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Barbier-type reactions of nitriles and alkyl iodides mediated by samarium(II) iodide in the presence of catalytic nickel(II) iodide

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Abstract

The samarium(II) iodide-mediated intermolecular Barbier-type reactions of nitriles and alkyl iodides have been investigated. In the presence of a catalytic amount of nickel(II) iodide, the reaction proceeded smoothly to provide the corresponding ketones. Amides also reacted to give ketones under the same Barbier-type conditions. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: samarium(II) iodide; Barbier reaction; nickel(II) iodides; nitriles; amides.

Samarium(II) iodide has been recognized as a versatile reagent in synthetic organic chemistry. The reactivity of this useful reagent has been exploited in a variety of ways. As a result, it has been accepted that functional groups such as esters, amides, or nitriles are tolerated in the normal reaction conditions under which THF is employed as a solvent. It is also known that the reactivity of samarium(II) iodide can be modified in the presence of suitable additives. Addition of metal salts as additives can modify the reactivity of this valuable reagent.¹ Among various metal salts, nickel(II) iodide has been shown to strongly increase the reactivity of samarium(II) iodide. Thus, the Kagan group has reported that in the presence of nickel(II) iodide, samarium(II) iodide promotes the intermolecular Barbier reaction between alkyl iodides and esters.² This reaction condition has been further applied to anhydrides.³ This discovery inspired us to investigate the application of the SmI₂/NiI₂ system to other functionalities.

Nitriles have been one of the most useful functionalities in organic chemistry. This group is stable under the usual conditions for samarium(II) iodide reactions (that is, THF as a solvent with or without the addition of HMPA). A literature survey revealed only a few reports on the intramolecular reaction between ketones and nitriles.⁴ Molander and co-workers have reported only one example of the intramolecular Barbier-type reaction between alkyl iodides and nitriles,⁵ in which they needed to add triphenylpiperidinophosphine oxide to achieve modest yields. No systematic studies on the Barbier-type reaction between alkyl iodides and nitriles, especially no report of the intermolecular Barbier-type reaction, has appeared. We wish to report our investigations of the intermolecular Barbier-type reaction of nitriles and alkyl iodides mediated by samarium(II) iodide in the presence of catalytic nickel(II) iodide (Eq. (1)).

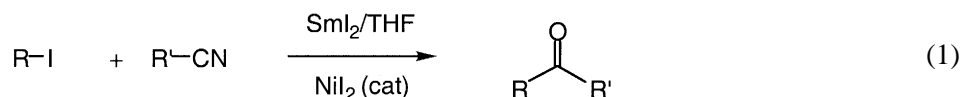
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Table 1
Reaction of alkyl iodides with nitriles under Barbier conditions mediated by $\text{SmI}_2/(\text{cat.}) \text{NiI}_2^{\text{a}}$

Entry	nitriles	RI	Product (Yield)
1	PhCN	$\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$	$\text{PhCOCH}_2\text{CH}_2\text{CH}_3$ (68%)
2	PhCN	$\text{Ph}(\text{CH}_2)_3\text{I}$	$\text{PhCO}(\text{CH}_2)_3\text{Ph}$ (67%)
3	$\text{PhCH}_2\text{CH}_2\text{CN}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$	$\text{Ph}(\text{CH}_2)_2\text{CO}(\text{CH}_2)_2\text{CH}_3$ (60%)
4	$\text{PhCH}_2\text{CH}_2\text{CN}$	$\text{Ph}(\text{CH}_2)_3\text{I}$	$\text{Ph}(\text{CH}_2)_2\text{CO}(\text{CH}_2)_3\text{Ph}$ (64%)
5 ^b	<i>p</i> -NCC ₆ H ₄ CN	$\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$	<i>p</i> -NCC ₆ H ₄ CO(CH ₂) ₂ CH ₃ (67%) + <i>p</i> -CH ₃ (CH ₂) ₂ COC ₆ H ₄ CO(CH ₂) ₂ CH ₃ (10%)
6 ^b	<i>m</i> -NCC ₆ H ₄ CN	$\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$	<i>m</i> -NCC ₆ H ₄ CO(CH ₂) ₂ CH ₃ (60%) + <i>m</i> -CH ₃ (CH ₂) ₂ COC ₆ H ₄ CO(CH ₂) ₂ CH ₃ (trace)
7 ^b	$\text{NC}(\text{CH}_2)_4\text{CN}$	$\text{Ph}(\text{CH}_2)_3\text{I}$	$\text{NC}(\text{CH}_2)_4\text{CO}(\text{CH}_2)_3\text{Ph}$ (33%)
8	<i>trans</i> -PhCH=CHCN	$\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$	<i>trans</i> -PhCH=CHCOCH ₂ CH ₂ CH ₃ (12%)
9	CH ₃ CN	$\text{Ph}(\text{CH}_2)_3\text{I}$	$\text{CH}_3\text{CO}(\text{CH}_2)_3\text{Ph}$ (35%)
10	PhCN	$\text{I}(\text{CH}_2)_3\text{CH}=\text{CH}_2$	$\text{PhCO}(\text{CH}_2)_3\text{CH}=\text{CH}_2$ (65%)
11	$\text{PhCH}_2\text{CH}_2\text{CN}$	$\text{I}(\text{CH}_2)_3\text{CH}=\text{CH}_2$	$\text{Ph}(\text{CH}_2)_2\text{CO}(\text{CH}_2)_3\text{CH}=\text{CH}_2$ (75%)

^aReaction conditions: 30 min at 0 °C unless otherwise indicated; 2.7 Equiv. of SmI_2 were used.

