	1.5	94	90:10		3483,3224
4	o-Nitroanisole	1.5	93	91:9		3468,3221
5	o-Nitrophenol	1.5	93	90:10		3416,3307
6	p-Nitrobenzoic acid	1.5	89	92:8		3468,3238
7	o-Nitrobenzoic acid	1.5	89	91:9		3450,3243
8	o-Nitrotoluene	1.5	93	91:9		3421,3069
9	m-Nitrotoluene	1.5	93	91:9		3435,3078
7	m-Nitrotoluene	1.5	93	91:9		3442,3083

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TABLE 2: Reduction of Azoarenes into Hydrazo-arenes by $Mg/N_2H_4.H_2SO_4$ in water

Entry	Substrate R	R'	Yield ^a (%)	M.p(°C) Found	Lit ¹⁴	IR(KBr) ν cm ⁻¹ NH-NH
1	H	H	93	126	126	3400,1600,1500
2	2-CH ₃	2'-CH ₃	90	164-166	165	3320,1595,1480
3	3- CH ₃	3'- CH ₃	90	37	38	3320,1595,1490
4	4- CH ₃	4'- CH ₃	91	133-134	134	3320,1595,1490
5	2-O CH ₃	2'-OCH ₃	90	102-103	102	3350,1600,1495
6	4-Cl	4'-Cl	90	124	123-124	3350,1595,1500
7	2-Br	2'-Br	90	97-98	97-98	3350,1600,1495

a Isolated yields

TABLE 3: Reduction of azoxyarenes into hydrazo-arenes by $Mg/N_2H_4.H_2SO_4$ in water

Entry	Substrate R	R'	Yield ^a (%)	M.p(°C) Found	Lit ¹⁴	IR(KBr) ν cm ⁻¹ NH-NH ν cm ⁻¹
1	H	H	93	126	126	3400,1600,1500
2	2-CH ₃	2'-CH ₃	90	164-166	165	3320,1595,1480
3	3- CH ₃	3'- CH ₃	90	37	38	3320,1595,1490
4	4- CH ₃	4'- CH ₃	91	133-134	134	3320,1595,1490
5	2-O CH ₃	2'-OCH ₃	90	102-103	102	3350,1600,1495
6	4-Cl	4'-Cl	90	124	123-124	3350,1595,1500
7	2-Br	2'-Br	90	97-98	97-98	3350,1600,1495

a Isolated yields

and on stirring the contents, the system gets heated up to 80°C until the disappearance of starting substance(monitored by TLC). The solid separated is filtered, washed with water and dried to get the crude products along with unreacted magnesium metal and is removed during recrystallization.

Characterization data of hydrazoarenes of TABLE 2 and 3 [(1-7)]

- (1) ¹HNMR (TMS) δ (ppm): 6.65-7.40(m, 10H, phenyl)
- (2) ¹HNMR (TMS) δ (ppm): 2.40(s, 6H, 2methyl); 6.65-7.42(m, 8H, phenyl)
- (3) ¹HNMR (TMS) δ (ppm): 2.42(s, 6H, 2methyl);

- 6.68-7.45(m, 8H, phenyl)
- (4) ¹HNMR (TMS) δ (ppm): 2.40(s, 6H, 2methyl); 6.70-7.50(m, 8H, phenyl)
- (5) ¹HNMR (TMS) δ (ppm): 3.85(s, 6H, 2methyl), 6.60-7.60(m, 8H, phenyl)
- (6) ¹HNMR (TMS) δ (ppm): 7.45-8.00(m, 8H, phenyl)
- (7) ¹HNMR (TMS) δ (ppm): 7.45-8.00(m, 8H, phenyl)

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