Communication

Deprotection of Oximes, Phenylhydrazones, Semicarbazones and Thiosemicarbazones to the Corresponding Carbonyl Compounds Using Cetyltrimethylammonium Peroxodisulfate as a New and Selective Oxidizing Agent

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Cetyltrimethylammonium peroxodisulfate $(CTA)_2S_2O_8$ was quantitatively prepared and used for the deprotection of oximes, phenylhydrazones, semicarbazones and thiosemicarbazones to the corresponding carbonyl compounds in acetonitrile. Its agent is more efficient and has advantages over similar reagents in terms of the amount of oxidant, short reaction time, simple work up, and high yield.

Keywords: Cetyltrimethylammonium peroxodisulfate; Deprotection; Oxime; Phenylhydrazone; Semicarbazone; Thiosemicarbazone.

INTRODUCTION

Derivatives of carbonyl compounds such as oximes, phenylhydrazones, semicarbazones and thiosemicarbazones are used not only for the characterization and purification of carbonyl compounds but also play an important role in the protection of carbonyl compounds, as they are highly crystalline and stable compounds. Thus, the regeneration of carbonyl compounds from their derivatives under mild condition is important process in organic synthetic chemistry.

The classical method for the cleavage of oximes, phenylhydrazones, semicarbazones and thiosemicarbazones to aldehydes and ketones is acid hydrolysis which is not suitable for acid sensitive compounds.[1] Several deprotection methods have been developed which have some advantages over the classical hydrolysis method.[2-15]

We report here a new and efficient procedure for the cleavage of oximes, phenylhydrazones, semicarbazones and thiosemicarbazones using cetyltrimethylammonium peroxodisulfate. The results obtained with this reagent are satisfactory and proved that it is a valuable addition to the existing oxidants.

$(CTA)_2S_2O_8$ is easily prepared by addition of an aqueous solution of cetyltrimethylammonium bromide to a solution of potassium peroxodisulfate in water.[16] The isolated $(CTA)_2S_2O_8$ was characterized by its spectroscopical and physical data.

RESULTS AND DISCUSSION

To find the optimum reaction conditions, we have chosen the C=N derivatives of the benzaldehyde as a model substrate. When we have treated the C=N compounds with reagent in different solvents, temperatures and mole ratio of substrate to reagent, we have found that a 1:1 mole ratio of substrate to reagent in refluxing acetonitrile gives the highest yeild of the corresponding carbonyl compound (Table 1, ertry 1).

In order to show the applicability and generality of this method we have examined the reaction of benzylic, allylic and aliphatic oximes, phenylhydrazones, semicarbazones and thiosemicarbazones with $(CTA)_2S_2O_8$ in refluxing acetonitrile (Scheme I).

The results are tabulated in Table 2. As indicated in this Table, varieties of C=N derivatives are converted to the parent C=O compounds in excellent yeild under optimum reactions condition (Table 2, entries 1-34). It is noteworthy that, unlike other oxidative hydrolytic methods, the major drawback of overoxidation of the resulting aldehydes, is not observed under the reaction conditions. Interestingly the α,β-unsaturated derivatives underwent deprotection

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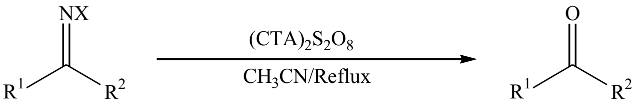
Table 1. Deprotection of C=N derivatives of benzaldehyde under different conditions using CTAP

Entry	Solvent	Temperature	Mole ratio (Substrate/Reagent)	Reaction period (min)	Yield (%)[a]
1	CH_3CN	Reflux	1:1	2	92-98
2	CH_3CN	Reflux	1:2	2	92-98
3	CH_3CN	Reflux	1:0.5	2	75-80
4	CH_3CN	r.t	1:1	60	20-30
5	CH_3CN	r.t	1:2	60	20-30
6	CH_3CN	r.t	1:0.5	60	5-10
7	C_3H_6O	Reflux	1:1	10	75-90
8	C_3H_6O	Reflux	1:2	10	75-90
9	C_3H_6O	Reflux	1:0.5	10	30-50
10	C_3H_6O	r.t	1:1	60	10-15
11	C_3H_6O	r.t	1:2	60	10-15
12	C_3H_6O	r.t	1:0.5	60	0-5
13	THF	Reflux	1:1	60	60-75
14	THF	r.t	1:1	60	0
15	CH_2Cl_2	Reflux	1:1	60	35-50
16	CH_2Cl_2	r.t	1:1	60	0
17	$CHCl_3$	Reflux	1:1	60	20-30
18	$CHCl_3$	r.t	1:1	60	0
19	n-C_6H_6	Reflux	1:1	60	5-10
20	n-C_6H_6	r.t	1:1	60	0

[a] Yields refer to isolated products.

