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Solid State Hydrogen Storage Metal Hydride Advancement and Update

Australian Mines Limited ("Australian Mines" or "the Company") is pleased to advise positive progress from its Research and Development program[1] targeting onboard Solid-State Hydrogen Storage solutions for light-duty vehicles.

Highlights

- Independently verified test results from LCGC Bioanalytic Solutions LLP, of a recently developed Metal Hydride, hereafter called ('MH-Oct22') demonstrated:
  - Absorption capacities of 4.86 wt% and 5.26 wt% of hydrogen at 300°C and 350°C, respectively at a pressure of 38 bar.
  - Desorption capacities of 4.33 wt% and 5.13 wt% of hydrogen at 300°C and 350°C respectively.
  - Favourable absorption and desorption kinetics were observed, with the best results showing 5.0 wt% of hydrogen absorbed in 9.8 min and released within 3.7 minutes at 350°C.
  - MH-Oct22 was prepared using a production process that the Company considers may be applicable for industrial scale manufacturing. Additionally, the hydrogen was stored and released in the gas phase.

[1] Australian Mines Limited, Australian Mines takes lead on scandium R&D for next generation battery storage technology (ASX: 2 Nov 2018)

Hydrogen Economy Background

Development of practical, safe, cost-effective and efficient storage of a large amount of hydrogen in a small volume remains one of the fundamental challenges of the hydrogen economy.

Currently, the two most common techniques used to store hydrogen are to compress it to a high pressure or to liquify it (liquefaction). These storage methods require tanks and/or cooling equipment, which are bulky and heavy and are not expected to achieve the desired gravimetric and volumetric densities required to fulfill the United States Department of Energy ('DOE') targets for onboard Hydrogen Storage for Light-Duty Vehicles[2].

Solid-state hydrogen storage is considered to have the potential to meet the DOE targets.

One of the most stringent DOE criteria for a hydrogen storage system is a target gravimetric capacity of 5.5 wt% of hydrogen by 2025. In addition to the requirement of high gravimetric capacities, a desired system should exhibit a high volumetric capacity, a high rate of (de)hydrogenation at near-ambient temperatures, high reversibility (operational cycle life), high stability, and cost effectiveness.

Metal Hydrides and Australian Mines R&D Program

High-capacity metal hydrides are expected to be very important for storage applications in the future hydrogen economy due to their exceptional attributes. The high gravimetric capacity of metal hydrides for hydrogen storage is one of the main advantages they have over the conventional mature compressed gas and liquid hydrogen storage methods. MgH_2, for example, has a gravimetric capacity of up to 7.6 wt% hydrogen. However, in practice it has not been possible to utilise the high gravimetric capacity of MgH_2 for practical hydrogen storage technologies due to two major problems:

1) the kinetics of hydrogen absorption and desorption in MgH_2 is extremely slow occurring over the timescale of hours; and

[2] https://www.energy.gov/eere/fuelcells/doe-technical-targets-onboard-hydrogen-storage-light-duty-vehicles

2) thermal stability of MgH_2 is too high, requiring high temperatures to release hydrogen.

To overcome these issues various researchers have focused on modifying Metal Hydride systems to improve hydrogen absorption and desorption properties, reaction rate kinetics and operating temperature. While some success has been achieved with alloying and nano-crystallisation of MgH_2 systems, results have been highly process dependant and have used processes that are difficult to apply to industrial scale manufacturing.

It is Australian Mines' collaborative research and development (R&D) partnership with Amrita Centre for Research and Development, which is focused on both modifying Metal Hydride systems and the manufacturing process that has led to the development of the metal hydride MH-Oct22.

Results

The absorption and desorption capacities of MH-Oct22 at 350ºC were tested over four runs. Figures 1a and 1b below show the second run which gave the best results. From the figures it can be observed that MH-Oct22 absorbs 5 wt% of hydrogen in 9.8 minutes and releases that same 5 wt % of hydrogen within 3.7 minutes.

