MariNH$_3$

Clean, green ammonia engines for maritime

2024 MariNH$_3$ Conference

Metal hydride - ammonia systems for onboard hydrogen fuel production

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The University of Nottingham and Science and Technology Facilities Council, UK

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Ask questions online

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Ammonia as a marine fuel

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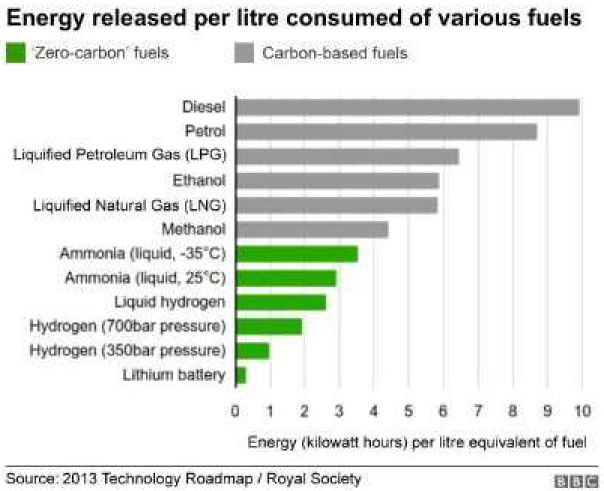
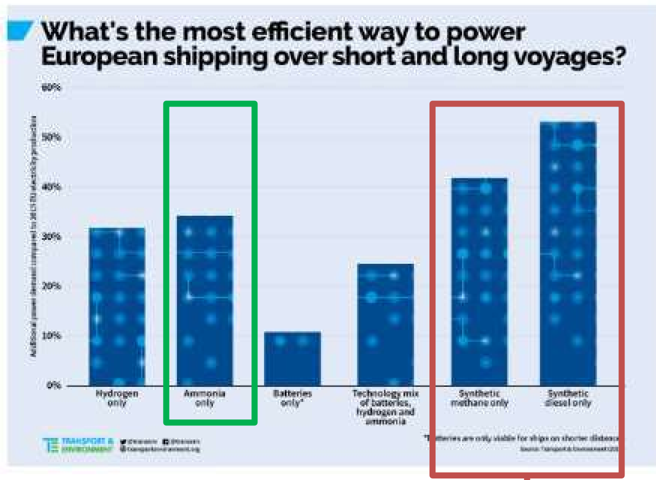
"Shipping"

3% GHGs ➔ 6th largest emitter!

- Hydrogen has already powered cars, planes and trains.
- Hydrogen is harder to transport, requiring large volumes even when compressed or as a liquid at 20 K.
- Ammonia is convenient to transport as liquid at 8 bar but toxic and corrosive.





Fossil fuels equivalent

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MariNH$_3$ programme overview

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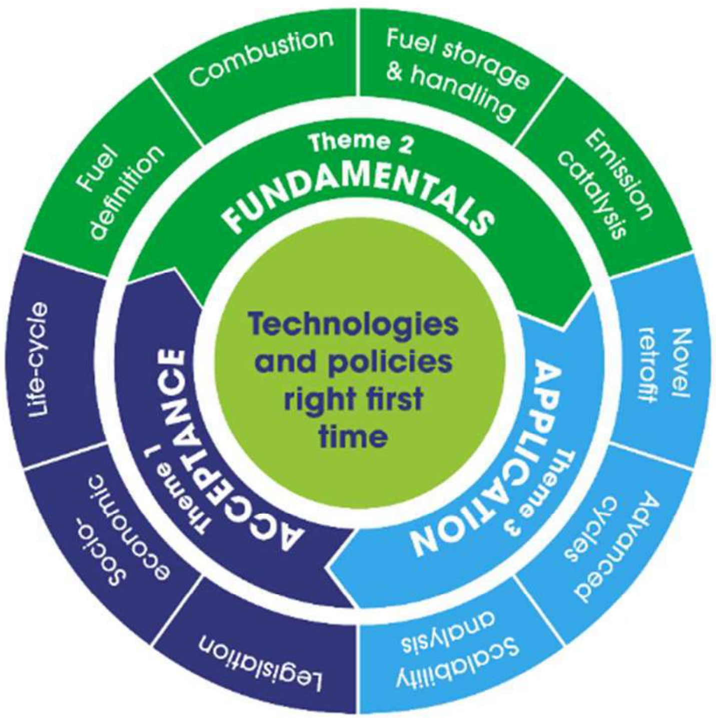

