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The Synthesis and Applications of Dibromoisocyanuric Acid (DBI) in Chemical Reactions

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Abstract

Halogenated organic substrats are extremely important in chemistry due to their roles in organic synthesis as starting compounds. Bromination is one of the most important transformations in organic synthesis and can be carried out using molecular bromine or bromine carrying agents. Dibromoisocyanuric acid (DBI) is one of the bromine carrying agents that plays important roles in synthetic chemistry and can bring about oxidations in organic molecules. In this mini review the synthesis methods of DBI and its excellent roles in synthetic organic chemistry reported.

Keywords: Dibromoisocyanuric acid, bromination, oxidation.

1. Introduction

The number of known halogenated natural products were fewer than 50 examples in 1968 and today is more than 5000 and they are steadily increasing (Gribble, 1996; 2010; 2007; 2012). Many of these compounds are bioactive compounds (Gribble 2012; 2015). Halogenated organic compounds play a very important role in chemistry, they are essential in organic synthesis as starting compounds and synthetic intermediates, as precursor molecules for material science, industrial chemicals and bioactive compounds (Podgorsek et al. 2009). The development of modern coupling reactions, such as the Suzuki-Miyaura and Mizoroki-Heck reaction, have greatly increased the demand for brominating compounds as starting materials which made bromination is fundamental transformation in organic chemistry (Dieck and Heck 1975; Miyaura and Suzuki 1979; Nicolaou et al. 2005). In the laboratory, however, halogenation is usually carried out with hazardous, toxic, and corrosive molecular halogens, and furthermore often performed in chlorinated solvents (Lenoir and Eissen 2008; Podgorsek et al. 2009).

There are more than twenty new alternative methods for bromination of alkenes and those have been evaluated taking into consideration their resource demands, waste production as well as environmental, health and safety aspects (Lenoir and Eissen 2008). In response to this situation many novel brominating reagents have been developed (Lenoir and Eissen 2008). Due to environmental problems involved in the manipulation of hazardous, toxic and corrosive halogens as well as not readily available alternative reagents used in such transformation, that methodology bromination with DBI becomes very attractive and consistent with green chemistry principles (Tozetti et al. 2007).

Synthesis of DBI

In 1967 Gottardi first reported the synthesis of DBI with an expensive silver salt in tedious methodology where silver cyanurate reacts with gaseous bromine at 150ºC to form the product along with silver bromine (Gottardi 1967). Another synthetic method for the obtaining of DBI reported by Gottardi, in 1968. According to this method, the synthesis of DBI was carried out by the reaction of cyanuric acid

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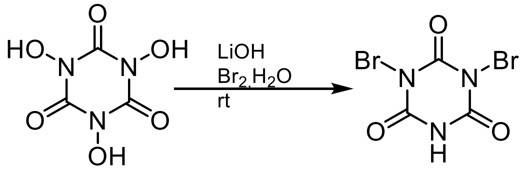
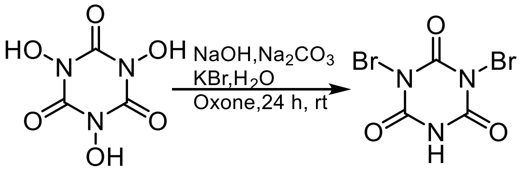
with a strong base LiOH and molecular bromine in water (Scheme 1) (Gottardi 1968).



Scheme 1

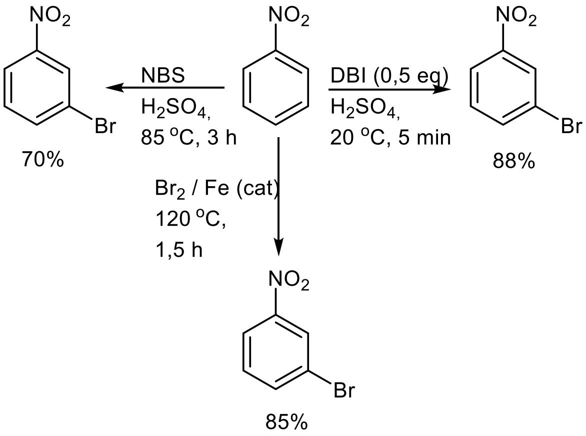
A simple one-step method for he preperation of dibromoisocyanuric acid developed by De Almeida and coworkers, in 2006. This methodology proved to be simpler and considerably less expensive than the preparation proposed by Gottardi (Scheme 2) (De Almeida 2006).



