

Samarium triiodide mediated dethiocyanation of phenacyl thiocyanates and its application in carbon–carbon bond formation reactions[†]

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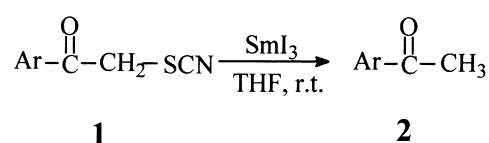
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Promoted by SmI₃, phenacyl thiocyanates can undergo efficiently dethiocyanation and thus give a samarium enolate intermediate. On treatment with water or aldehydes and water subsequently, this *in situ* generated intermediate can give acetophenones or α,β -unsaturated ketones respectively in high yields under mild conditions.

Keywords: samarium triiodide, dethiocyanation, phenacyl thiocyanates

In the last decades, the application of lanthanides in organic synthesis has been of great interest. In particular, a number of exciting samarium diiodide promoted synthetic transformations have been well documented.¹ In addition, the use of trivalent lanthanide compounds in organic chemistry has also increased rapidly in recent years. For example, lanthanide trichloride was used in combination with NaBH₄,² LiAlH₄,³ or Grignard reagents⁴ for selective reduction or alkylation of carbonyl compounds. Fukuzawa reported that CeI₃ or CeCl₃/NaI could promote the aldol type reaction of α -haloketones and aldehydes to give enones.⁵ We found that similar reactions could be efficiently promoted by SmI₃.⁶ More recently, we also found that samarium (III) iodide could promote Michael addition of active methylene compounds to α,β -unsaturated esters to form δ -carbonyl esters,⁷ and the condensation of α -diketones or α -ketoesters with aldehydes to form benzyldene-substituted α -diketones or α -ketoesters in fair yields.⁸

Reduction of α -heterosubstituted ketones has long been recognised as a useful synthetic transformation. Several distinct classes of heterosubstituted ketones have been used in such transformations in organic synthesis, and many different reducing agents have been utilized to accomplish the desired reduction. As important synthetic intermediates, α -haloketones, keto sulfides, keto sulfoxides and keto sulfones, together with thiocyanates, have found considerable utility in organic synthesis and these processes necessitate efficient methods for the removal of the sulfur-containing functional groups subsequent to the transformations. However, compared with the plentiful methods available for reduction of α -haloketones, keto sulfides, keto sulfoxides and sulfones to the corresponding unsubstituted ketones, to the best of our knowledge, only one example has been reported in literature to



Scheme 1

accomplish the desired reduction for phenacyl thiocyanates.⁹ Herein we wish to report that SmI₃ can promote dethiocyanation of phenacyl thiocyanates (**1**) to afford the corresponding unsubstituted ketones (**2**) in high yields under mild conditions (Scheme 1). The results are listed in Table 1.

From Table 1, we can see that phenacyl thiocyanates can undergo dethiocyanation and afford the corresponding ketones in high yields in the presence of SmI₃. All reactions are completed in a few hours at room temperature and thus this method has advantages over the reported method for the reductive dethiocyanation of phenacyl thiocyanates,⁹ in which the desired products have been obtained by means of controlled-potential reduction at a macro Hg cathode. Since keto thiocyanates have found considerable utility in organic synthesis and may be used in regioselective ketone alkylation reaction just as sulfides, keto sulfoxides and keto sulfones, our method may provide an alternative way for the removal of the thiocyanate group subsequent to the transformations.

With consideration of the isolation of sulfur from the reaction mixture as well as the reducing ability of I⁻ in dehalogenation of α -haloketones reported previously,¹¹ it could be concluded that the formation of ketone may proceed via a samarium(III) enolate intermediate **A** (Scheme 2), which would be formed through SmI₃ mediated removal of the thiocyanate group from the substrate (**1**). In this process, I⁻ as

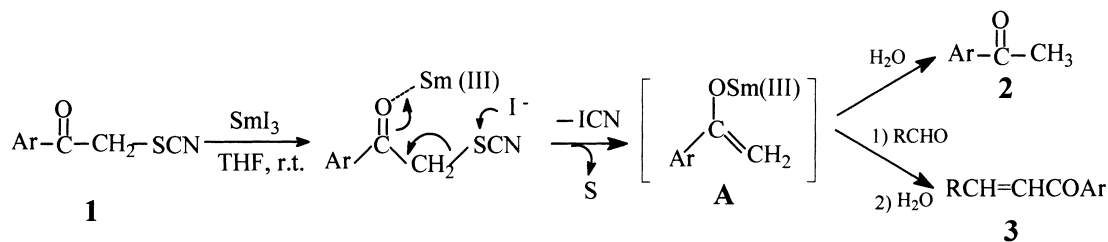
Table 1 Dethiocyanation of phenacyl thiocyanates promoted by SmI₃

Entry	Substrate product	Yield/% ^a	m.p./°C (lit.)
a	C ₆ H ₅ COCH ₂ SCN	C ₆ H ₅ COCH ₃ 92	Oil
b	4-CH ₃ C ₆ H ₄ COCH ₂ SCN	4-CH ₃ C ₆ H ₄ COCH ₃ 89	Oil
c	4-CH ₃ OC ₆ H ₄ COCH ₂ SCN	4-CH ₃ OC ₆ H ₄ COCH ₃ 87	Oil
d	4-BrC ₆ H ₄ COCH ₂ SCN	4-BrC ₆ H ₄ COCH ₃ 91	49–50 (51 ¹⁰)
e	4-ClC ₆ H ₄ COCH ₂ SCN	4-ClC ₆ H ₄ COCH ₃ 85	Oil

^aYields of isolated products, characterised by comparison with authentic samples (IR, ¹H NMR and TLC).

