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Wet Silica-Supported Permanganate for the Cleavage of Semicarbazones and Phenylhydrazones under Solvent-Free Conditions

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Received February 19, 2003

Abstract: Wet silica-supported potassium permanganate was used as an inexpensive and efficient reagent for conversion of semicarbazones and phenylhydrazones to the corresponding carbonyl compounds under solid-state conditions.

Hydrazine derivatives of carbonyl compounds are highly crystalline and are used for the characterization and purification of carbonyl compounds.[1] Since, the regeneration of carbonyl compounds under mild conditions is important, extensive studies on the cleavage of these derivatives to the parent carbonyl compounds have been carried out.[2−8]

Over the last 2 decades, the use of solid supports has become popular due to their characteristic properties such as enhanced selectivity and reactivity, straightforward workup procedure, milder reaction conditions, and associated ease of manipulation.[9] Adsorption of potassium permanganate[10] on the surface of solid supports changes the selectivity and reactivity in various reactions.[11] We previously reported potassium permanganate supported on alumina for the oxidation of urazoles to triazolinediones,[12a] oxidation of alcohols to aldehydes and ketones under solvent-free conditions,[12b] oxidation of sulfides and thiols to sulfoxides and disulfides,[12c] the oxidative deprotection of trimethylsilyl and tetrahydropyranyl ethers and of ethylene acetals to the corresponding carbonyl compounds,[12d] and conversion of oximes to carbonyl compounds under solid-state conditions.[12e] There has also been increasing interest in reactions that proceed in the absence of solvent.[13,14] We now report potassium permanganate supported on wet silica gel as an inexpensive, selective, and efficient reagent for the oxidative cleavage of semicarbazones **1a**−**q** and phenylhydrazones **1r**−**y** to the corresponding carbonyl compounds **2a**−**y** under solvent-free conditions.

The oxidative cleavage of 3-methoxybenzaldehyde semicarbazone **1d** as a model compound with potassium permanganate failed in the absence of the supporting agent, even upon grinding for a prolonged period of time. The reaction carried out in the presence of dry alumina and silica gel indicated that wet silica gel is the most effective. Dry silica gel required longer time and gave lower yield (60%) whereas the yield of **2d** increased to 91% in the presence of premoistened reagent. The optimum molar ratio of substrate to oxidant (1:3) was determined for complete conversion of semicarbazones **1a**−**q** and phenylhydrazones **1r**−**y** to the corresponding carbonyl compounds **2a**−**y** while the reaction was incomplete with lesser amounts of reagent (i.e., 1:1, 1:2, and 1:2.5). The mechanism of the reaction and the role of wet silica gel are not clear for us at this stage.

In this method, oxidative cleavage is achieved by grinding a mixture of semicarbazones **1a**−**q** or phenylhydrazones **1r**−**y** (1 mmol) and potassium permanganate (3 mmol) supported on wet silica gel (3 g) in a mortar with a pestle under solvent-free conditions at room temperature. The reaction time is usually short (15−45 min) and isolation of product is straightforward (Table 1 and Scheme 1). It is very important to note that the procedure is effective for the selective cleavage of semi-

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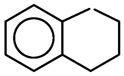
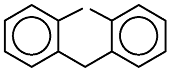
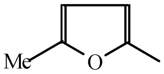
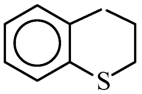
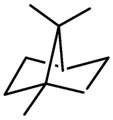
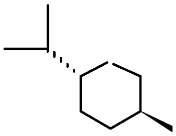
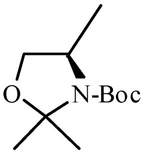
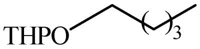
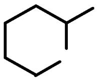
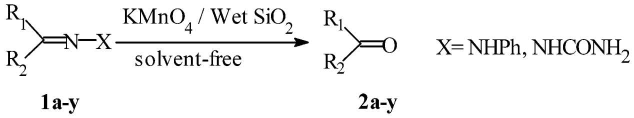
10.1021/jo034217y CCC: $25.00

TABLE 1. Conversion of Semicarbazones 1a–q and Phenylhydrazones 1r–y to the Carbonyl Compounds 2 Using $KMnO_4$/Wet SiO_2 under Solvent-Free Conditions[a]

substrate[b]	R$_1$	R$_2$	time (min)	yield (%)[c]	mp/°C or bp/°C/Torr (lit.[15,16])
1a	Ph	Me	15	90	200-202/760 (202)
1b	Ph	H	15	85	176-178/760 (178-179)
1c	3-ClC_6H_4	H	25	80	211-213/760 (213-214)
1d	3-MeOC_6H_4	H	20	91	141-143/50 (143)
1e	PhCH=CH	H	20	75	245-248/760 (248)
1f	4-BrC_6H_4	Me	25	70	49-52 (50-52)
1g	4-PhC_6H_4	Me	30	75	117-118 (116-118)
1h	4-Pyridyl	Me	20	80	210-212/760 (212)
1i	1-Naphthyl	H	15	78	160-162/15 (160-161)
1j		–	15	90	126-127/23 (127)
1k		–	15	88	82-84 (82-85)
1l		H	20	76	185-187/760 (187)
1m		–	25	91	153-154/12 (154)
1n		–	30	80	176-178 (175-177)
1o		–	45	85	207-209 (207-210)
1p		H	35	81	95-97/1.5 (83-88/1.4)
1q		H	45	82	124-126 (125-127)
1r[d]	3-MeOC_6H_4	H	40	70	141-143/50 (143)
1s[d]	3,4-$(MeO)_2C_6H_3$	H	25	77	82 (81-83)
1t[d]	Ph	H	30	72	176-178/760 (178-179)
1u[d]	Ph	Me	30	70	200-202/760 (202)
1v[d]	2-HOC_6H_4	H	40	85	196-199/760 (197)
1w[d]	4-HO$(CH_2)_2C_6H_4$	Me	45	78	128-130/0.4 (121-124/0.3)
1x[d]	4-HOC_6H_4	H	40	90	118-119 (117-119)
1y	4-$No_2C_6H_4$	H	25	90	106-107 (106-107)
1z[d]	4-$No_2C_6H_4$	H	25	98	106-107 (106-107)
1z'[d]		–	45	82	98-100 (97-102)