Scheme 2

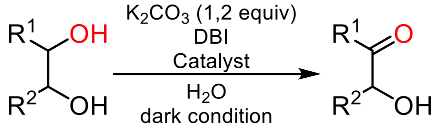
How Used DBI in Organic Reactions?

Firstly, Gottardi reported DBI as a highly effective brominating reagent when compare with NBS and molecular bromine at the same conditions (Scheme 3) (Gottardi 1968).



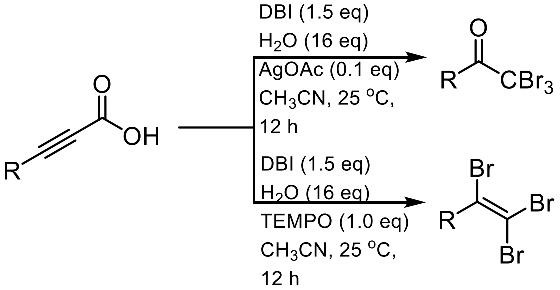
Scheme 3

DBI is also used selective oxidations of cyclic and acyclic 1,2-diols to α-hydroxyketones with the existence of calayst dimethyltin(IV)dichloride-catalyzed (Me_2SnCl_2) in water and in good to excellent yields. Also boronic acid used as a catalyst for selective oxidations of cyclic and acyclic 1,2-diols to α-hydroxyketones via their boronate esters and DBI as a terminal chemical oxidants (Scheme 4) (William *et al.* 2014).



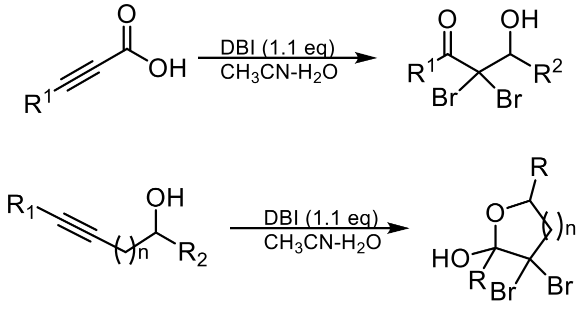
Scheme 4

In the presence of DBI, an effective and interesting transformation about selective synthesis of tribromomethyl ketone and tribromovinyl derivatives from decarboxylative tribromination have been displayed by Lee and his coworkers. Besides DBI, in the presence of AgOAc (10 mol%), tribromomethyl ketone derivatives were successfully obtained in good yields. When the reaction was conducted in the presence of TEMPO, tribromovinyl derivatives were exclusively formed in good yields (Scheme 5) (Jayaraman *et al.* 2018).



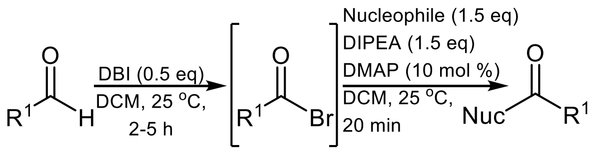
Scheme 5

Sheppard group used DBI in the dibromohydration of alkynols into dibromides in the optimum conditions than involved using 1.1 equiv. of DBI in a biphasic solvent system (water:acetonitrile) (Gibson et al. 2018). The required dibromohydration of propargylic alcohols was achieved efficiently using DBI (Virgil, 2001) under closely related conditions to their previously described di-chlorohydration reaction (D'Oyley et al. 2014). These useful building blocks were shown to be important to access structurally diverse halogenated molecules. Furthermore, dibromohydration of extended alkynols allowed access to dihalogenated tetrahydrofurans (Gibson et al. 2018). This method displayed the dibromohydration of alkynols to give dibromoketones (Scheme 6) that is applicable to a wide range of substrates, along with the extension of previous paper that reported dichlorohydration reaction to new substrates (D’Oyley et al. 2014).