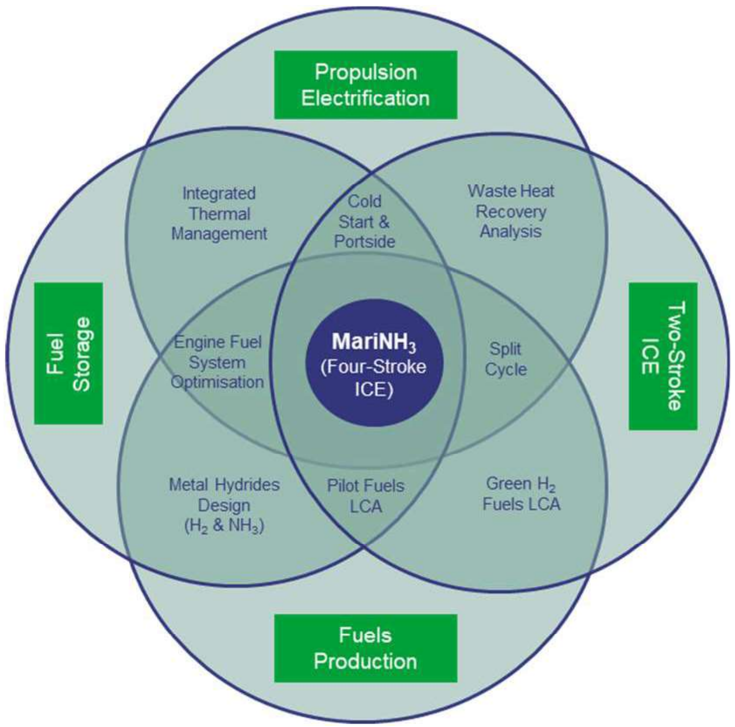

Peripheral research areas

Navy text denotes specific overlaps with peripheral areas

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Material-based options

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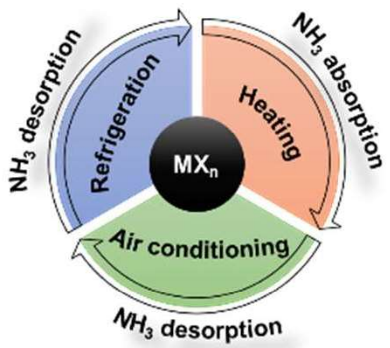
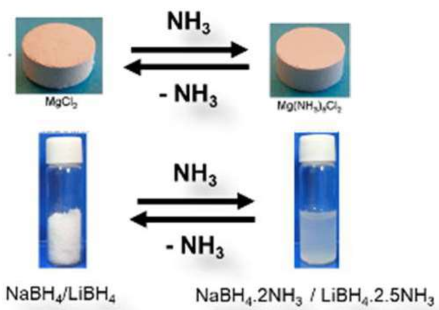
Thermal stores

- In port, the material would keep the engine hot to avoid a cold start
- At sea, NH_3 desorption is used for onboard cooling or refrigeration
- High ΔH values for high energy densities
- **Potential candidate: Mg-based halides/hydride (desorption 220-350°C)**



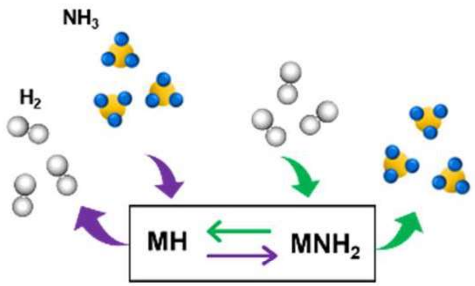
Reversible NH_3 stores

- Up to 60 wt.% NH_3 storage in $CaCl_2/Ca(BH_4)_2$, $MgCl_2/Mg(BH_4)_2$
- Stores with low NH_3 vapor pressure – for example, Mg-based ammoniates
- **Potential candidates: solid solution of CaX_2-$Ca(BH_4)_2$ or MgX_2-$Mg(BH_4)_2$ [X=Cl, I]**
- Challenges: i) material expansion during NH_3 Abs, ii) capacity loss, iii) decomposition of B-H or loss of boron



Reversible MH-NH_3 systems

- Splitting of NH_3 from the stores using a catalyst or alkali metals/hydrides
- Use of dihydrogen bonds in $CaX_2{\cdot}8NH_3$-$Ca(BH_4)_2$ systems to split NH_3 into a mix of NH_3/H_2 or H_2
- Ammonia reacts with alkali metal hydrides at RT to generate MNH_2 and pure H_2
- **Potential candidates: KH, NaH, LiH**
- Challenges: slow reaction kinetics



