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A new ytterbium iodide mediated coupling of acyl cyanides and synthesis of 1,2-diketones

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Abstract—Conversion of acyl cyanides **1** into 1,2-diketones **2** has been achieved by the action of ytterbium iodide in dry tetrahydrofuran at room temperature, in high yields. © 2002 Elsevier Science Ltd. All rights reserved.

1,2-Diketones occupy a unique position in organic chemistry.[1] The chemistry of ytterbium/samarium continues to be the subject of intensive investigation and their use in the preparation of diketones has also been documented.[2,4a,b] Several methods for the synthesis of 1,2-diketones are reported in the literature which include acyloin condensation of esters with sodium metal and subsequent oxidation,[3] coupling of acid chlorides,[4] and multistep selenium dioxide oxidation of various monoketones.[5] 1,2-Diketones are also available through oxidative procedures such as the ene reaction of singlet oxygen with alkenes[6] in the presence of titanium alkoxide or by the oxidation of acetylenes with $NaIO_4/RuO_2$.[7] Recently, diethyl[1-alkyl(aryl)-1-(trimethylsiloxy)methyl]phosphonate in the presence of lithium diisopropylamide was also employed.[8] Low-valent titanium species generated from $LiAlH_4$–$TiCl_3$ transformed benzoyl chloride into tetraphenylfuran instead of a diketone.[9] Therefore, the practical application of these methods suffer from disadvantages such as the use of expensive or less easily available reagents, harsh reaction conditions, selectivity, general applicability, number of steps and tedious manipulation in the isolation of the pure products. Consequently, there is a need for the development of a protocol using readily available and safer reagents which lead to high yields of 1,2-diketones. Moreover, in recent years lanthanide metals, lanthanide metal salts and organolanthanide compounds have been widely employed as useful reagents or catalysts in organic synthesis. Since the pioneering studies by Kagan and co-workers demonstrated the particular effectiveness of ytterbium/samarium as a strong one-electron transfer reducing agent, the utilization of ytterbium reagents in synthetic organic chemistry has been comparatively less investigated.[10] We disclose herein, the first example of the coupling of acyl cyanides to form 1,2-diketones directly using ytterbium iodide in dry tetrahydrofuran. The reaction proceeds efficiently in high yields at room temperature and there was no evidence for the formation of any α-ketol type by-products (Scheme 1).

$$\underset{\mathbf{1}}{\mathrm{RCOCN}} \xrightarrow{\mathrm{YbI_2/MgI_2/THF}} \underset{\mathbf{2}}{\mathrm{RCOCR}}$$

Scheme 1.

In a typical procedure, benzoyl cyanide (0.13 g, 1 mmol) dissolved in dry tetrahydrofuran (5 ml) under nitrogen was added slowly to a solution of ytterbium (0.17 g, 1 mmol) and iodine (0.50 g, 2 mmol) in tetrahydrofuran (10 ml) and stirred at room temperature for 5 h. The progress of the reaction was monitored by TLC. After completion of the reaction dilute HCl was added and product extracted with diethyl ether (3×20 ml). The combined ether extract was washed with sodium bicarbonate solution, sodium thiosulphate solution, dried over anhydrous sodium sulphate, and concentrated under reduced pressure to afford the crude product which on further purification by column chromatography using chloroform/pet. ether (3:1) as eluent afforded the 1,2-diketone **2a** in 80% yield. Similarly keto cyanides **1b–i** were reacted and the corresponding 1,2-diketones were obtained in 70–82% yields. The structures of the diketones were unambiguously identified on the basis of their spectral data (IR, NMR, MS). The results and scope of this reaction are

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Keywords: ketocyanides; 1,2-diketones; ytterbium iodide; magnesium iodide.

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Table 1. YbI_2/MgI_2 mediated coupling of acyl cyanides into 1,2-diketones

Entry	R	Reaction time (h) YbI_2	Yield[a] (%) of **2**	Reaction time (h) MgI_2	Yield (%) of **2**
1a	C_6H_5	5	80	6	75
1b	4-ClC_6H_4	6	75	7	76
1c	4-IC_6H_4	7	78	8	75
1d	$PhCH_2$	7	75	8	76
1e	4-MeC_6H_4	6	82	7	78
1f	4-$NO_2C_6H_4$	6	75	8	75
1g	4-$MeOC_6H_4$	5	78	6	75
1h	4-$MeOOCC_6H_4$	6	70	8	70
1i	n-C_8H_{11}	8	70	9	60