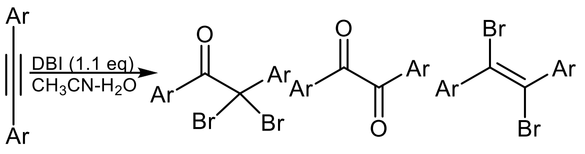
Scheme 6

DBI was interestingly used to conversion of aldehydes into esters and thioesters via an acid bromide intermediate species under mild conditions and being metal free (Kwon et al. 2018). These interesting organic transformations were performed in dichloromethane at room temperature afforded the acid bromides, and in the subsequent conversion, esters and thioesters was achieved through reaction of acid bromide and alcohols or thiols in the presence of DIPEA/DMAP (Scheme 7) (Kwon et al. 2018).



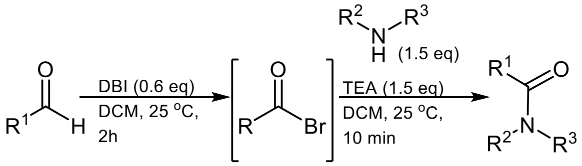
Scheme 7

The reaction of internal alkynes and DBI with the presence of water led to form α,α-dibromoketones, 1,2-diketones and 1,2-dibromoalkenes (Cho et al. 2019). DBI acts as both oxidant and bromide source and reacts with arylalkynes in the presence of water. The obtained products are highly dependent on the substituent on the aryl ring of the alkyne (Cho et al. 2019).



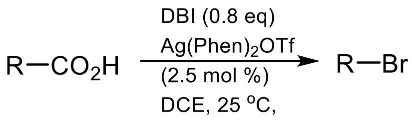
Scheme 8

In 1979 Cheung displayed to form acyl bromides from the oxidation of aldehydes by N-bromosuccinimide. After that, discovery in 2018, DBI was found also suitable for performing that transformations a facile synthesis of amides from aldehydes via acyl bromide intermediates (Kang et al. 2018). The reaction investigated on both aliphatic and aromatic aldehydes, as well as investigating primary amines, secondary amines and anilines (Scheme 9) (Kang et al. 2018).



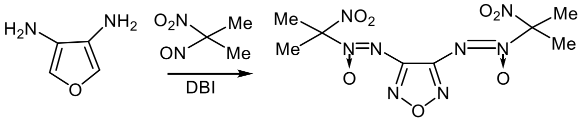
Scheme 9

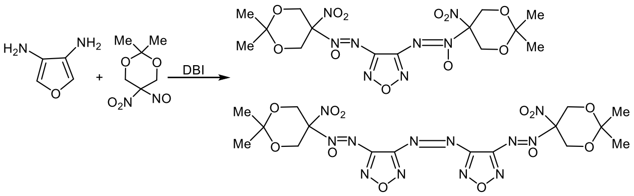
The silver catalysed Hunsdiecker bromination on a broad range of carboxylic acids yielding alkyl and benzyl bromides, described by Li, in 2017. DBI was discovered as the best brominating source when compare with NBS and 1,3-dibromo-5,5-dimethylhydantoin (DBH) When NBS was utilized, no reaction occurred, and only trace amounts of product formed when employing DBH. A silver-catalyzed radical process (2.5 mol% of $\text{Ag(Phen)}_2\text{OTf}$) was discovered by Li and coworkers, was optimum even using mild conditions (Scheme10) (Tan et al. 2017).



Scheme 10

Luk’ yanov’s research group carried out the transformation of heterocyclic amines into azo compounds in the presence of DBI. The reaction of pseudonitroles and their derivatives with diaminofurazan in the presence of DBI resulted in symmetrical 3,4-bis-(αnitroalkyl-*ONN*-azoxy) furazans or their derivatives (Scheme 11) (Semenov et al. 1991; Luk’ yanov et al. 2012; .2015; 2015; Parakhin et al. 2016).