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Metal hydride-ammonia systems

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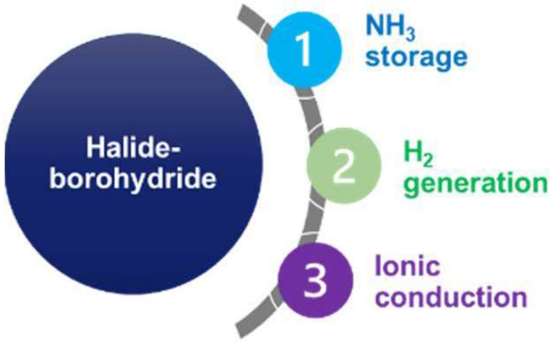
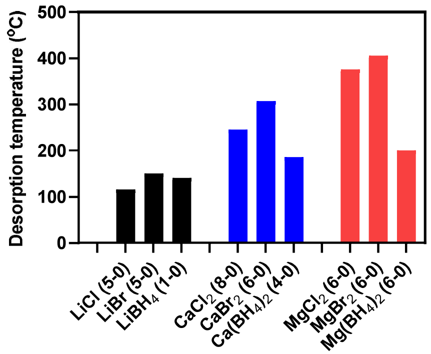
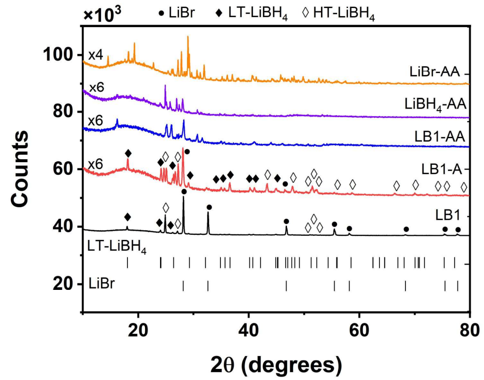
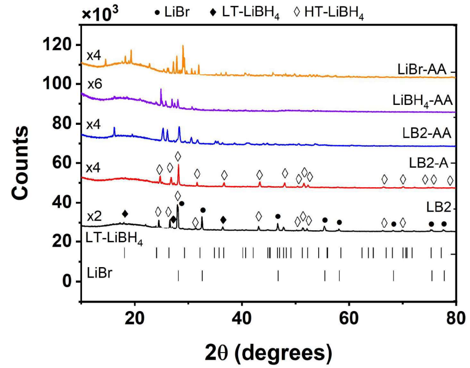
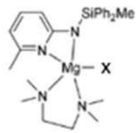


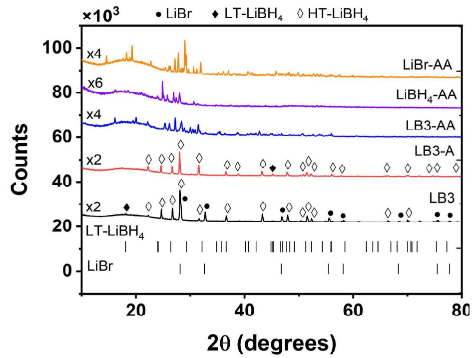


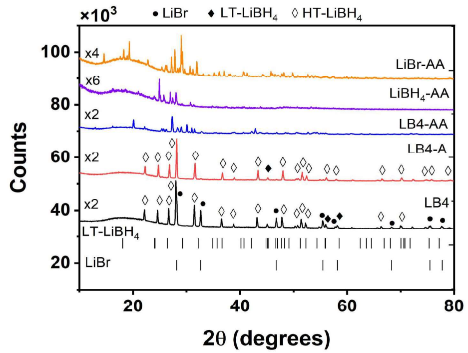




Chem. Eur. J. **2019**, 25, 6840–6846







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MH-NH_3 systems for hydrogen production – How does it work?

