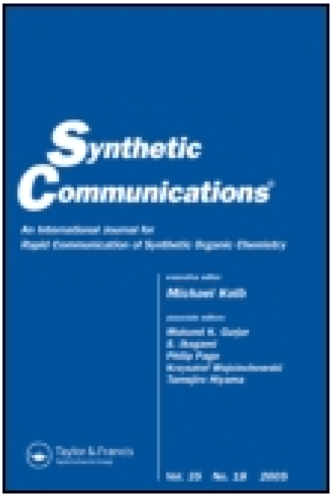

Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/lsyc20

γ-PCC and γ-PCC-SiO_2 as Efficient Reagents for Oxidation of Thiols to Disulfides

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To cite this article: Mohammad Mehdi Khodaei, Peyman Salehi, Maryam Goodarzi & Ateesa Yazdanipour (2004) γ-PCC and γ-PCC-SiO_2 as Efficient Reagents for Oxidation of Thiols to Disulfides, Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry, 34:20, 3661-3666, DOI: 10.1081/SCC-200032406

To link to this article: http://dx.doi.org/10.1081/SCC-200032406

SYNTHETIC COMMUNICATIONS®
Vol. 34, No. 20, pp. 3661–3666, 2004

γ-PCC and γ-PCC-SiO_2 as Efficient Reagents for Oxidation of Thiols to Disulfides

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ABSTRACT

Oxidative coupling of thiols to the corresponding symmetrical disulfides was performed in the presence of γ-picolinium chlorochromate and its silica gel supported. The reactivity of silica gel supported γ-picolinium chlorochromate for thiophenol derivatives is more than the reactivity of pyridinium and γ-picolinium chlorochromates.

Key Words: Disulfides; Oxidative coupling; γ-PCC-SiO_2; Thiols.

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DOI: 10.1081/SCC-200032406
0039-7911 (Print); 1532-2432 (Online)

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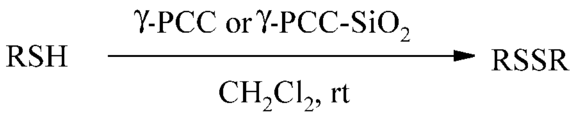
Selective oxidation of thiols to disulfides under mild conditions is important from both biological[1] and synthetic points of view.[2] Thiols can be easily overoxidized; therefore, extensive studies have been carried out for their control oxidation.[3–13]

Corey in 1975 introduced pyridinium chlorochromate (PCC) as an oxidizing agent for oxidation of primary and secondary alcohols.[14] Thenceforth, many chlorochromate reagents have been used for synthetic organic transformation.[15–19]

Recently we reported γ-picolinium chlorochromate (γ-PCC) as an efficient catalyst for different organic reactions, including the oxidation of alcohols to ketones and aldehydes,[20]deprotection of oximes,[21] and deprotection of acetals and ketals.[22] We now report the selective and efficient conversion of a number of thiols to disulfides by γ-PCC and silica gel supported γ-PCC under mild and nonaqueous conditions (Sch. 1).

Oxidative coupling of different types of mercaptans was investigated. First, commercially aromatic thiols have been used and coupled in dichloromethane at room temperature using γ-picolinium chlorochromate or silica gel supported γ-picolinium chlorochromate. Under these conditions, the mercaptans were selectively and efficiently oxidized to the corresponding disulfides in 0.3–2.2 h (Table 1, entries 1–6). Next, saturated linear and cyclic mercaptans were subjected to oxidation, and the yields and reaction times were satisfactory. 2-Hydroxyethanthiol did not oxidize in the presence of γ-PCC, and thiosalicylic acid did not proceed using γ-PCC or γ-PCC-SiO_2 (Table 1, entries 11 and 12). In all reactions, equimolar amounts of the catalyst were used, and no signs of overoxidation were observed. The selectivity of the present method was evident by the oxidation of 2-mercaptoethanol, where only mercaptan functionality was converted to the disulfide. The results show that the oxidation reaction in the presence of silica gel supported γ-PCC is faster than the reaction using γ-PCC. Also, the reactivity of aromatic thiols in the presence of γ-PCC-SiO_2 is more than the reactivity of arylthiols using PCC.[23]

