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EDITORIAL

After hard work by the editorial members, BNM 2024 Vol. 22 is finally published. The editors would like to express its sincere thanks to all contributors and readers for their patients and loyal support to BNM. This effort is very much appreciated and we hope this spirit will continue for all MNS activities and BNM in particular. We know that the issuance of BNM needs very strong support and commitment from all members of MNS and readers in general. The editorial is very optimistic, with the good support and enough articles from the contributors the biannual issue of this bulletin will be published on schedule. We also observed that from the past few years there was encouraging response from contributors from wide range of organizations and agencies. This can probably be improved in the future, as sharing and disseminating knowledge and information is one of the agendas of Malaysian Nuclear Society (MNS). Authors could deliver the same message but probably from a different approach. The editorial would also like to welcome contribution from students at various levels of education and MNS has agreed to provide some token as an incentive for your efforts. The editor welcomes articles and news from any related science, technology, engineering regulatory and economy issues. However, the articles should reflect the the title of this bulletin on news and information on nuclear. With the current scenario and trends on world energy demand, food and water security, environmental concerned, it is hoped that the contributed articles and news could be “hot” topic of discussions on nuclear.

Chief Editor
Buletin Nuklear Malaysia,
June 2024

G2-Tag Radig Meter: First Survey Meter Certified by SSDL In Malaysia

Nor Arymaswati Abdullah, Nur Aira Abd Rahman, Lojius Lombigit, Mohd Taufik Dolah, Nabilah Ramli, Noor Farhana Husna A. Aziz, Azraf Azman and Maslina Mohd Ibrahim

Nuklear Malaysia, Bangi

Act 304 delineates the disparities in radiation exposure limits between the public and radiation workers, as established by the Malaysian Ministry of Health and the Malaysian Atomic Energy Department. Notably, the total body radiation exposure limit for the public stands at 1 mSv annually, whereas radiation workers have a limit of 20 mSv per year. These limits vary for specific body parts such as skin, eye lenses, hands, feet and pregnant women.

The repercussions of excessive radiation exposure encompass a range of diseases and harm. Diagnostic gears like x-rays (0.1 mSv) and whole-body tomography scans (10 mSv) play a crucial role in medical decision-making. However, an acute dose of 1 Sv can lead to radiation - related inflammation, manifesting as nausea, blisters and diarrhea, while a 5 Sv exposure is sufficient to cause fatality within a few months. To address these concerns, the deployment of a survey meter becomes imperative. The G2Tag Radig Meter (Gamma GeoTagging Radiation Digital Meter) survey meter serves the diverse needs of industries, hospitals / clinics, universities, schools and regulatory bodies. Moreover, it proves suitable for public use or by organizations concerned about the ambient radiation levels.

Currently in Malaysia, reliance on imported survey meters incurs high costs due to the absence of locally manufactured alternatives. Offering an attractive price point, this product has the potential to stimulate growth in the domestic industry by promoting the adoption of cutting-edge technology. Beyond fostering increased social engagement in Malaysia, the benefits of digital technology are harnessed through the integration of a GPS system and digital storage (SD card), expediting the automated recording of measurement data. Furthermore, the product undergoes rigorous testing and successfully meets the standards set by SSDL laboratory calibration, ensuring its qualification for use in compliance with Act 304.

Figure1. G2 Tag Radig Meter

Typically, the design requirements for survey meter devices are tailored for safety and health purposes in industrial and environmental monitoring. The newly created device has been improved by incorporating a GPS module, enabling automatic location identification and data retention. The data stored in the micro SD card are **1. Time and date, 2. Latitude and longitude and 3. Dose reading**

This recent technological innovation introduces a user-friendly product with several notable features. It is remarkably lightweight, tipping the scales at just 227.3 grams, inclusive of the battery. Its compact dimensions, measuring 13.1cm x 8.1cm x 2.5cm, contribute to its small and portable nature. Designed

with ergonomics in mind, the product aligns seamlessly with the contours of the palm, ensuring user comfort. Additionally, its case is crafted for both comfort and suitability. The utilization of membrane buttons enhances the overall user experience, adding a tactile and responsive element to the product's interface.

The product underwent thorough testing and calibration at the Secondary Standard Dosimetry Lab (SSDL) Nuklear Malaysia laboratory, successfully meeting the calibration standards of the SSDL as a radiation detection device. The SSDL, responsible for certifying the qualification of survey meters, has endorsed this product for use. Furthermore, it promptly satisfies the industrial usage requirements outlined in Act 304. Having secured victories in numerous innovation competitions, this product has attained international acclaim. Alongside clinching the gold prize at the Malaysian Nuclear Agency and International Invention, Innovation and Technology Exhibition (ITEX) competitions, it reached the global stage at the Seoul International Invention Fair (SIIF) competition in 2023, garnering three distinct recognitions. Notably, these recognitions are gold from SIIF, special awards from Korea Fire Institute and special awards from Taiwan Invention Association

Prize giving ceremony at the Seoul International Invention Fair (SIIF) competition 2023.

