Amino alanes – possible new materials for hydrogen storage

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Complex metal aluminium and boron hydrides were regarded as hydrogen storage materials for fuel cell applications over the last 15 years. Unfortunately, none of these materials fulfil all the requirements for mobile transportation systems. In general, hydrogen storage capacities are too low or the thermodynamic properties are not suitable resulting in huge amounts of heat which must be dissipate during the refilling process. Nowadays, high pressure gas systems (70 MPa) are the method of choice for automotive systems.

The combination of a high pressure gas system and unstable metal hydrides has the opportunity to overcome some of these problems. These unstable metal hydrides do not exist under ambient conditions. They are stable only at high gas pressure conditions or at low temperatures.

Possible unstable materials for this purpose are amino alane compounds. The non-substituted amino alane NH_3AlH_3 shows a multistep decomposition process (first step: -40°C, 3.9 wt.% H_2, second step: -20°C, 4.3 wt.% H_2, third step: 150°C, 4.7 wt.%H_2) according to the following reaction sequence:

$$AlH_3\text{-}NH_3 \xrightarrow[3.9\%\ H_2]{-40^\circ C} AlH_2\text{-}NH_2 \xrightarrow[4.3\%\ H_2]{-20^\circ C} \text{-[AlH-NH]-} \xrightarrow[4.7\%\ H_2]{150^\circ C} AlN$$

The overall amount of released hydrogen can be reached 12.8 wt.% H_2. During the last step aluminium nitride is produced, meaning that this step can't be used for reversible hydrogen storage applications. Understanding of the decomposition process, description of structural transformations and measurements of the thermodynamic values of the decomposition and hydrogenation processes are crucial for the use of these new materials for hydrogen storage applications. Experimental results and an outlook of future research actives are presented.

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Amino alane (AlH_3NH_3) and related compounds are unstable materials releasing up to 12.8 wt% H_2 in several decomposition steps a temperatures < 0°C. In combination with a high pressure tank system, unstable materials have the chance to achieve volumetric and gravimetric storage densities for automotive applications.