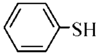
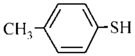
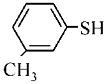
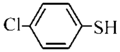
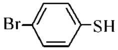
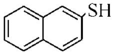
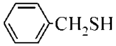
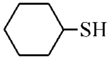
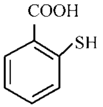
Summing up, the supported and unsupported γ-PCC efficiently and selectively oxidized thiols to the corresponding symmetrical disulfides. The supported γ-PCC is more reactive than γ-PCC and PCC when thiophenol and its derivatives are used.



$$\mathrm{RSH} \xrightarrow[\mathrm{CH_2Cl_2,\ rt}]{\gamma\text{-PCC or }\gamma\text{-PCC-SiO}_2} \mathrm{RSSR}$$

Scheme 1.

Table 1. Oxidation of thiols to disulfides by γ-PCC and γ-PCC-SiO_2.

		γ-PCC		γ-PCC-SiO_2		mp (°C) or bp (°C)/Torr	
Entry	Thiol	Time (h)	Yield (%)	Time (h)	Yield (%)	Found	Reported
1		0.6	85	1.0	85	60–61	60–61[24]
2		0.3	90	0.5	93	45–46	47–48[24]
3		0.7	90	1.0	91	−19	−20[8]
4		0.9	87	0.5	90	70–72	72–74[24]
5		0.6	94	1.0	91	90–92	92–95[24]
6		2.2	86	1.0	91	142–143	143–144[24]
7		2.8	83	4.0	95	70–71	71–72[24]
8		4.0	96	20.0	83	125–129	125–128[24]
9	$CH_3(CH_2)_7SH$	1.8	94	10.0	87	203–205/14	198–199/10[11]
10	$CH_3(CH_2)_3SH$	1.3	81	7.0	75	116–118/19	116–118/20[8]
11	$HOCH_2CH_2SH$	0.8	38	No reaction		139/0.8	140/0.8[9]
12		No reaction		No reaction			

EXPERIMENTAL

Products are known compounds and were characterized by comparison of their spectral data [hydrogen nuclear magnetic resonance (^{1}H-NMR), infrared (IR)] and physical properties with those reported in the literature. Monitoring of the reactions were accomplished by thin-layer chromatography (TLC) on precoated silica gel 60 F_{254} sheets. All yields refer to isolated products.

General Procedure for Oxidative Coupling of Thiols to Disulfides by γ-Picolinium Chlorochromate

To a solution of thiol (1 mmol) in dichloromethane (5 ml), γ-picolinium chlorochromate (1 mmol) was added, and the mixture was stirred magnetically at room temperature for the appropriate time (Table 1). The progress of the reaction was followed by TLC (eluent: methanol/acetic acid: 5/1). The mixture was then filtered on a sintered glass funnel, and the residue was washed with ether three times (each 15 ml). Solvent evaporation gave the corresponding disulfides, which were recrystallized from methanol to afford the pure products in 75–95% yields.

General Procedure for Oxidative Coupling of Thiols to Disulfides by Silica Gel Supported γ-Picolinium Chlorochromate

To a solution of thiol (1 mmol) in dichloromethane (5 ml), the oxidant (1 mmol) was added. The mixture was stirred magnetically at room temperature for the appropriate time (Table 1). The progress of the reaction was monitored by TLC (eluent: *n*-hexane/ethyl acetate: 5/1). The mixture was then filtered on a sintered glass funnel, and the residue was washed with dichloromethane (3 × 10 ml). Solvent evaporation gave the corresponding disulfides, which were recrystallized from methanol to afford the pure products in 38–96% yields.

ACKNOWLEDGMENT

We are grateful to the Research Council of Razi University for partly financially supporting this work.

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Received in the UK January 12, 2004