International Journal of ChemTech Research
CODEN(USA): IJCRGG ISSN : 0974-4290
Vol.5, No.1, pp 24-27, Jan-Mar 2013

Effective And Facile Synthesis Of Nitriles From Aldoximes By Using $SnCl_4$

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Abstract: A simple, effective and solvent free method for the conversion of varieties of aldoximes to the corresponding nitrile has been achieved in good to high yields by employing SnCl4 as a reagent, under solvent free condition.

Keywords: Nitriles; Aldoximes; Dehydration; Solvent free condition; $SnCl_4$.

Introduction

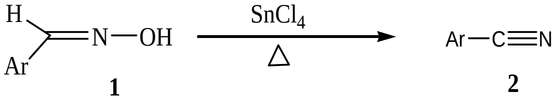
The nitriles are the key constituent of many naturally occurring compounds and also serves as an important synthetic intermediate for various therapeutics[1], agricultural chemicals, dyes, material sciences[2] and as intermediates in microbial metabolism. Nitriles are widely used as chemical solvents, recrystallizing agents[3]. Nitriles are of important synthon in preparative organic chemistry due to their conversion into amidines[4], aldehydes[1&3], amides[1&3], amines[1&3], ketones[1&3], carboxylic acids[1&3] and nitrogen containing heterocycles[5].

Because of its role in synthetic chemistry, chemists are searching newer methods for nitrile synthesis. The conversion of aldehydes into the corresponding nitriles is having significant importance. They are also usually prepared by regenerating CN group *via* oxidation[6], rearrangement[7] or elimination. The most general methods for synthesis of alkyl nitriles are direct nucleophilic substitution of alkyl halides with inorganic cyanides or replacement of diazo group by CN ion in Sandmeyer reaction. Nitriles are also directly prepared from the dehydration of the corresponding aldoximes using common reagents[8] or other new reagents like $CuCl_2$, dicyclohexylcarbodiimide, triphenylphosphine, 1-(*N*,*N*-diethyl-amino)-propyne[9], trimethylamine/SO_2[10], trichloroacetyl chloride/ triethylamine, $TiCl_4$[11], *N*,*N'*-carbonyldiimidazole, $Cu(OAc)_2.H_2O$[12], acetic anhydride[13], trichloro isocyanuric acid, crown ethers, chlorosulfonyl isocyanate[14], Burgess reagent[15]. Some of the methods are also included the use of expensive[16&17], hazardous[18] or corrosive[19] reagents and tedious work-up procedures, vigorous reaction conditions, prolong standing or heating at moderately high temperatures. α,β-Unsaturated nitriles can be prepared via a Wittig reaction of the corresponding aldehydes with cyanoalkyl phosphonate. Apart from the recent progress, still there is a strong need for a preparative method for the highly efficient and catalytic conversion of aldoximes to nitriles using readily available and safer reagents.

Results And Discussion

Herein, we wish to report a new, simple and facile and an environmentally benign solvent free method for accomplishing the conversion of aldoximes **(1)** to their corresponding nitriles **(2)** by $SnCl_4$. The reaction proceeds efficiently in good to high yield under mild conditions (Scheme 1).

Scheme 1: Synthesis of nitriles from aldoximes by using $SnCl_4$



To study the effect of substitution, reactions were performed on different precursors as shown in Table 1, precursors with electron-withdrawing groups showed better yield in a shorter time. By paying attention to this evidence, the mechanism shown in (Scheme 2) is proposed for the dehydration of aldoximes which is similar to most of the dehydrating reactions. Here the chlorine ion released during the progress of the reaction acts as a base for removal of hydrogen at the next stage. Longer reaction times had no effect on the conversion of aldoximes.

Scheme 2: The plausible mechanism for the synthesis of nitriles from oximes by using $SnCl_4$

