Surfactant Induced Synthesis of Alanate Nanoparticles for Hydrogen Storage

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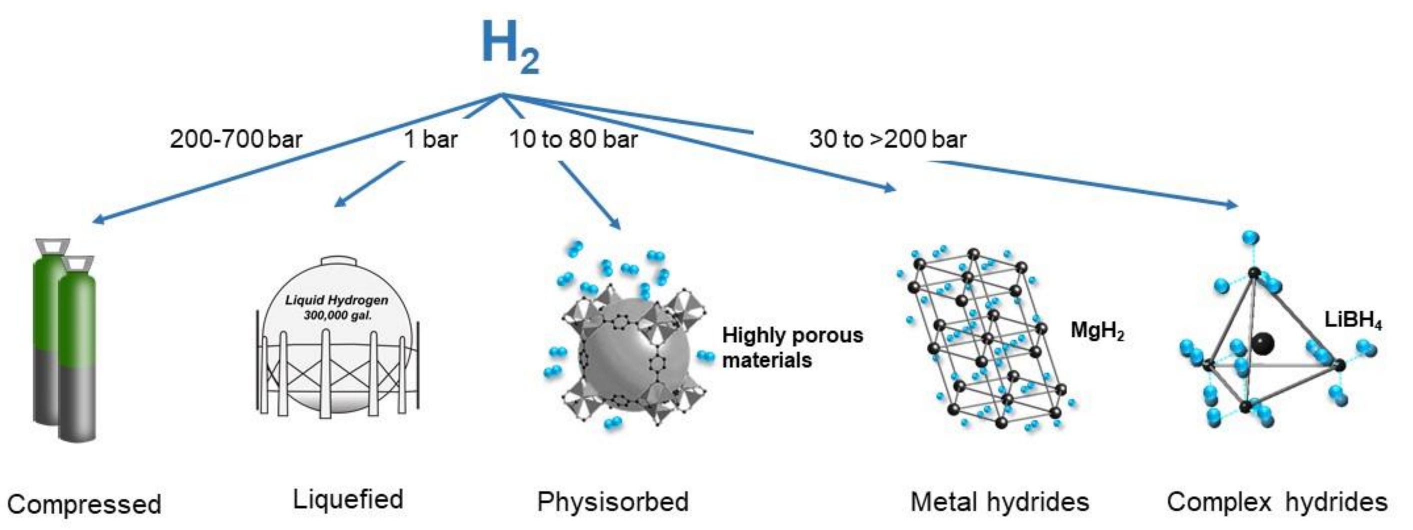
Hydrogen: needs and storage

Hydrogen is considered as one of the best alternative sustainable energy carriers due to its high energy density and near-zero carbon emissions potential.



	Compressed	Liquefied	Physisorbed	Metal hydrides	Complex hydrides
Cost ($/Kg H_2)	3	5.6	-	> 4.2	-
ρ_V (Kg H_2 / m^3)	7-27	70	20-50	120-150	120-150
ρ_m (mass% H_2)	13	~2	2-7	1.4 to 12	up to 19
	Ambient	- 253 °C	-196 °C	Ambient to 500 °C	> 300 °C

End use (electricity, steel, chemical processes, transport)

Solid-state storage via material-based means has several advantages over conventional compressed hydrogen because of the higher hydrogen storage densities and improved safety.[1]

Alanates for hydrogen storage

Materials like $NaAlH_4$ and $LiAlH_4$ are considered promising hydrogen storage material due to their high gravimetric hydrogen storage capacities (7.5 and 10.5 mass % respectively).

$$MAlH_4 \rightarrow M_3AlH_6 + 2\,Al + 3\,H_2 \quad (1)$$
$$M_3AlH_6 \rightarrow 3MH + Al + 3/2\,H_2 \quad (2)$$
$$MH \rightarrow M + H \quad (3)$$