Scheme 11

2. *Conclusion*

The synthesis of dibromoisocyanuric acid and its remarkable applications in chemical reactions have been reported in this review. DBI is used effectively transformation of cyclic and acyclic 1,2-diols to α-hydroxyketones, and also used interesting transformation about selective synthesis of tribromomethyl ketone and tribromovinyl derivatives from decarboxylative tribromination. The conversion of aldehydes into esters and thioesters via an acid bromide are carried out interestingly even mild conditions with the presence of DBI. Dibromohydration of alkynols to dihalogenated tetrahydrofurans and dibromoketones is performed with DBI. Furthermore, transformation of internal alkynes to α,α-dibromoketones, 1,2-diketones and 1,2-dibromoalkenes, synthesis of amides from aldehydes via acyl bromide intermediates, synthesis of alkyl and benzyl bromide from carboxylic acids and transformation of heterocyclic amines into azo compounds can be effectively accomplished with the presence of DBI.

References

CHO, E., JAYARAMAN, A., LEE, J., KO, K. C., LEE, S. (2019). Substituent effect in the synthesis of α,α-dibromoketones, 1,2-dibromalkenes, and 1,2-diketones from the reaction of alkynes and dibromoisocyanuric acid. *Adv. Synth. Catal*., 361,1846–1858.

CHEUNG, Y.-F. (1979). N-bromosuccinimide: direct oxidation of aldehydes to acid bromides. *Tetrahedron Lett.* 20, 3809–3810.

DE ALMEIDA, L. S., ESTEVES, P. M.,. DE MATTOS, M. C. S. (2006). Tribromoisocyanuric Acid: A New Reagent for Regioselective Cobromination of Alkenes, *Synthesis* , 2, 221.

DIECK, H. A. and HECK, R. F., (1975). Palladium-catalyzed Conjugated Diene Synthesis of from Vinylic Halides and Olefinic Compound. *J. Org. Chem*., 40, 1083–1090**.**

D'OYLEY, J. M., ALIEV, A. E., SHEPPARD, T. D. (2014). Regioselective Dihalohydration Reactions of Propargylic Alcohols: Gold-Catalyzed and Noncatalyzed Reactions *Angew. Chem. Int. Ed.* 53, 10747–10750;

D'OYLEY, J. M., ALIEV, A. E., SHEPPARD, T. D. (2014). Regioselective Dihalohydration Reactions of Propargylic Alcohols: Gold-Catalyzed and Noncatalyzed Reactions. *Angew. Chem*. 2014, 126, 10923–10926.

EISSEN, M. and LENOIR, D. (2008). Electrophilic Bromination of Alkenes: Environmental, Health and Safety Aspects of New Alternative Metots. *Chem-Eur J.*,14, 9830-9841.

GIBSON, S. M., D'OYLEY, J. M., HIGHAM, J. I., SANDERS, K., LASERNA, V., ALIEV, A. E., SHEPPARD, T. D. (2018). *Eur. J. Org. Chem.* 4018–4028

GOTTARDI, W. (1967). Uber die reaktion von brom mit silbercyanuraten. *Monatsh. Chem*..,98, 1613–1617.

GOTTARDI, W., (1968). Uber Bromierungen mit Dibromoisocyanursiiure unter ionischen Bedingungen, 1. Mitt: Monobromierungen Von. *Monatsh. Chem.* 99, 815–822.

GOTTARDI, W., (1977).Zur chemic der bromisocyanursaure:Eigenschaften und reaktionen der dibromisocyanursaure *Monatsh. Chem*..,108, 1067–1084.

GRIBBLE, G.W. (1996). Naturally occurring organohalogen compounds-A comprehensive survey. *Prog. Chem. Org. Nat. Prod.*, 68, 1–496.

GRIBBLE, G.W. (2010). Naturally occurring organohalogen compounds-A comprehensive update. *Prog. Chem. Org. Nat. Prod.* , 91, 1-613.

GRIBBLE, G.W. (2012). Occurrence of halogenated alkaloids. In *The Alkaloids: Chemistry and Biology*; Knölker, H.-J., Ed.; Academic Press: Amsterdam, The Netherlands, 71,1–165.

GRIBBLE, G.W. (2012). Recently discovered naturally occurring heterocyclic organohalogencompounds.*Heterocycles*, *84*, 157–207.

GRIBBLE, G.W. (2015). Biological Activity of Recently Discovered Halogenated Marine Natural Products, Mar. Drugs,13, 4044-4136.