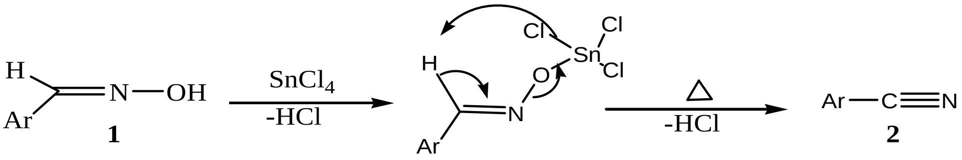


Table 1: Nitriles obtained from oximes on treatment with $SnCl_4$

Oxime	Nitrile	Yield (%)	Reaction Time (min)	mp or bp in ^{0}C
Benzaldoxime	Benzonitrile	84^b	45	bp-190 (192)[19]
4-Methylbenzaldoxime	4-Methylbenzonitrile	83^a	50	mp-26 (25-27)[20]
4-Methoxy Benzaldoxime	4-Methoxy benzonitrile	86^a	50	mp-58 (58-59)[19]
2,4-Dimethoxy benzaldoxime	2,4-Dimethoxy benzonitrile	88^a	55	mp-94 (96)[21]
2-Chlorobenzaldoxime	2-Chlorobenzonitrile	83^a	44	mp-42 (40-42)[22]
3-Chlorobenzaldoxime	3-Chlorobenzonitrile	92^a	40	mp-38 (37-39)[22]
4-Chlorobenzaldoxime	4-Chlorobenzonitrile	89^a	40	mp-92 (94-96)[19]
2-Bromobenzaldoxime	2-Bromobenzonitrile	92^a	30	mp-52 (52-54)[19]
2-Nitrobenzaldoxime	2-Nitrobenzonitrile	90^a	25	mp- 108 (109-110)[19]
3-Nitrobenzaldoxime	3-Nitrobenzonitrile	94^a	30	mp-116 (115-117)[22]
4-Nitrobenzaldoxime	4-Nitrobenzonitrile	92^a	30	mp-146 (147)[18]
1-Naphthylaldoxime	1-Naphthanitrile	78^a	40	mp-34 (34-35)[23]
2-Naphthylaldoxime	2-Naphthanitrile	81^a	50	mp-66 (64)[18]
2-furanaldoxime	2-furancarbonitrile	75^b	55	bp-144 (145-146)[18]
4-(N,N-dimethyl)benzaldoxime	4-(N,N-dimethyl) benzonitrile	84^a	50	mp-70 (69-70)[18]

a - Yield obtained after recrystalization.
b - Yield obtained after column.

We found to be that, this protocol was applicable to different types of aldoximes (Table 1). Similarly, to test the scope and limitations of this reagents; we examined the dehydrating reaction of benzaldoxime by performing the reactions under following reaction conditions. To improve the eco-compatibility of this process, among the several solvents were examined at variable temperature listed in Table 2. Without any solvent, this reaction yielded to a greater extent (Table 1, entry 1). A small rate increase of condensation were observed on changing the solvent from CH_2Cl_2 to CCl_4 (Table 2, entry 2-4) after a prolonged reaction time. Other solvents such as MeCN, THF and acetic acid lead to lower yields and to the formation of undesirable by-products (Table 2, entries 5-7).

Table 2: Screening of solvents at variable temperature[a]

Entry	Solvent	Temp. (^oC)	Time (h)	Yield[b] (%)
1	No solvent	80-90	0.75	84
2	CH_2Cl_2	40	24	<22
3	$CHCl_3$	61	24	<28
4	CCl_4	77	24	<36
5	MeCN	82	12	<30
6	THF	100	12	<28
7	Acetic acid	120	12	<12

Conditions: [a]Benaldoxime (5 mmol), Stannic chloride (5 mmol), solvent.
[b]Yields of isolated pure product obtained by recrystallization or by column.

In the summary, we have developed a solvent free method for the preparation of nitriles from aldoximes by using $SnCl_4$ in absence of expensive metal like samarium.

Experimental

Typical Experimental Procedure

Aldoxime **1** (5 mmol) was taken in a dry round bottom flask. To this aldoxime 1.3 g (5 mmol) of Stannic chloride ($SnCl_4$) was added slowly. After fitting a condenser along with a guard tube, the reaction mixture was heated at a temperature range of 80-90 ^{0}C with constant stirring. The reaction was monitored by TLC (ethyl acetate:hexane, 1:9). After completion of reaction, the mixture was cooled to room temperature and the solid, thus, formed was dissolved in hot water and made alkaline with 10% NaOH solution. It was extracted with a CH_2Cl_2 (50 mL X 3) and dried over anhydrous Na_2SO_4. The solvent was distilled off under reduced pressure to afford crude nitrile. The crude product was either purified by recrystalization from hexane or purified via silica gel column chromatography (silica mesh size 60–120 by eluting hexane). All compounds were known and their physical and spectroscopic data were compared with those of authentic samples and found to be identical.