> 400 °C

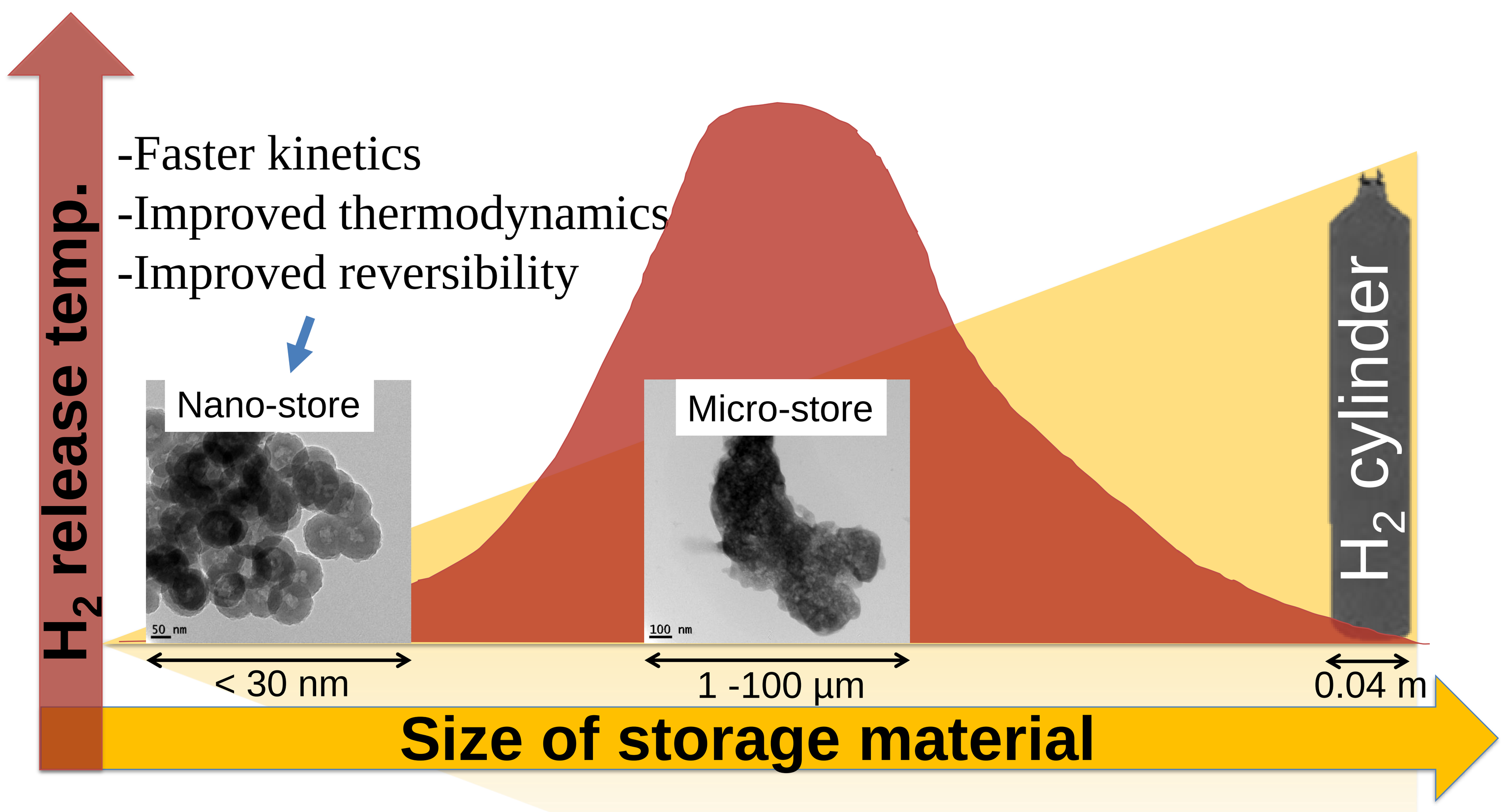
Current limitations

Poor reversibility

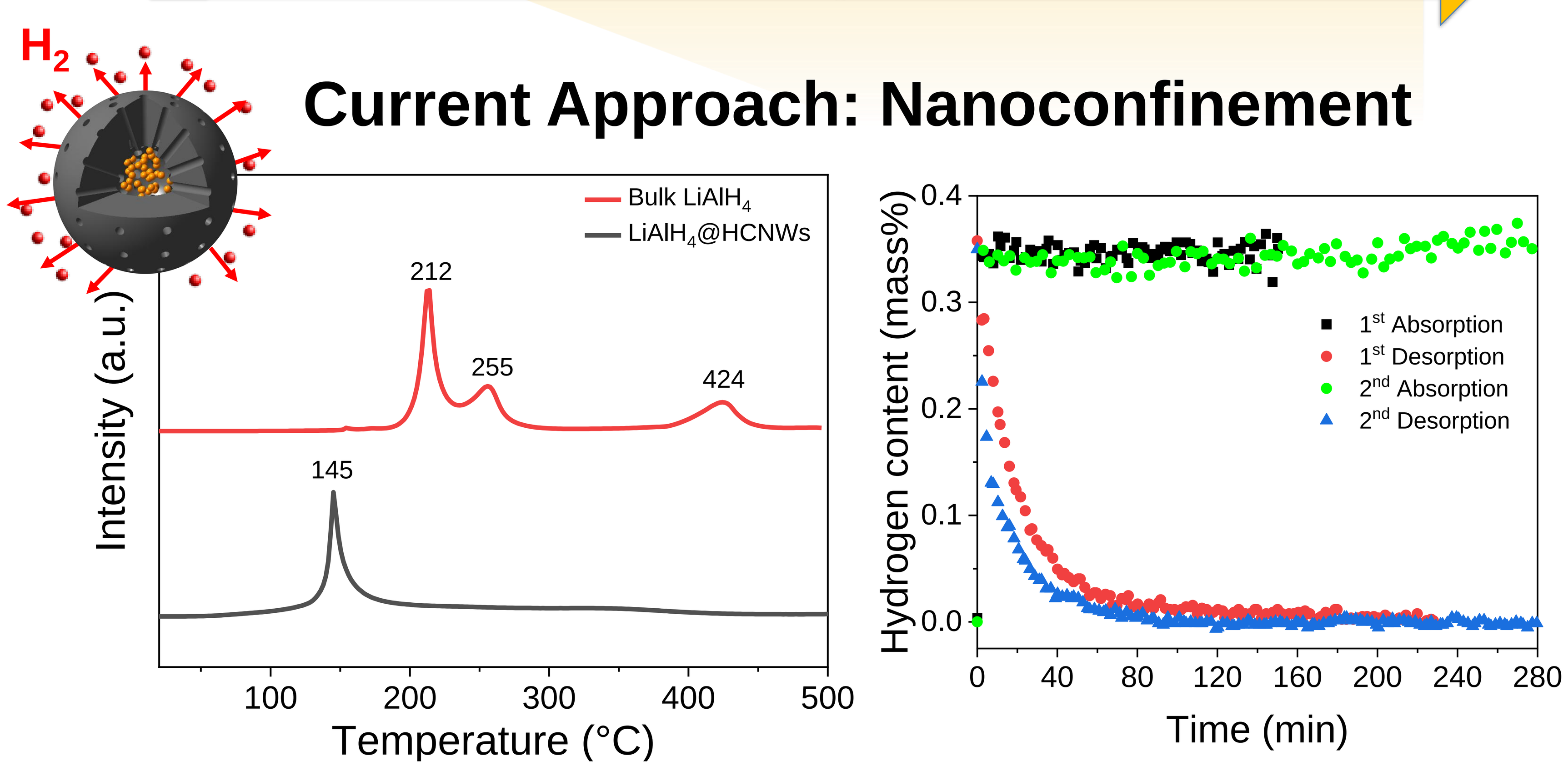
High desorption temperature

Slow kinetics

Nanosizing



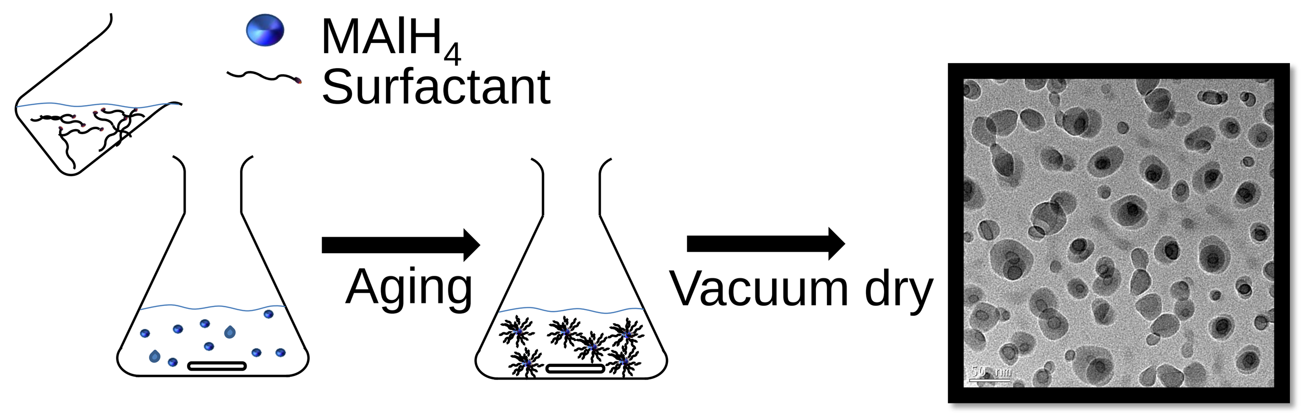
Current Approach: Nanoconfinement



The nanoconfinement of $LiAlH_4$ in hollow carbon spheres led to drastic improvement, particularly on desorption temperatures, kinetics, and reversibility. Unfortunately, this approach suffers from drawback of significant dead weight, thus reducing the practical hydrogen storage capacity to < 1 mass %.

