SYNLETT
Spotlight 186

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

Synthetic Applications of Sodium in Liquid Ammonia

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Introduction

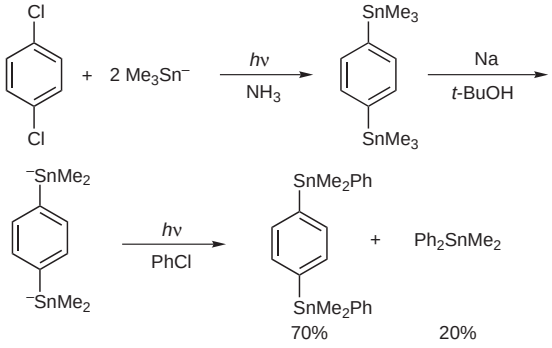
Sodium in liquid ammonia forms a useful reagent system for carrying out a variety of transformations. Sodium reacts slowly with ammonia to produce sodium amide and hydrogen (Figure 1). This reaction is catalyzed by metal ions such as iron, cobalt and nickel. The sodium/ammonia system forms an excellent reducing agent with a half-life potential of –2.59 V at –50 °C.[1]

Scheme 1

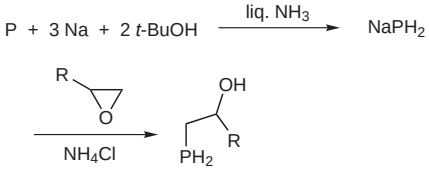
Besides its classical application in Birch reduction[2] it has been found to bring about several reactions such as the reductive cleavage of C–Cl, N–N, S–S and C–S bonds; nucleophilic substitution of the aryl halides, proton abstraction, reduction of alkenes and alkynes, aminolysis of trichlorosilanes, and multiple deprotections in a single step. These useful applications of this reagent system coupled with its ready availability make it a powerful tool for practical organic synthesis.

Abstracts

(A) *Preparation of substituted aryl stannanes:*
When *p*-bis(trimethylstannyl)benzene is treated with sodium metal in liquid ammonia, a dianion is generated, which, upon photostimulated reaction with PhCl, affords the disubstitution product in 70% yield. This method has been elaborated for the preparation of numerous substituted aryl stannanes.[3]



(B) *Preparation of 2-hydroxyorganophosphines:*
Arbuzova et al. reported an efficient method for preparing primary 2-hydroxyorganophosphines by the direct interaction of oxiranes with red phosphorus in the system sodium/*tert*-butanol/liquid ammonia.[4]



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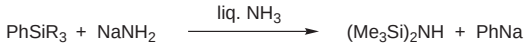
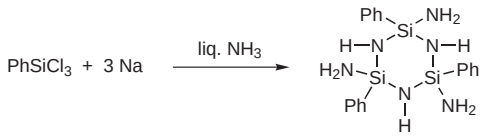
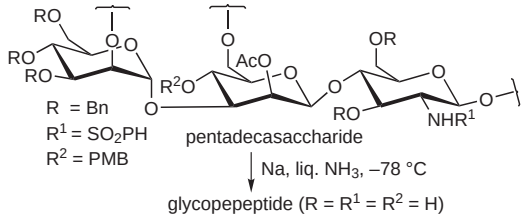
(C) *Cleavage of arylalkylsilanes:*
The aryl carbon–silicon bonds in arylalkylmonosilanes can be cleaved by sodium amide in liquid ammonia.[5]



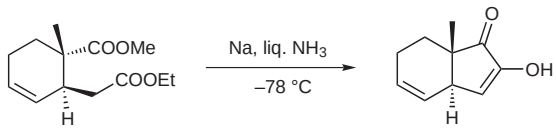
(D) *Aminolysis of trichlorosilanes:*
Treatment of trichlorosilanes with sodium in liquid ammonia leads to the formation of silicon–nitrogen compounds, which find industrial application in the synthesis of heat-resistant silicon nitrides. A six-membered cyclic compound containing silicon and nitrogen was found to be the major product when trichlorophenyl silane was used as starting material.[6]



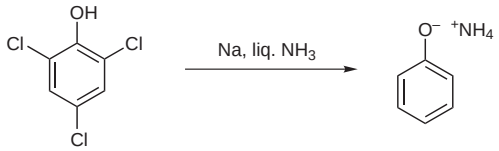
(E) *Single-step multiple deprotections:*
Danishefsky and co-workers have recently demonstrated the utility of the sodium/liquid-ammonia system in the global deprotection of pentadecasaccharide to obtain glycopeptide. Several hydroxyl and amine groups carrying Bn, SO_2Ph and PMB protecting groups were deprotected in a single step.[7]



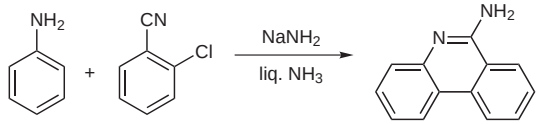
(F) *Abnormal acyloin condensation:*
We have reported the synthesis of a substituted hydrindane system utilizing sodium/liquid ammonia for the annulation of the five-membered ring. A synthetically useful α-hydroxy-α,β-unsaturated ketone was produced by treatment with sodium in liquid ammonia at –78 °C.[8]



(G) *Dehalogenation in aqueous medium:*
Halogenated organic compounds such as solvents, pesticides, herbicides, PCBs, CFSs have caused serious environmental problems due to their presence in soils, sludges, estuaries, etc. Na/liq. NH_3 has been found to efficiently dehalogenate these halogenated compounds even in the presence of water, thus converting them into less toxic material.[9]



(H) *Synthesis of aminophenanthridines from anilines:*
Diversely substituted phenanthridines have been obtained by condensation of anilines with 2-chlorobenzonitriles promoted by sodium amide in liquid ammonia.[10]



References

(1) Smith, M. In *Reduction: Techniques and Applications in Organic Synthesis*; Augustine, R. L., Ed.; Dekker: New York, **1968**.
(2) Birch, A. J. *J. Chem. Soc.* **1944**, 430.
(3) Córsico, E. F.; Rossi, R. A. *Synlett* **2000**, 227.
(4) Arbuzova, S. N.; Brandsma, L.; Gusarova, N. K.; van der Kerk, A. H. T. M.; van Hooijdonk, M. C. J. M.; Trofimov, B. A. *Synthesis* **2000**, 65.
(5) Sun, G.-R.; He, J.-B.; Zhu, H.-J.; Pittman, C. U. Jr. *Synlett* **2000**, 619.
(6) Ackerhans, C.; Räke, B.; Krätzner, R.; Müller, P.; Roesky, H. W.; Usón, I. *Eur. J. Inorg. Chem.* **2000**, 827.
(7) Iserloh, U.; Dudkin, V.; Wang, Z.-G.; Danishefsky, S. J. *Tetrahedron Lett.* **2002**, *43*, 7027.
(8) Pandey, G.; Raikar, S. B. *Tetrahedron Lett.* **2006**, *47*, 2029.
(9) Ol'shevskaya, V. A.; Ayuob, R.; Brechko, Z. G.; Petrovskii, P. V.; Kononova, E. G.; Levit, G. L.; Krasnov, V. P.; Charushin, V. N.; Chupakhin, O. N.; Kalinin, V. N. *J. Organomet. Chem.* **2005**, *690*, 2761.
(10) Gug, F.; Bach, S.; Blondel, M.; Vierfond, J.-M.; Martin, A.-S.; Galons, H. *Tetrahedron* **2004**, *60*, 4705.

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