Scheme I



X = OH, NHC_6H_5, $NHCONH_2$, $NHCSNH_2$
R^1 = Alkyl, Aryl, Vinyl
R^2 = Alkyl, Aryl, H
$(CTA)_2S_2O_8$ = Cetyltrimethylammonium peroxodisulfate

very efficiently without affecting the olefinic bond and the reaction is essentially chemoselective (Table 2, entries 13, 22, 28, 34). Furthermore, functional groups such as chloro, bromo, methoxy, hydroxy, nitro, and alkyl were also inert to this reagent and no byproduct formation was observed (Table 2, entries 3-9, 15-19, 24-26, 30-32).

To show the advantage and drawbacks of this method we have compared some of our results with those reported in the literature. As indicated in the Table 3, $(CTA)_2S_2O_8$ compared to the other reagents, performs this transformation in higher yield, shorter reaction times, and milder reaction conditions.

In conclusion, we have developed an efficient method for the regeneration of carbonyl compounds from oximes, phenylhydrazones, semicarbazones and thiosemicarbazones that possess significant advantages over the existing methods such as simple procedure, high yield and mild reaction conditions.

EXPERIMENTAL SECTION

Products were isolated and their physical data were compared with those of known samples. Solvents were freshly distilled. Oximes, phenylhydrazones, semicarbazones and thiosemicarbazones were prepared according to the described procedure.[17]

Preparation of Cetyltrimethylammonium Peroxodisulfate, $[(CH_3(CH_2)_{14}N(CH_3)_3)]_2S_2O_8$, $(CTA)_2S_2O_8$

To a solution of hexadecyl trimethylammonium bromide (3.7 g, 10 mmol) in 75 mL of water $K_2S_2O_8$ (1.3 g, 5 mmol) in 100 mL of water was added dropwise and the reaction mixture was stirred for 20 min at room temperature. A white solid was formed. The precipitate was filtered, washed with cold distilled water (50 mL) and dried under vacuum over calcium chloride to afford a white powder. The yield of $(CTA)_2S_2O_8$ was 92%; it decomposes at 125 °C to a light brown material.

Table 2. Deprotection of oximes, phenylhydrazones, semicarbazonees and thiosemicarbazones with $(CTA)_2S_2O_8$ in acetonitrile at reflux

