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Inorganic hydrides for energy storage as hydrogen or as battery materials

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Abstract

A wide variety of complex metal borohydrides, closo-borates and carborates have been discovered and characterized during the past decade, revealing an extremely rich chemistry including fascinating structural flexibility and a wide range of compositions and physical properties. New classes of boron based electrolytes for batteries have recently been discovered along with high hydrogen density materials relevant for hydrogen storage. Here we present new design criteria of functional electrolytes developed by analysis of the underlying phenomena responsible for the high ion conductivity. This is both useful for mono- and divalent cations including Mg^{2+}. Structural dynamics in the solid state, i.e. entropy effects, are of extreme importance for ionic conductivity. Disorder of high temperature polymorphs often lead to increased dynamics. The structure of high temperature polymorphs can be stabilized to lower temperatures by anion substitution. Disorder in the solid state can also be created by stabilization of eutectic molten states by nano-structuring. Neutral molecules and a 3D network of dihydrogen bonds may increase the coordination flexibility and thereby increase cation mobility. We conclude that the chemistry of boronhydrides is very divers, towards rational design of multi-functional materials, including new ion-conductors for batteries and hydrogen storage materials.

Biography

Torben R Jensen received a Ph.D. degree in materials chemistry at University of Southern Denmark, Odense in 1999. He was awarded a Steno research stipend (2002) and Carlsberg research stipends form the Carlsberg Foundation in 2005, a doctor of science degree (D.Sc.) in 2014 and were awarded the Hydrogen Energy Award in Japan 2016. Torben became Professor of Inorganic Chemistry 2016 at Department of Chemistry and the interdisciplinary Nano science center (iNANO) at Aarhus University. His research interests are focused on synthesis, structural, physical and chemical properties of new inorganic materials, mainly as 'energy materials' with utilizations for novel batteries or for solid state hydrogen storage. He is a frequent user of synchrotron X-ray and neutron radiation for materials characterization and has developed new sample environments for investigation of solid gas reactions (>266 publications, +8900 citations, and H=50).

Publications

1. Ammonium–Ammonia Complexes, N2H7+, in Ammonium closo-Borate Ammines: Synthesis, Structure, and Properties
2. Structural Diversity and Trends in Properties of an Array of Hydrogen-Rich Ammonium Metal Borohydrides
3. Ammine Lanthanum and Cerium Borohydrides, M(BH4)3·nNH3; Trends in Synthesis, Structures, and Thermal Properties
4. Hydroxylated closo-Dodecaborates M2B12(OH)12 (M = Li, Na, K, and Cs); Structural Analysis, Thermal Properties, and Solid-State Ionic Conductivity
5. Hydrogen Sorption and Reversibility of the LiBH4-KBH4 Eutectic System Confined in a CMK-3 Type Carbon via Melt Infiltration
6. Ammonia-assisted fast Li-ion conductivity in a new hemiammine lithium borohydride, LiBH4·1/2NH3
7. The mechanism of Mg2+ conduction in ammine magnesium borohydride promoted by a neutral molecule
8. Mechanochemistry of Metal Hydrides: Recent Advances
9. Crystal Structures and Energy Storage Properties of Ammine Sodium Decahydro-closo-decaboranes (Na2B10H10·nNH3, n = 1, 2)

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