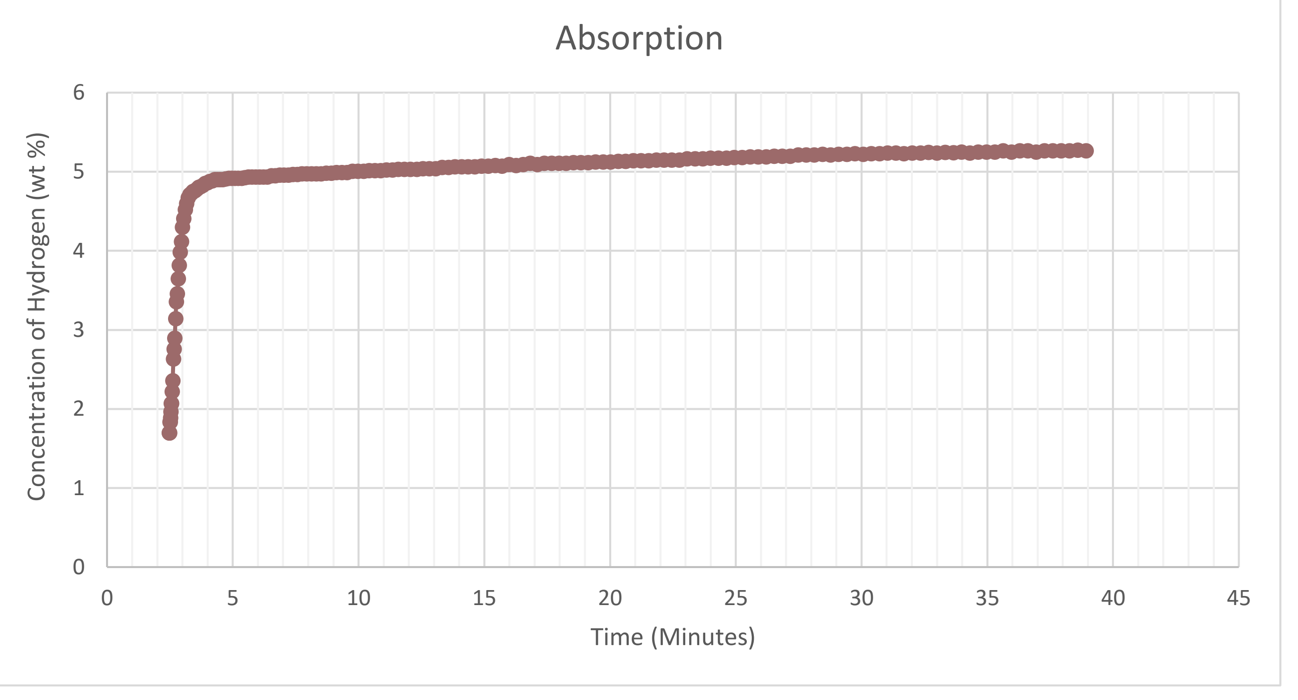

Figure 1a: MH-Oct22 hydrogen absorption

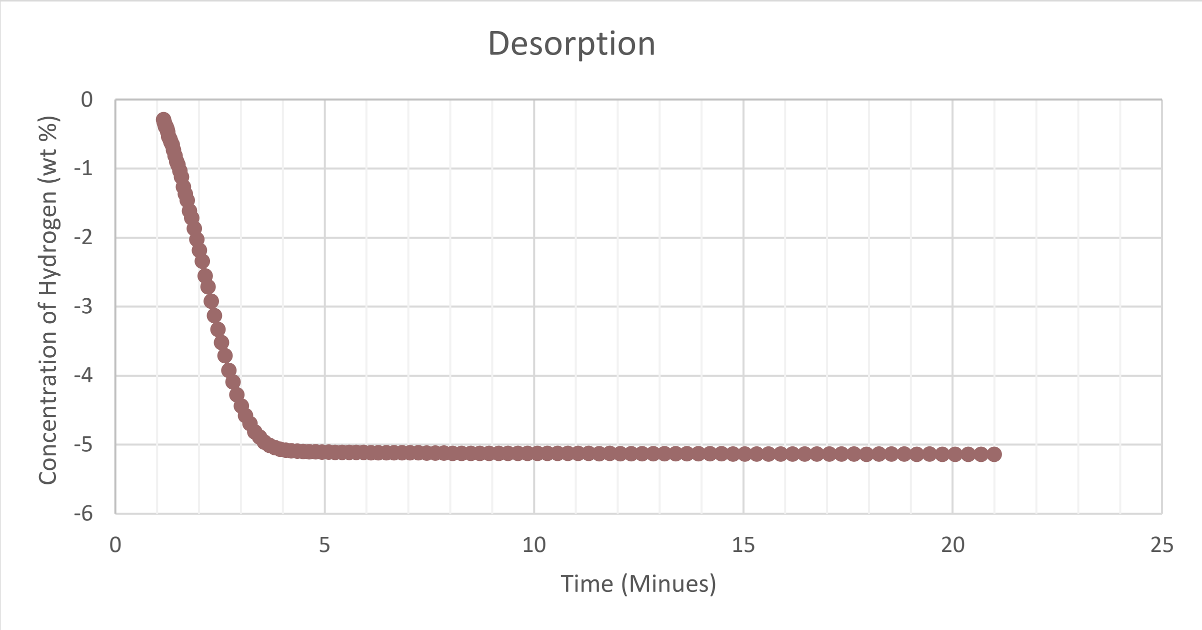

Figure 1b: MH-Oct22 hydrogen desorption

Competing Metal Hydrides Technologies

There are competing metal hydride hydrogen storage technologies. One example is a thin film magnesium hydride storage technology being promoted by the company Plasma Kinetics[3]. Plasma Kinetics forms a thin film magnesium hydride into a disk resembling a CD that requires the use of a laser to extract the hydrogen. In contrast, Australian Mines' strategy is to prepare MH-Oct22 according to a newly developed process, which has been found to impart enhanced hydrogen storage properties. It is envisaged that if an industrial scale technology is developed with this approach, it may allow the absorption and desorption using a gas phase chemical reactor.

Next Steps

Although the results are promising, further development is required to achieve the 2025 DOE target for onboard Hydrogen Storage for Light-Duty Vehicles. Although MH-Oct22 exhibited hydrogen absorption and desorption at higher temperatures and pressures than the DOE operating temperature and pressure targets of $60^{\circ}C$ and 5-12 bar respectively, the company has several strategies that may improve reaction kinetics and operating temperatures and pressures. Over the coming quarters the

[3] https://plasmakinetics.com/

Company will continue to test these strategies to seek to develop new metal hydrides to improve on the performance of MH-Oct22.

The Company will also commence a program of intellectual property protection.

Risks

There are several risks that could affect Australian Mines' ability to advance the development of metal hydrides to produce a commercially viable solid state hydrogen storage material. These risks include, but are not limited to, experimental uncertainties, the technology may not achieve the DOE Targets for onboard Hydrogen Storage for Light-Duty Vehicles, including inadequate system gravimetric capacity, system volumetric capacity, system storage costs, system durability and operability, charging and discharging rates, fuel quality or dormancy.

ENDS

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Authorised for release by the Board of Directors of Australian Mines Limited

Climate Active Carbon Neutral ORGANISATION

Australian Mines Limited supports the vision of a world where the mining industry respects the human rights and aspirations of affected communities, provides safe, healthy, and supportive workplaces, minimises harm to the environment, and leaves positive legacies.