GRONOWITZ, S., STENHAMMAR, K., SVENSSON, L. (1981). Lithiation of some 3[2-(2’-bromophenyl)ethyl]thiophenes and intramolecular transmetalation. *Heterocycles* 1981, 15, 947–959.

JAYARAMAN, A., CHO, E., KIM, J., LEE, S. (2018). Decarboxylative Tribromination for the Selective Synthesis of Tribromomethyl Ketone and Tribromovinyl Derivatives. *Adv. Synth. Catal.* 360, 3978–3989.

KANG, S., LA, M. T., KIM, H.-K. (2018). Convenient metal-free direct oxidative amidation of aldehyde using dibromoisocyanuric acid under mild conditions. *Tetrahedron Lett.,* 59, 3541–3546.

KWON, Y.-D., LA, M. T., KIM, H.-K. (2018). Aerobic oxidative esterification and thioesterification of aldehydes using dibromoisocyanuric acid under mild conditions: no metal catalysts required† *New J. Chem.* 42(13), 10833–10841.

LUK’YANOV, O. A., POKHVISNEVA, G. V. TERNIKOVA, T. V. SHLYKOVA, N. I. (2012). 3,4-Bis(α-nitroalkyl-ONN-azoxy)furazans and some of their derivatives. *Russ. Chem. Bull.,Int. Ed.* 2012, 61, 360–365.

LUK’YANOV, O. A., POKHVISNEVA, G. V. TERNIKOVA, T. V. (2015). A novel method to access dinitromethyl-*ONN*-azoxy compounds. *Russ. Chem. Bull*. 64, 83–86.

LUK’YANOV, O. A., POKHVISNEVA, G. V., TERNIKOVA, T. V. *Russ. Chem. Bull.* (2015). Nitro-substituted bis(methyl-*ONN*-azoxyfurazanyl)furoxans, 64, 137–141.

MIYAURA, N., SUZUKI, A., (1979). Stereoselective Synthesis Of Arylated (E)-Alkenes By The Reaction of Alk-1-Enylboranes with Aryl Halides In The Presence of Palladium Catalyst. J. Chem. Soc. Chem.Commun., 19, 866-867.

NICOLAOU, K. C., BULGER, P. G., SARLAH, D. (2005). Palladium-Catalyzed Cross-Coupling Reactions in Total Synthesis, *Angew. Chem. Int. Ed.*, 44, 4442 – 4489.

PARAKHIN, V. V., LUK’YANOV, O. A. (2016). Synthesis of (α-nitroalkyl-*ONN*-azoxy)furoxan derivatives. *Russ. Chem. Bull*., 65, 295–297.

PODGORŠEK, A., ZUPAN, M., ISKRA J. (2009). Oxidative Halogenation with “Green” Oxidants: Oxygen and Hydrogen Peroxide. *Angew. Chem. Int. Ed.* 2009, 48, 8424-8450.

SEMENOV, S. E., CHURAKOV, A. M., LOFFE, S. L., VINOGRADOVA, E. A., ZLOTIN, S. G. LUK’YANOV O. A. (1991). Dibromoisocyanuric acid-A new reagent for the preparation of azo compounds from heterocyclic amines. *Russ. Chem. Bull*. 1991, 40, 1727.

TAN, X., SONG, T., WANG, Z., CHEN, H., CUI, L., LI, C. (2017). Silver-Catalyzed Decarboxylative Bromination of Aliphatic Carboxylic Acids. *Org. Lett.,*19, 1634–1637.

TOZETTI, S. D. F., DE ALMEIDA, L. S., ESTEVES P. M., DE MATTOS, C. S. M. (2007). Trihaloisocyanuric Acids/NaX: an environmentaly friendly system for vicinal dihalogenation of alkenes without using molecular halogen.. *J. Braz. Chem. Soc.*, 18, 4, 675-677.

VIRGIL, S. C. (2001). 1,3-Dibromoisocyanuric Acid. In Encyclopedia of Reagents for Organic Synthesis, (Ed. P. L. Fuchs), John Wiley & Sons.

WILLIAM,J. M., KURIYAMA, M., OSAMU ONOMURA, O. (2014). Boronic acid-catalyzed selective oxidation of 1,2-diols to *a*-hydroxy ketones in water. *Adv. Synth. Catal.*,356,934-940.