[a] All the yields refer to isolated chromatographically pure compounds.

shown in Table 1. Aliphatic acyl cyanide **1i** was also coupled with YbI_2 to directly form the 1,2-diketone, however, the reaction completion time was about 9 h. Further increase of reaction time gave no significant improvement, rather decomposition of starting materials occurred. When ytterbium iodide is replaced by inexpensive magnesium iodide the coupling proceeded effectively and the corresponding diketones were obtained in almost comparable yields. In most cases the reaction was over within 5–7 h with ytterbium iodide, however, the reaction takes a little more time with magnesium iodide. Enhancing further the reaction time gave no improvement in yield but rather formation of the corresponding benzoin occurred. Furthermore, the reaction conditions are tolerant of the ester group (entry **1h**) and the ether group (entry **1g**). Also, aromatic halides showed remarkable selectivity to give the diketone without any dehalogenation (entries **1b** and **1c**) or formation of complex mixtures. Moreover, aromatic nitro compounds which are known to be reduced by iron carbonyl[11] coupled with ease with ytterbium iodide to give the corresponding diketones in 75% yield without any reduction of the nitro group.[12] More detailed studies aimed at expanding the scope of this reaction and to understand its mechanism are in progress.

In conclusion, we have provided a novel and efficient method for the coupling of keto cyanides into 1,2-diketones employing ytterbium and magnesium iodide in dry THF, which involves a simple work-up and will make a useful and important addition to the existing methodologies. This new procedure has the advantages such as mild reaction conditions, lack of side products and better yields than the classical methods and above all the method is highly selective.

References

1. Inamoto, T. In *Comprehensive Organic Synthesis*; Trost, B. M.; Fleming, I., Eds.; Pergamon: Oxford, 1991; Vol. 4, pp. 231–250 and pp. 251–282.
2. Molander, G. A. *Chem. Rev.* **1992**, *92*, 29–68.
3. McElvain, S. M. *Org. React.* **1948**, *4*, 256.
4. Using samarium diiodide to produce α-diketone and α-ketol see: (a) Gotard, P.; Countgoal, R.; Kagan, H. B.; *Tetrahedron Lett.* **1981**, *22*, 3959; (b) Souppe, J.; Namy, J.-L.; Kagan, H. B. *Tetrahedron Lett.* **1984**, *25*, 2869; using pyrophoric lead see: (c) Meszaros, I. *Tetrahedron Lett.* **1967**, 4951; using lithium wire and ultrasound see: (d) Han, H. B.; Boudjouk, P. *Tetrahedron Lett.* **1981**, *22*, 2757.
5. Rabyohn, N. *Org. React.* **1949**, *5*, 331.
6. Adam, W.; Goesbeck, A.; Stach, E. *Tetrahedron Lett.* **1986**, *27*, 2839.
7. (a) Zibuck, R.; Seebach, D. *Helv. Chim. Acta* **1988**, *71*, 237. For using zerovalent complexes of nickel/enneacarbonyl diiron see: (b) Flood. T. C. *Tetrahedron Lett.* **1977**, 3861; using beryllium metal powder in 40–50% yield see: (c) Lapkin, I. I.; Anvarovs, G. Y.; Povarnitsyna, T. N. *J. Gen. Chem., USSR (Eng-trans)* **1966**, *36*, 1945; yields are difficult to reproduce according to (d) Seebach, D. *Angew. Chem., Int. Ed.* **1969**, *8*, 639; footnote p. 641.
8. Olah, G. A.; An-harang, W. *J. Org. Chem.* **1991**, 902.
9. Dams, R.; Malinowski, M.; West drop, I.; Geise, H. J. *J. Org. Chem.* **1981**, *46*, 2406.
10. Girard, P.; Namy, J.-L.; Kagan, H. B. *J. Am. Chem. Soc.* **1980**, *102*, 2693.
11. Abbayes, H.; Alper, H. *J. Am. Chem. Soc.* **1977**, *99*, 98.
12. Several years ago we were investigating pentazocine synthesis via a Grignard reaction and we observed the dimerization of anisyl bromide to bianisyl with MgI_2 in quantitative yields. By analogy, we assume that the MgI_2 triggers the coupling of acyl cyanides to 1,2-diketones via a single electron transfer reaction.