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[†] This is a Short Paper, there is therefore no corresponding material in *J. Chem. Research (M)*.

**Table 2** Carbon-carbon bond formation between phenacyl thiocyanates and benzaldehydes

Entry	Ar	R	Yield/% ^a	m.p./°C (lit.)
1	C ₆ H ₅	C ₆ H ₅	78	54–55 (55–56 ¹²)
2	C ₆ H ₅	4-CH ₃ C ₆ H ₄	76	90–91 (92–94 ¹²)
3	C ₆ H ₅	3-BrC ₆ H ₄	88	81–83 (83–85 ¹²)
4	C ₆ H ₅	4-ClC ₆ H ₄	87	110–111 (112–113 ¹²)
5	4-CH ₃ C ₆ H ₄	C ₆ H ₅	75	94–95 (96–97 ¹²)
6	4-CH ₃ C ₆ H ₄	4-CH ₃ C ₆ H ₄	65	94–95 (94–95 ¹²)
7	4-CH ₃ OC ₆ H ₄	C ₆ H ₅	63	103–105 (106–107 ¹²)
8	4-BrC ₆ H ₄	C ₆ H ₅	86	98–100 (100–102 ¹²)
9	4-ClC ₆ H ₄	C ₆ H ₅	82	96–98 (98–100 ¹²)
10	4-ClC ₆ H ₄	4-ClC ₆ H ₄	84	151–152 (152–154 ¹²)

^aYields of isolated products, characterised by comparison with authentic samples (m.p., IR, ¹H NMR)

a soft base and Sm(III) as a hard acid might act as the removing agent. The extruded thiocyanate group then decomposed with the assistance of I⁻ to give sulfur and ICN.

In our previous work, we have found that samarium(III) enolates formed through SmI₃ promoted dehalogenation of α -haloketones can undergo an aldol-like reaction with carbonyl compounds to give enones.⁶ This led us to study the one-pot preparation of α , β -unsaturated ketones through the reaction of phenacyl thiocyanates with aldehydes in the presence of samarium triiodide.

When equimolar of phenacyl thiocyanates and benzaldehyde or its derivatives were treated with one equivalent of SmI₃, the corresponding enones (**3**) could be obtained in high yields (Scheme 2). In these reactions, dethiocyanation, carbon-carbon bond formation and subsequent dehydration all occurred in one pot under mild conditions. The results are listed in Table 2.

Chalcones and their derivatives are important intermediates in organic synthesis.¹³ Moreover, many chalcone derivatives display interesting pharmacological and biological activities.¹⁴ Usually, the preparation of enones is achieved with NaOH, KOH or Ba(OH)₂ in hydroalcoholic medium from benzaldehyde and ketones,¹⁵ but the use of a relatively strong base to effect dehydration and force the aldol condensation to completion is not always successful because the enones may undergo further condensation and lead to polymeric products. In our hands, chalcones can be obtained through a simple process, under mild and neutral conditions and in high yields. With these advantages, the above method may provide a new choice for the preparation of chalcones and their derivatives.

Experimental

Tetrahydrofuran was distilled from sodium-benzophenone ketyl immediately prior to use. Melting points were uncorrected. Infrared spectra were recorded on a Bruker Vector 22 spectrometer in KBr with absorption in cm⁻¹. ¹H NMR spectra were determined on a Bruker AC 90 spectrometer as CDCl₃ solutions.

General procedure for the dethiocyanation of phenacyl thiocyanates: Under anhydrous conditions, a mixture of powdered samarium (0.15 g, 1 mmol) and iodine (0.375 g, 1.5 mmol) in dry THF (20 ml) was stirred at room temperature until the samarium

disappeared. To the resulting pale yellow suspension of SmI₃ was added phenacyl thiocyanates (1 mmol). The mixture was stirred at room temperature for 2 h. At completion, the reaction mixture was poured onto 1 mol/l HCl (5 ml) and extracted with diethyl ether (3×15 ml). The combined extracts were washed subsequently with a saturated solution of Na₂S₂O₃ (15 ml) and a saturated solution of NaCl (15 ml) and dried over anhydrous Na₂SO₄. After evaporating the solvent under reduced pressure, the crude product was purified by preparative TLC on silica gel using ethyl acetate-cyclohexane (1:6) as eluent. The proposed structure of the product was confirmed by spectroscopic (IR, ¹H NMR) and chromatographic (TLC) methods.

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