G2-Tag Radig Meter and Award Medals / Certificates

REGIONAL WORKSHOP ON SITE EVALUATION FOR SMALL MODULAR REACTORS HAIKOU, CHINA

Dr. Norfarizan Mohd Said

Nuklear Malaysia, Bangi

The Regional Workshop on Site Evaluation for Small Modular Reactors (SMR) was held on 6th – 10th November 2023 at Baohua Harbour View Hotel, Haikou, China. The Asian Nuclear Safety Network (ANSN) event is hosted by the Government of China through the Nuclear and Radiation Safety Center (NSC) with the support of the International Atomic Energy Agency (IAEA).

The workshop was attended by 22 participants from seven countries including Bangladesh, Indonesia, Malaysia, Thailand, Vietnam, Korea and China. Malaysia was represented by two attendees, one from the Malaysian Nuclear Agency and the other from Atomic Energy. Three members of IAEA experts team conducting the workshop were Mr. Ayhan Altinyollar (Nuclear Safety Officer, IAEA), Mr. Mazhar Mahmood (Consultant, IAEA) and Prof. Kemal Onder Cetin (External Expert, Turkiye).

Group photo of participants and IAEA experts.

Country Presentation.

Lecture sessions.

The objectives of the workshop are to enhance the understanding and competence of regulatory bodies and future operators with regard to site evaluation for SMRs as per IAEA safety standards and

supporting documents and member states practices. In general, the course consisted of lectures on SMRs vs Large Reactors siting and site characterization, practical progress on SMR siting of Member States and Management of site evaluation activities for SMRs. A trip to Changjiang nuclear Power Plant was arranged during the course. The journey takes about two and the half hours by bus from Haikou. Participants were given the opportunity to visit the SMR model at the Popular Science exhibition of nuclear power plant and the SMR engineering site.

Visit to the SMR Engineering Sites.

Briefing on SMRs Site Selection and Evaluation in China at China National Nuclear Corporation (CNNC).

Final agenda of the event was the ANSN Siting Topical Group (STG) Meeting chaired by Ms. Park Seonjeong of Korea. Climate change and more specific topics on site evaluations for SMR were proposed to be the theme for the next meeting. The next hosting country was also determined in the meeting.

ANSN Siting Topical Group (STG) Meeting.

IAEA safety standards series related to site selection, site evaluation, design and safety evaluation for an advance reactor and nuclear installations, considering site specific challenges to reactor safety and radiological risks in case of an accident including all external hazards, monitoring activities and site-specific parameters relevant for the safety of the nuclear installation. A graded approach should be applied in determining the scope of the site evaluation, proportion with the radiation risk posed to people and the environment. Recent progress in the development of advance reactors such as SMR emphasized the need for additional and / or updated guidance to comply with requirements provided in the IAEA safety standards series.

This regional event introduced the IAEA requirements, guidance and supporting documents in the area of site evaluation for SMRs. Through the sharing of experience from the IAEA experts and the member states, participant had a clear and deep understandings about the site evaluation for SMRs. The excursions to nuclear facilities and engineering sites were well- organized, resulting in a remarkable

experience in which all participants had the opportunity to tour the 'under construction' nuclear installation. The participants were also enjoyed the beautiful scenery of Haikou city and local delicacies especially the coconut drinks.

Haikou City Highlight.

Haikou City Tour Highlight.

IAEA Training Workshop on Radiological Mapping Using Mobile Instrumentation in Seibersdorf, Austria, 9-13 October 2023 (EVT2103399)

Nur Aira Abd Rahman

Nuklear Malaysia, Bangi

Radiation mapping is the process of measuring and mapping the radiation intensity distribution throughout the target area. Data collected from this process is used to construct radiation map, which is useful to visualised the radiation distribution and identify the position of hotspots. This process is relevant for various applications, such as in post-emergency response to identify the location of contaminated area, or for safety inspections in plant / facility occupational safety assessments or environmental monitoring.

The International Atomic Energy Agency (IAEA) has conducted a training workshop on Radiological Mapping Using Mobile Instrumentation on 9th to 13th October 2023 in the Nuclear Science and Instrumentation Laboratory in Seibersdorf, Austria. The workshop was attended by 13 participants from Malaysia, Greece, Brazil, Thailand, Italy, Canada, Sweden, Morocco, Egypt, Jordan, Saudi Arabia and Norway. The aim of this workshop is to share new knowledge in the field of radiological mapping using mobile technologies and to provide a practical demonstration of the capabilities of ground and air systems in real field conditions.