[a] Confirmed by comparison with authentic samples (IR, TLC. and ^{1}H NMR).[2–8,15–17] [b] Semicarbazones (X = NHCONH_2) unless otherwise noted. [c] Yield of isolated pure product after purification. [d] Phenylhydrazones (X = PhNH).

SCHEME 1



carbazones of complex molecules such as sterically hindered camphor **1n** and menthon **1o**. Other derivatives bearing acid-sensitive as well as base-sensitive functional groups such as *t*-butoxycarbonyl group **1p**, tetrahydropyranyl ether **1q**, and aliphatic or aromatic hydroxy groups **1v**−**1y** remain intact under the reaction conditions. Interestingly, the α,β-unsaturated derivatives such as cinnamaldehyde semicarbazone **1e** underwent oxidative cleavage very efficiently without affecting the C=C bond. Cleavage of thiochroman-4-one derivative **1m** to **2m** is readily carried out without oxidation of the sulfide group. However, the oxidative cleavage of 2,4-dinitrophenylhydrazones and azines failed by this method. As is shown in Table 1 the substitution on R_1 and R_2 does not effect the yield of products. However this method will only work when X = NHPh or $NHCONH_2$. Therefore this methodology offers a simple, inexpensive, and selective route for converting semicarbazones and phenylhydrazones to the corresponding carbonyl compounds.

In conclusion, it is important to note that this simple and easy method under solid-state conditions offers carbonyl compounds from their derivatives in a shorter reaction period using wet silica-supported potassium permanganate. Moreover, the oxidative cleavage of these derivatives takes place at room temperature in the absence of solvent. Also, this oxidation system is able to convert complicated semicarbazones in the presence of other oxidizable functional groups to parent carbonyl compounds.

Experimental Section

General Methods. Yields refer to isolated products after purification. The products were characterized by comparing their spectral (IR, ^{1}H NMR), TLC, and physical data with those of authentic samples.[2−8,15−17] All ^{1}H NMR spectra were recorded at 90 and 300 MHz in $CDCl_3$ relative to TMS as an internal standard. All reactions were carried out under solvent-free conditions at room temperature. Silica gel 60 (230−400 mesh) was obtained commercially.

Typical Procedure for Oxidative Cleavage of Semicarbazones and Phenylhydrazones. Wet silica gel was prepared by shaking silica gel (20 g, 230−400 mesh) with distilled water (5 mL). The reagent was prepared by mixing $KMnO_4$ (3 mmol, 0.48 g) with wet silica gel (3 g) using a pestle and mortar until a fine, homogeneous, and purple powder was obtained. A mixture of acetophenone semicarbazone **1a** (1 mmol, 0.177 g) and $KMnO_4$/wet SiO_2 (3 mmol, 3.48 g) was ground with a pestle in a mortar until TLC showed complete disappearance of starting material, which required 15 min (Table 1). Cyclohexane (2 × 15 mL) was added to the reaction mixture and after vigorous stirring was filtered through a sintered glass funnel. The solvent was then evaporated under vacuum. Acetophenone **2a** was obtained in 90% yield (0.16 g), bp 200−202 °C/760 mmHg (lit.[15] bp 202 °C/760 mmHg). In the case of phenylhydrazones **1r**−**y**, the crude product after evaporation of the solvent was purified by column chromatography on silica gel using a mixture of cyclohexane and ethyl acetate as eluent (90:10).

5-Methylfurfural (2l): δ 9.50 (s, 1H), 7.11 (d, J = 3.5 Hz, 1H), 6.20 (d, J = 3.5 Hz, 1H), 2.52 (s, 3H); IR (neat) υ 1695 (s), 1585 (s), 1565 (m), 1395 (s), 1197 (s), 1070 (m), 990 (m), 810 (s), 550 (w) cm^{-1}.

Thiochroman-4-one (2m): ^{1}H NMR ($CDCl_3$) δ 8.20 (d, 1H), 7.60−7.21 (m, 3H), 2.90 (t, 3H), 2.40 (t, 3H); IR (KBr) υ 3050 (w), 2900 (w), 1690 (s), 1600 (s), 1510 (s), 1220 (m), 720 (s) cm^{-1}.

L-Oxazolidine aldehyde (2p): ^{1}H NMR ($CDCl_3$) δ 9.55 (bs, 1H), 3.96−4.00 (m, 1H), 3.91 (dd, J = 8.8 and 2.8 Hz, 1H), 3.74 (dd, J = 8.8 and 8.3 Hz, 1H), 1.53 (bs, 3H), 1.40 (bs, 3H), 1.34 (s, 9H); IR (neat) υ 1735, 1700 cm^{-1}.

Acknowledgment. We gratefully acknowledge the funding support received for this project from the Isfahan University of Technology (IUT), IR Iran (A. R. H.), and Grant GM 33138 (A. E. R.) from the National Institutes of Health.

JO034217Y

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