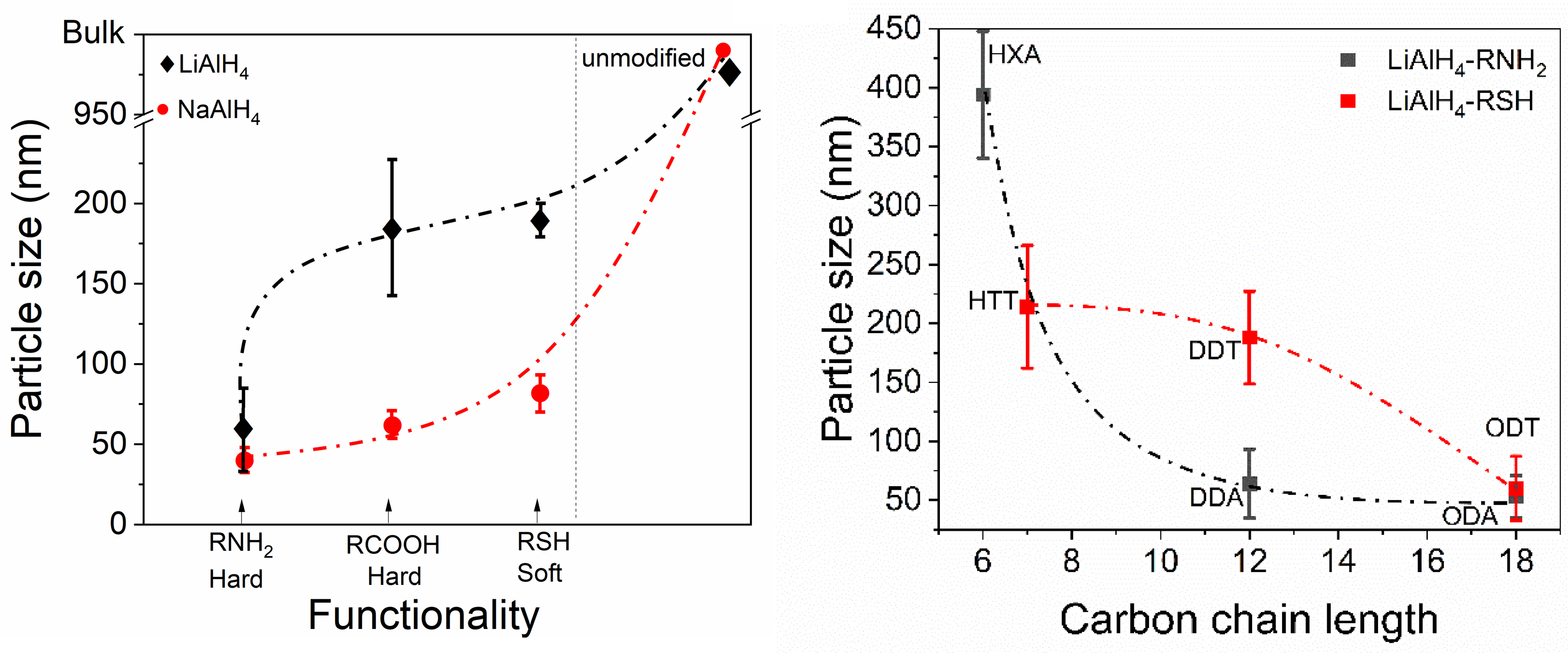
Synthesis strategy

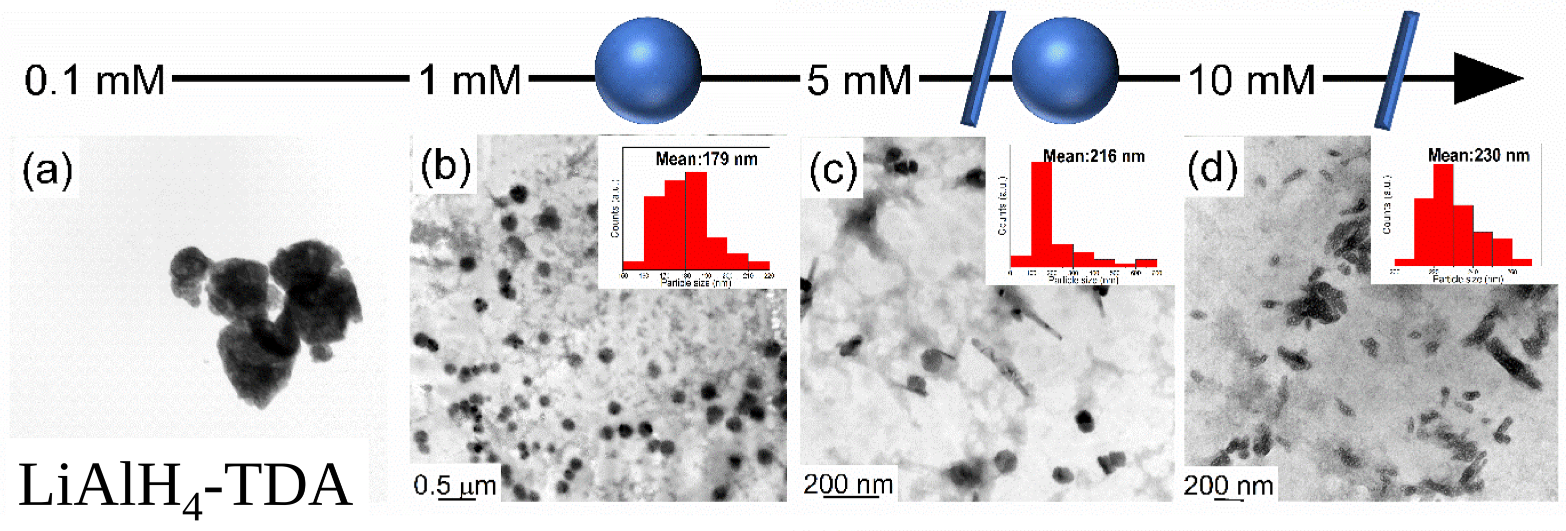
To date, the synthesis methods and the understanding of the parameters that control the growth of alanate nanoparticles is still unclear. In this solvent evaporation method, the solubilized alanate precursor is forced to precipitate with the help of stabilizing agents into various nanoparticles of controlled morphology and size.

