MECHANOCHEMICAL APPROACH TO SYNTHESIZE AMINE-AlH_3 ADDUCTS AS ENERGETIC MATERIALS

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The direct synthesis of AlH_3 from Al with H_2 requires extreme conditions beyond technical feasibility, which limits the use of AlH_3. However, this limitation can be bypassed via stabilizing nitrogen-based ligands and ball milling.[1]

Two approaches using *triethylenediamine* (TEDA) and *hexamethylenetetramine* (HMTA) resulted in the formation of $[(TEDA)•AlH_3]_n$ and $[(HMTA)•AlH_3]_n$, while using quinuclidine resulted in isolated molecular complexes $(quinuclidine)_2•AlH_3$[2]. The solvochemical method uses $LiAlH_4 + AlCl_3$ to obtain AlH_3, which is then reacted with amines at low temperature. In contrast, the mechanochemical method operates under 100 – 180 bar H_2–pressure with metallic Al powder and amines at ~RT. The crystal structures were determined from X-ray powder diffraction data (Figure 1); decomposition behavior was analyzed by TGA-DSC coupled with mass spectrometry.

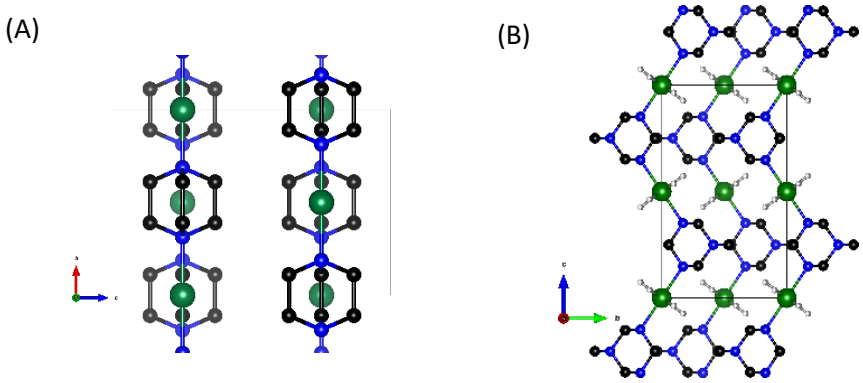

Figure 1. Packing motifs of coordination polymers $[TEDA\text{-}AlH_3]_n$ (A) and $[HMTA\text{-}AlH_3]_n$ (B)

Due to the high hydrogen capacity of 10.1 wt.% in AlH_3 and its easy dehydrogenation at mild conditions, AlH_3 has attracted particular attention as an energetic material, including solid propellants for rockets, promoting the specific impulse while reducing the erosion of the engine nozzles.[3] Since AlH_3 is not stable towards oxidizers in the solid propellant mixture, adding Lewis bases to form Al-N compounds significally enhanced the stability while maintaining a desireable combustion energy.

In summary, we showed two procedures to the direct hydrogenation of Al metal in the presence of amines to obtain remarkably stable AlH_3 complexes as energetic materials for solid rocket boosters.

References

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