Entry	Substrate	t/min	Products[a]	Yield (%)[b]
1	$C_6H_5CHNNHC_6H_5$	2	C_6H_5CHO	96
2	$(C_6H_5)_2CNNHC_6H_5$	22	$(C_6H_5)_2CO$	90
3	*o*-$ClC_6H_4CHNNHC_6H_5$	24	*o*-ClC_6H_4CHO	87
4	*p*-$ClC_6H_4CHNNHC_6H_5$	15	*p*-ClC_6H_4CHO	95
5	*o*-$MeC_6H_4CHNNHC_6H_5$	25	*o*-MeC_6H_4CHO	94
6	*m*-$MeOC_6H_4CHNNHC_6H_5$	20	*m*-$MeOC_6H_4CHO$	93
7	*p*-$HOC_6H_4CHNNHC_6H_5$	8	*p*-HOC_6H_4CHO	96
8	5-Br, 2-$HOC_6H_3CHNNHC_6H_5$	8	5-Br, 2-HOC_6H_3CHO	93
9	$C_6H_5C($*p*-$ClC_6H_4)NNHC_6H_5$	25	$C_6H_5($*p*-$ClC_6H_4)CO$	95
10	$C_6H_5CH_2CHNNHC_6H_5$	60	$C_6H_5CH_2CHO$	75
11	$(CH_3(CH_2)_5)(CH_3)CNNHC_6H_5$	60	$(CH_3(CH_2)_5)(CH_3)CO$	60
12	$(C_6H_5CHCH)_2CNNHC_6H_5$	30	$(C_6H_5CHCH)_2CO$	92
13	$C_6H_5(CH)_2CHNNHC_6H_5$	25	$C_6H_5(CH)_2CHO$	88
14	C_6H_5CHNOH	20	C_6H_5CHO	93
15	*p*-$MeOC_6H_4CHNOH$	22	*p*-$MeOC_6H_4CHO$	92
16	*p*-ClC_6H_4CHNOH	24	*p*-ClC_6H_4CHO	92
17	*p*-$NO_2C_6H_4CHNOH$	35	*p*-$NO_2C_6H_4CHO$	69
18	$C_6H_5C($*p*-$ClC_6H_4)NOH$	12	$C_6H_5($*p*-$ClC_6H_4)CO$	90
19	*p*-$ClC_6H_4C(CH_2CH_3)NOH$	22	*p*-$ClC_6H_4COCH_2CH_3$	94
20	$(C_6H_5)_2CNOH$	35	$(C_6H_5)_2CO$	90
21	$C_6H_5CH_2CHNOH$	60	$C_6H_5CH_2CHO$	45
22	$C_6H_5(CH)_2CHNOH$	40	$C_6H_5(CH)_2CHO$	80
23	$C_6H_5CHNNHCONH_2$	15	C_6H_5CHO	96
24	*p*-$MeOC_6H_4CHNNHCONH_2$	19	*p*-$MeOC_6H_4CHO$	93
25	*p*-$ClC_6H_4CHNNHCONH_2$	22	*p*-ClC_6H_4CHO	94
26	*p*-$ClC_6H_4C(CH_2CH_3)NNHCONH_2$	28	*p*-$ClC_6H_4CO\ CH_2CH_3$	90
27	$C_6H_5CH_2CHNNHCONH_2$	60	$C_6H_5CH_2CHO$	70
28	$C_6H_5(CH)_2CH\ NNHCONH_2$	40	$C_6H_5(CH)_2CHO$	80
29	$C_6H_5CHNNHCSNH_2$	15	C_6H_5CHO	97
30	*p*-$MeOC_6H_4CHNNHCSNH_2$	18	*p*-$MeOC_6H_4CHO$	96
31	*p*-$ClC_6H_4CHNNHCSNH_2$	20	*p*-ClC_6H_4CHO	91
32	*p*-$ClC_6H_4C(CH_3)NNHCSNH_2$	25	*p*-$ClC_6H_4COCH_3$	87
33	$C_6H_5CH_2CHNNHCSNH_2$	60	$C_6H_5CH_2CHO$	73
34	$C_6H_5(CH)_2CHNNHCSNH_2$	40	$C_6H_5(CH)_2CHO$	80

[a] All the products were characterized by comparison of their IR and ^1H NMR spectra with authentic samples.[17] [b] Yields refer to isolated products.

Table 3. Deprotection of oximes, phenylhydrazones, semicarbazones and thiosemicarbazones by $(CTA)_2S_2O_8$ in comparison with other reagents

Substrate	Reagent	Reagent:Sustrate (mol ratio)	Time (min)	Temp/Solvent	Yield	Ref.
$C_6H_5CHNNHC_6H_5$	$(CTA)_2S_2O_8$	1:1	2	Reflux/CH_3CN	96	
C_6H_5CHNOH			20		93	
$C_6H_5CHNNHCONH_2$			15		96	
$C_6H_5CHNNHCSNH_2$			15		97	
$C_6H_5CHNNHC_6H_5$	2,6-DCPFC[a]	1:1	16	r.t/CH_3CN	96	18
C_6H_5CHNOH			20		93	
$C_6H_5CHNNHCONH_2$			15		97	
$C_6H_5CHNNHC_6H_5$	Caro's Acid/Silica Gel	3:1	120	Reflux/CH_2Cl_2	95	15(e)
$C_6H_5CHNNHCONH_2$			20		100	
$C_6H_5CHNNHCONH_2$	ACC[b]/Alumina	1:1	240	Reflux/CH_2Cl_2	72	19
C_6H_5CHNOH	3-CPCC[c]	2:1	60	Reflux/CH_2Cl_2	85	3(b)

[a] 2,6-dicarboxypyridinium fluorochromate. [b] Ammonium chlorochromate. [c] 3-Carboxypyridinium chlorochromate.

General Procedure for Deprotection of Oximes, Phenylhydrazones, Semicarbazones and Thiosemicarbazones with $(CTA)_2S_2O_8$

In a round-bottomed flask (50 mL) equipped with a magnetic stirrer, a mixture of the substrate (1 mmol) in CH_3CN (5 mL) and $(CTA)_2S_2O_8$ (1 mmol) was placed. The and stirred at reflux temperature for the specified time (Table 2). The progress of the reaction was monitored by TLC. After the reaction was completed the mixture was filtered, and the solid material was washed with diethyl ether (2 × 10 mL). The combined filtrate was evaporated under reduced pressure to afford pure carbonyl compound in 45-97%. If necessary, the products were further purified on a silica-gel plate or silica-gel column with appropriate eluent.

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