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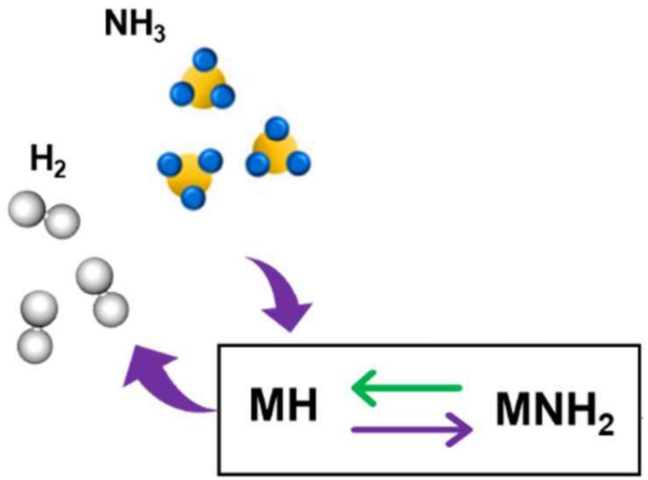
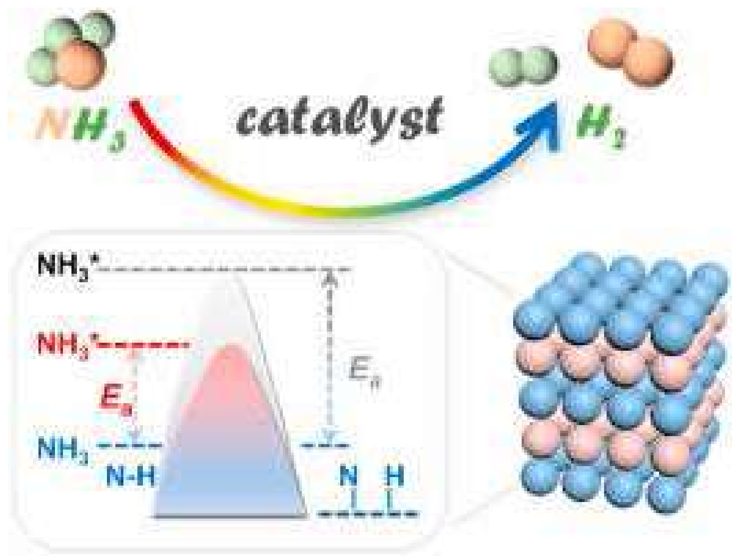


$$LiH + NH_3 \overset{\Delta}{\leftrightarrow} LiNH_2 + H_2$$

(RT, ~8.1 mass% H_2)



Renew. Sustain. Energy Rev., **2022**, 169, 112918.

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LiH-NH_3 System

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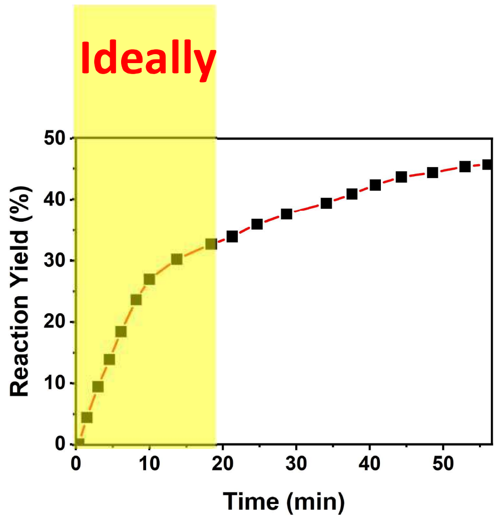
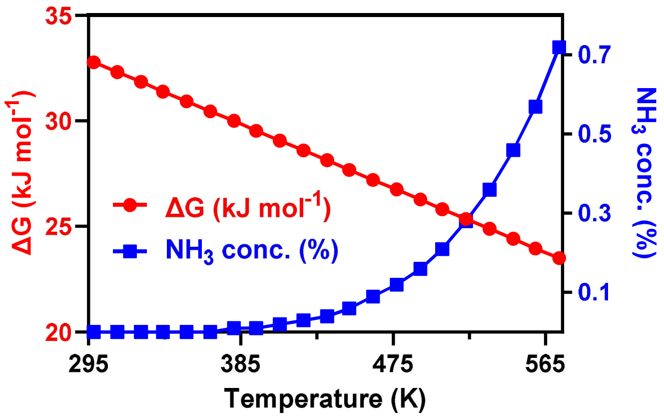
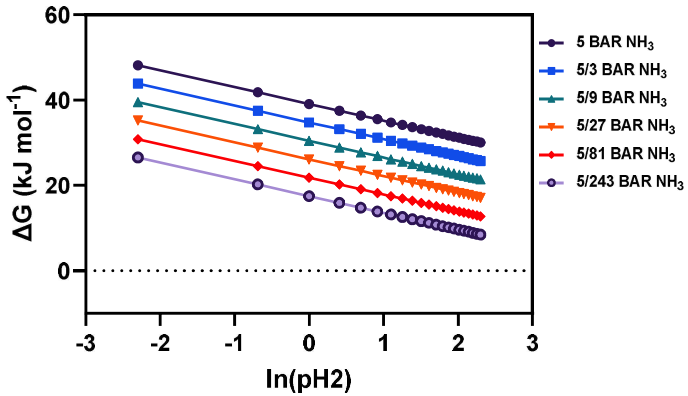
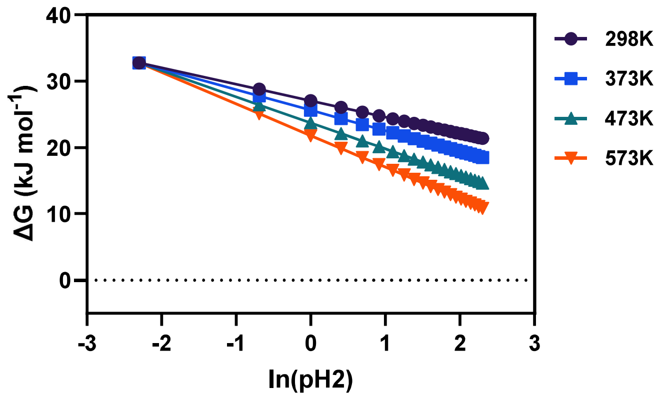