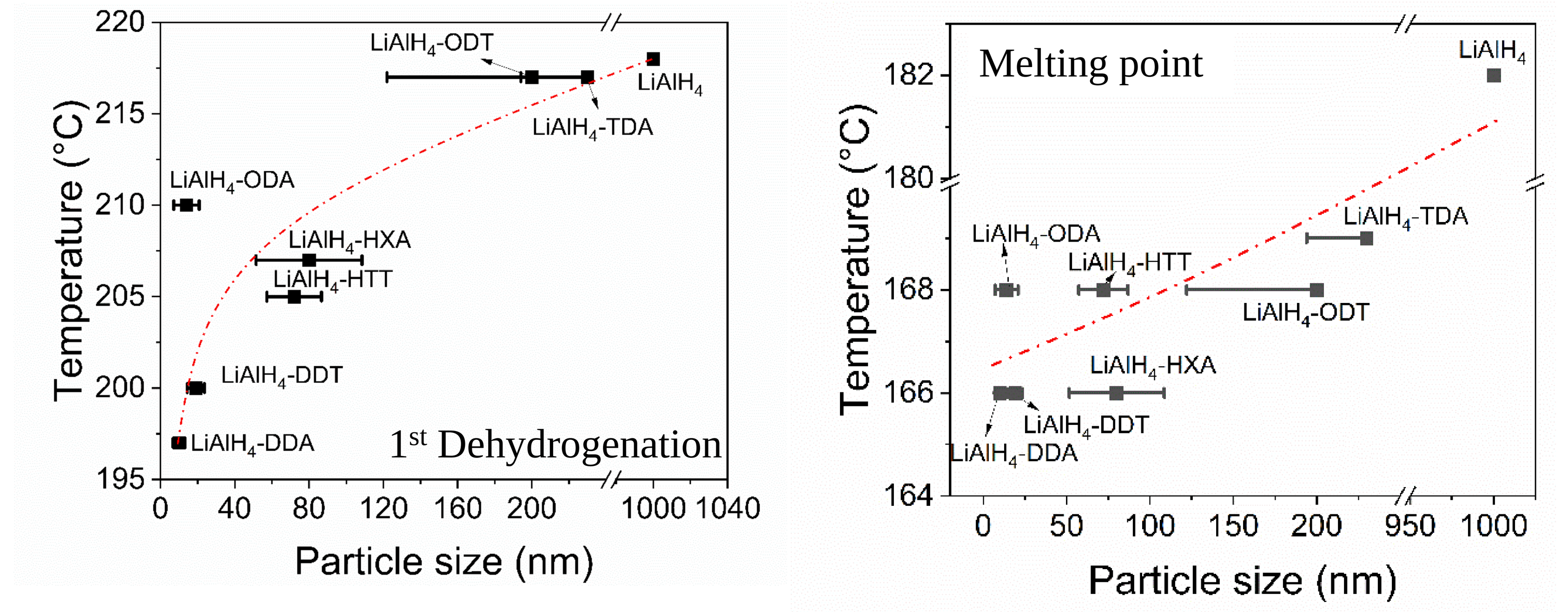


Effect of surfactants in directing the alanate structure

Surfactants with long linear carbon chains and matching the hard character of alanates are more prone to lead to the formation of small particles due to the resulting steric hindrance.

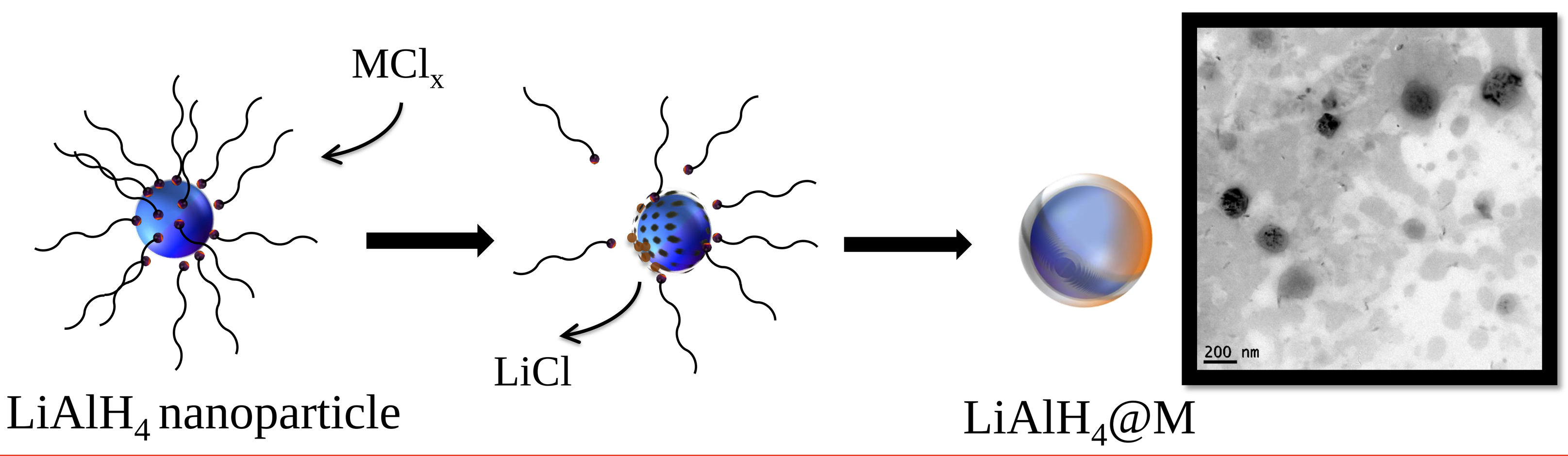






Future development

The morphology and size of alanate can be effectively controlled with an appropriate choice of surfactant through the steric repulsion of surfactants and their interactions with the surface of alanates's particles. Future work, particularly along the core-shell approach, is required to stabilize and restrict the alanate particles and allow close vicinity of the products upon hydrogen release.



References

1. *Salman, Muhammad Saad, et al. Solid-State hydrogen storage as a future renewable energy technology. In: Nano Tools and Devices for Enhanced Renewable Energy. Elsevier, 2021. p. 263-287.*

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