^bReaction started at 0 °C and gradually warmed to room temperature for 2 h. 4.8 Equiv. of SmI_2 were used.

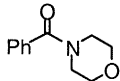


Samarium(II) iodide-promoted reactions of alkyl iodides with nitriles in the presence of nickel(II) iodide (catalytic amount) proceeded smoothly. Among the additives tested, NiI_2 (catalytic amount) provided the best results. $\text{Fe}(\text{DBM})_3$ also gave the ketones, albeit in lower yields.⁶ We also found that the addition of HMPA alone did not provide the desired products. The results of the Barbier-type reactions of nitriles with alkyl iodides by $\text{SmI}_2/\text{NiI}_2$ (cat.) are summarized in Table 1.⁷ Benzonitrile and alkyl nitriles reacted to give the desired ketones in moderate yields (entries 1–4). The reactions were performed at 0 °C and usually completed in 30 min. At temperatures lower than 0 °C no reaction or only slow reactions were observed. In the absence of additives no reaction occurred even when heated to reflux. More than two equiv. of samarium(II) iodide in THF were used to complete most of the reactions. Acetonitrile also provided the expected ketone when reacted with 3-phenylpropyl iodide although the yield was not high (entry 9). Compounds having two cyano groups have also been tested (entries 5 and 6). Both 1,4-dicyanobenzene and 1,3-dicyanobenzene gave the corresponding ketones as the major products with one nitrile group remaining intact. In these cases, the corresponding diketones were produced in minor amounts. Reacting adiponitrile with 3-phenylpropyl iodide offered the ketone, in which only one cyano group reacted, as the major product (entry 7). For these dicyano-substituted compounds, more than four

equiv. of samarium(II) iodide were employed to obtain reasonable yields. α,β -Unsaturated nitriles also gave the ketones, albeit in lower yield (entry 8). 4-Pentenyl iodide also reacted with nitriles to provide the expected ketones (entries 10 and 11).

After confirming the improved reactivity of samarium(II) iodide in the presence of nickel(II) iodide, we briefly investigated the reaction of amides and alkyl iodides under this condition. Amides also reacted to give the corresponding ketones. The results are shown in Table 2. More samarium(II) iodide (>4 equiv.) was required to complete the reactions with yields usually lower than those obtained from nitriles.

Table 2
Reaction of alkyl iodides with amides under Barbier conditions mediated by $\text{SmI}_2/(\text{cat.}) \text{NiI}_2^{\text{a}}$

entry	amides	RI	Products (Yield)
1	$\text{PhCON}(\text{CH}_3)_2$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$	$\text{PhCOCH}_2\text{CH}_2\text{CH}_3$ (40%)
2	$\text{CH}_3\text{CON}(\text{CH}_3)_2$	$\text{Ph}(\text{CH}_2)_3\text{I}$	$\text{CH}_3\text{CO}(\text{CH}_2)_3\text{Ph}$ (43%)
3		$\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$	$\text{PhCOCH}_2\text{CH}_2\text{CH}_3$ (48%)

^a 4.8 Equiv. of samarium(II) iodide were used.

In summary, we have found that the reactivity of samarium(II) iodide is improved in the presence of a catalytic amount of nickel(II) iodide. Successful intermolecular Barbier-type reactions of both nitriles and amides with alkyl iodides were achieved under this condition. This new method for the preparation of ketones, based on the enhanced reactivity of samarium(II) iodide, from nitriles or amides under mild conditions should have an important synthetic utility.

Acknowledgements

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References

- (a) Kagan, H. B.; Namy, J.-L. In *Lanthanides: Chemistry and Use in Organic Synthesis*; Kobayashi, S., Ed.; Springer, 1999; pp. 156–198. (b) Krief, A.; Laval, A.-M. *Chem. Rev.* **1999**, *99*, 745–777.
- Machrohi, F.; Hamann, B.; Namy, J.-L.; Kagan, H. B. *Synlett* **1996**, 633–634.
- Machrouchi, F.; Parlea, E.; Namy, J.-L. *Eur. J. Org. Chem.* **1998**, 2431–2436.
- (a) Kraus, G.; Sy, J. O. *J. Org. Chem.* **1989**, *54*, 77–83. (b) Kraus, G. A.; Wan, Z. *Tetrahedron Lett.* **1997**, *37*, 6509–6512.
- Molander, G. A.; McKie, J. A. *J. Org. Chem.* **1993**, *58*, 7216–7227.
- Molander, G. A.; McKie, J. A. *J. Org. Chem.* **1991**, *56*, 4112–4120.
- Typical procedure: Preparation of phenyl propyl ketone. A catalytic amount (1%) of NiI_2 was added to a solution of samarium(II) iodide in THF (1.35 mmol). To this solution was added a solution of benzonitrile (51.6 mg, 0.5 mmol) and iodopropane (170 mg, 1.0 mmol) in THF (4 mL) dropwise at 0°C. After stirring for 30 min at 0°C, the reaction mixture was quenched with Rochell's salt solution.⁸ Extraction with dichloromethane, drying (MgSO_4) and concentration followed by flash chromatography provided phenyl propyl ketone (50.4 mg, 68%).
- Schwaebe, M. K.; Little, R. D. *Synth. Commun.* **1997**, *27*, 837–840.