SYNLETT Spotlight 228

Dimethyl Carbonate (DMC): A Versatile and Environmentally Benign Building Block

Compiled by Sunay V. Chankeshwara

This feature focuses on a reagent chosen by a postgraduate, highlighting the uses and preparation of the reagent in current research

Sunay V. Chankeshwara was born in 1981. He started studying chemistry in 2002 at the National Institute of Pharmaceutical Education and Research (NIPER), Punjab, India. Currently, he is working towards his PhD thesis under the tutelage of Prof. Asit K. Chakraborti. His primary research interests focus on the synthesis of bioactive small heterocyclic organic molecules and the development of environmentally benign procedures for their synthesis.

Department of Medicinal Chemistry, National Institute of Pharmaceutical Education and Research (NIPER), SAS Nagar, Punjab 160062, India.

E-mail: sunay_vc@yahoo.com

Dedicated to Prof. Asit K. Chakraborti

Introduction

Dimethyl carbonate (DMC) is a unique molecule with versatile chemical reactivity. In many aspects, DMC is an environmentally benign building block¹ because of its cheap commercial availability and high ecological safety profile; it possesses interesting solvating properties, low toxicity, and is highly biodegradable.²

Preparation

Originally, DMC was synthesized in a clean process of catalytic oxidative carbonylation of methanol in the presence of oxygen.³ Very recently, DMC was efficiently synthesized from methanol, propylene oxide, and CO₂,

catalyzed by recyclable organic/inorganic bases (Scheme 1).

Scheme 1

The versatile role of DMC as solvent,⁴ methoxycarbonylation agent,⁵ esterification⁶ and transesterification agent,⁷ green oxidant⁸ and selective methylating agent^{9–12} is summarized below.

Abstract

(A) *Solvent*: Environmentally friendly oxidations of various organic compounds with the H₂O₂/methyltrioxorhenium (MeReO₃, MTO) catalytic system have been performed in dimethyl carbonate as solvent. Oxidations proceeded with good conversions and in good yields. Spectrophotometric analysis demonstrated that the [MeReO(O–O)₂] complex was formed in dimethyl carbonate and that it was stable for several days at room temperature.⁴

(B) *N-Methoxycarbonylation Agent*: Primary and secondary aliphatic amines could react with DMC using ionic liquids as solvent and catalyst to give alkyl carbamates in good yields.⁵ The desired solid carbamate could be recovered by simple filtration from the two-layer mixture of DMC and ionic liquid. The formation of N-methylated and deammoniated products was restrained.

(C) *Esterification Agent*: An environmentally friendly process for the esterification of carboxylic acids with DMC can be accelerated (20–480-fold) by employing a combined strategy of microwave and using DBU as the catalyst. This approach provides synthetic advantages, niches, and upscalability.⁶

(D) *Trans-Esterification/Disproportionation Reaction*: Diphenyl carbonate (DPC) is considered a substitute for phosgene to synthesize polycarbonate resins. Trans-esterification of DMC with phenol in the presence of titanocene and other titanium complexes yields methyl phenyl carbonate (MPC), which gives DPC by further trans-esterification with DMC or the disproportionation.⁷

(E) *Oxidant*: In the remarkable reactions where DMC behaves as an oxidant cyclic ketones are transformed into α,ω -dimethyl esters⁸ with an atom efficiency of 1.0.¹³ DMC has a potential as valuable green oxidant for industrial application in reaction of cyclopentanone and cyclohexanone with DMC (or DEC) and a base (K_2CO_3) to yield adipic and pimelic methyl (or ethyl) esters, respectively.

(F) *N-Methylating Agent*: At 130–150 °C and in the presence of K_2CO_3 , *o*-aminophenol (**1**)⁹ and oximes (**2**)¹⁰ readily react with dimethyl carbonates to give the corresponding *N*-methylbenzoxazol-2-ones in high yields. This reaction is a rare example where dialkyl carbonates may simultaneously act as carbonylating and alkylating agents likely via a $B_{AC}2/B_{AL}2$ sequence. Moreover, DMC also serves as solvent. Methylation with DMC is often very selective and *N*-methylation of anilines is another example.

(G) *O-Methylating Agent*: DMC is a safe substitute for dimethyl sulfate or methyl halides. These conventional methylating agents are toxic and corrosive and give a stoichiometric amount of inorganic byproducts. Methylation of catechol with DMC as an alkylating agent has been carried out over calcined Mg–Al hydrotalcites with O-selectivity of 96.1% with a guaiacol selectivity of 84%.¹¹

(H) *C-Methylating Agent*: The most interesting and well-studied reaction, particularly in view of its selectivity, is the mono-C-methylation of arylacetonitriles and methyl arylacetates to produce monomethylated 2-arylpropionitriles and methyl 2-arylpropionates, respectively, with a selectivity of >99.5%. Further, DMC also proved to be the best solvent for such reactions. This reaction is interesting in view of the synthesis of anti-inflammatory drugs.¹²

References

- (1) Tundo, P.; Selva, M. *Acc. Chem. Res.* **2002**, *35*, 706.
- (2) Romano, U.; Rivetti, F.; Di Muzio, N. US Patent 4,318,862, **1979**; *Chem. Abstr.* **1981**, *95*, 80141w.
- (3) Tian, J.-S.; Miao, C.-X.; Wang, J.-Q.; Cai, F.; Du, Y.; Zhao, Y.; He, L.-N. *Green Chem.* **2007**, *9*, 566.
- (4) Bernini, R.; Mincione, E.; Barontini, M.; Crisante, F.; Fabrizic, G.; Gambacortad, A. *Tetrahedron* **2007**, *63*, 6895.
- (5) Sima, T.; Guo, S.; Shi, F.; Deng, Y. *Tetrahedron Lett.* **2002**, *43*, 8145.
- (6) Shieh, W.-C.; Dell, S.; Repi, O. *Tetrahedron Lett.* **2002**, *43*, 5607.
- (7) Gong, J.; Ma, X.; Wang, S. *Appl. Catal., A* **2007**, *316*, 1.
- (8) Selva, M.; Marques, C. A.; Tundo, P. *Gazz. Chim. Ital.* **1993**, *123*, 515.
- (9) Selva, M. *Synthesis* **2003**, 2872.
- (10) Marques, C. A.; Selva, M.; Tundo, P.; Montanari, F. *J. Org. Chem.* **1993**, *58*, 5765.
- (11) Jyothi, T. M.; Raja, T.; Talawar, M. B.; Rao, B. S. *Appl. Catal., A* **2001**, *211*, 41.
- (12) (a) Selva, M.; Marques, C. A.; Tundo, P. *J. Chem. Soc., Perkin Trans. 1* **1994**, 1323. (b) Loosen, P.; Tundo, P.; Selva, M. US Patent 5,278,533, **1994**.
- (13) Trost, B. M. *Science* **1991**, *254*, 1471.