$$LiH + NH_3 \overset{\Delta}{\leftrightarrow} LiNH_2 + H_2$$

Slow kinetics!







$$LiNH_2 + H_2 \overset{\Delta}{\leftrightarrow} LiH + NH_3$$

Not favourable!

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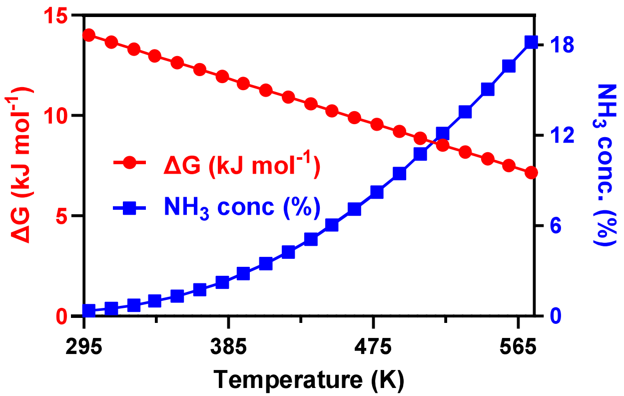
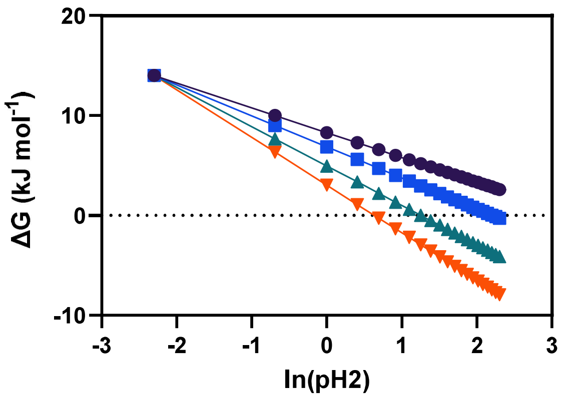
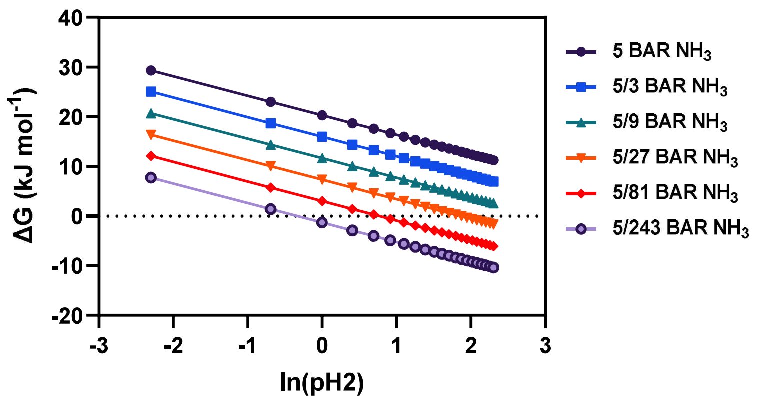
$NaH-NH_3$ System

$$NaH + NH_3 \overset{\Delta}{\leftrightarrow} NaNH_2 + H_2$$







$$NaNH_2 + H_2 \overset{\Delta}{\leftrightarrow} NaH + NH_3$$

Favourable!