References

1. Friedrich K. and Wallensfels K., The Chemistry of Cyano Group, Rappoport Z., Ed., Wiley-Interscience, New York, 1970.
2. Fatiadi A.J., Patai S. and Rappaport Z., Preparation and Synthetic Applications of Cyano Compounds, Wiley-Interscience, New York, 1983.
3. Mowry D.T., The Preparation of Nitriles, Chem. Rev., 1948, 42, 189-283.
4. Patil U.D. and Mahulikar P.P., A Convenient,$TiCl_4$/$SnCl_4$ Mediated Synthesis of *N*-Phenyl or *N*-Aryl Benzamidines and *N*-Phenylpicolinamidines, ISRN Organic Chemistry, Volume 2012, Article ID 963195 (doi:10.5402/2012/963195).
5. Bhosale S.V., Patil U.D., Kalyankar M.B., Nalage S.V., Patil V.S. and Desale K.R., J. Heterocyclic Chem., 2010, 47, 691-696.
6. Stevens T.E., Amine Oxidations with Iodine Pentafluoride: Preparation of Azoisobutane, J. Org. Chem., 1961, 26, 2531-2533.
7. Pakusch J. and Ruchardt C., Steris Behinderung der Isocyanid-Cyanid-Umlagerung in einer Bruckenkopfosition, Chem. Ber., 1991, 124, 971-972.

8. Harrison I.T. and Harrison S., Compendium of Organic Synthetic Methods, Interscience Publishers, New York, 1971, vol. I, pp. 457–458, and 1972, vol. II, 185-192.
9. Bernhart C. and Wermuth C-G., Benzonitriles from Benzaldoximes and an Ynamine, Synthesis, 1977, 338-339.
10. Olah G.A. and Vankar Y.D., Synthtic Methods and Reactions: Preparation of Nitriles from Aldoximes via Dehydration with Trimethylamine/Sulfur Dioxide Complex, Synthesis, 1978, 702-703.
11. Patil U.D., Nagle P.S., Patil N.L. and Mahulikar P.P., A Simple and Effective Procedure for Preparation of Nitriles by Dehydration of Oximes under Solvent Free Conditions, International Journal of Chemical and Analytical Sciences, 2012, 3(2), 1316-1317.
12. Attanasi O., Palma P. and Serra-Zanetti F., Effect of Metal Ions in Organic Synthesis; XVII. Mild, Easy, and High-Yield Conversion of Aldoximes into Nitriles under Copper (II) Acetate Catalysis, Synthesis, 1983, 741-742.
13. Buck J.S. and Ide W.S., Veratronitrile, Organic Syntheses, Coll. Vol. 2, p. 622 (1943); Vol. 15, p. 85 (1935).
14. Olah G.A., Vankar Y.D. and Garcia-Luna A., Synthetic Methods and Reactions: Preparation of Nitrites from Amides and Aldoximes with Chlorosulfonyl Isocyanate, an Effective and Mild Dehydrating Agent, Synthesis, 1979, 227.
15. Binoy J., Sulatha M.S., Madhavan P.P. and Prathapan S., A New Method for the Generation of Nitriles from Aldoximes, Synth. Commun., 2000, 30, 1509-1514.
16. Miller M. and Loudon G., A Convenient, High-Yield Conversion of Aldehydes to Nitriles, J. Org. Chem., 1975, 40, 126-127.
17. Fizet C. and Streith J., Hydroxylamine-O-Sulfonic Acid: A Convenient Reagent for the Oxidative Conversion of Aldehydes into Nitriles, Tetrahedron Lett. 1974, 15, 3187-3190.
18. Sosnovsky G., Krogh J.A. and Umhoefer S.G., A One-Flask Conversion of Aldehydes to Nitriles using Hydroxylamine Hydrochloride and Selenium Dioxide, Synthesis, 1979, 722-724.
19. Olah G.A. and Keumi T., Synthetic Methods and Reactions: Improved One-Step Conversion of Aldehydes into Nitriles with Hydroxylamine in Formic Acid Solutio, Synthesis, 1979, 112-113.
20. Kokare N.D. and Shinde D.B., Efficient Conversion of Aldoximes to Nitriles using Phosphoric Acid Diethyl Ester 2-Phenylbenzimidazol-1-yl Ester, Monatsh Chem., 2009, 140, 185-188.
21. Dauzonne D., Demerseman P. and Royer R., A New Direct Synthesis of Aromatic Nitriles From Aldehydes, Synthesis, 1981, 739-740.
22. Smith R.F. and Walker L.E., A Facile Conversion of Aldehydes to Nitriles, Synthesis, 1962, 4372-4375.
23. Ali S.L., Nikalje M.D., Dewkar G.K., Paraskar A.S., Jagtap H.S. and Sudalai A., Formamide Assisted One-Pot Conversion of Aromatic Aldehydes into the Corresponding Nitriles, J. Chem. Research (S), 2000, 30-31.

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