All the experts and participants with the Orpheus Robot by BRNO Technical University, used to demonstrate the UGV technology.

The five-day workshop comprehensively covers both the theoretical and practical aspects of radiological mapping operations. The lectures commence with an exploration of fundamental scenarios in radiological mapping, accompanied by an introduction to the R-Markdown tool. This tool facilitates post-data processing, enabling participants to visualize both raw and interpolated data on Google Earth maps.

Participants are then familiarized with four types of mobile instrumentation, including backpack radiation detectors, unmanned aerial vehicle (UAV) based technology, carborne technology and unmanned ground vehicle (UGV) based technology. The workshop also delves into the concept of photogrammetry for radiological mapping. Moreover, the session includes an introduction to the InterSpec software, designed for gamma spectroscopy and radionuclide identification.

The practical segment of the workshop involves field exercises for each technology, allowing participants to gain hands-on experience with the tools and actively participate in source-searching missions. This hands-on approach enhances the participants' understanding and proficiency in utilizing the various instruments discussed during the workshop.

Field exercise with BRD technology where the participants were instructed to scan an outdoor field to locate the source position.

The UAV technology utilizes quadcopter with plastic scintillation detector to quickly scan a large area where the mapping data and progress can be monitored from a safe location.

Carborne technology demonstrations.

In conclusion, the IAEA's workshop on Radiological Mapping Using Mobile Instruments provided a valuable opportunity for international collaboration and knowledge sharing. Participants not only learned about the latest advancements in radiological mapping but also gained practical skills. Participating in international workshops is a valuable opportunity to update our knowledge and be better prepared for unforeseen radiological emergencies. These experiences contribute to a safer global environment by fostering international collaboration and progress.

TRAINING WORKSHOP ON ADVANCED USE OF NEUTRON IMAGING FOR RESEARCH AND APPLICATION (AUNIRA 23)

Asyraf Arif Abu Bakar & Dr. Khair'iah Yazid @ Khalid

Nuklear Malaysia, Bangi

Pada 30 Oktober sehingga 3 November 2023 yang lalu, dua pegawai penyelidik Agensi Nuklear Malaysia telah terpilih untuk menyertai latihan dan bengkel berkaitan pengimejan neutron anjuran *International Atomic Energy Agency* (IAEA). South African Nuclear Energy Corporation (NECSA) telah menjadi tuan rumah bagi penganjuran AUNIRA 23. Seramai 40 orang yang terdiri daripada peserta dan pakar dalam bidang pengimejan neutron telah menghadiri bengkel tersebut.

Para peserta AUNIRA 23 dari pelbagai negara iaitu Algeria, Mesir, India, Indonesia, Iran, Mexico, Peru, Thailand, German, Switzerland, Afrika Selatan, Malaysia dan Nigeria.

Bengkel ini melibatkan pembentangan hasil penyelidikan para peserta, pembentangan oleh pakar bidang dan sesi perbincangan bagi tujuan penambahbaikkan. Objektif utama bengkel ini adalah untuk menyumbang kepada peningkatan pengetahuan saintifik dan teknologi, inovasi dalam infrastruktur dan latihan sumber manusia dalam bidang pengimejan neutron. Antara topik perbincangan adalah :-

1. Prinsip radiografi neutron dan tomografi neutron.
2. Peralatan dan reka bentuk instrumen untuk pengimejan neutron.
3. Pengesan untuk pengimejan neutron.
4. Teknik pengimejan neutron yang canggih.
5. Aplikasi pengimejan neutron dalam penyelidikan, industri dan warisan budaya.
6. Kajian kursus e-pembelajaran IAEA tentang pengimejan neutron.
7. Laporan kemudahan: kemudahan sedia ada, baru dan yang dalam perancangan.

Asyraf Arif Abu Bakar (kiri) dan Dr. Khair'iah Yazid@Khalid (kanan) telah membentangkan hasil penyelidikan mereka yang berkaitan pengimejan neutron menggunakan reactor TRIGA PUSPATI.

Bengkel ini telah berjaya mencapai objektif, banyak input dan idea yang telah dikongsi oleh para peserta dan pakar bagi penambahbaikkan dan masa depan penyelidikan dalam bidang pengimejan neutron. Akhir sekali, hubungan yang dibina antara wakil negara diperkukuhkan dalam bengkel ini dan membolehkan para peserta sentiasa berhubung bagi perkongsian teknologi dan pengalaman sepanjang menjalankan kajian penyelidikan berkaitan pengimejan neutron.

INTRODUCTION TO HYDROGEN STORAGE

Julie Andrianny Murshidi, Ainur Najwa Mohamad Pouzi, Suhaila Hani Ilias and Ummi Tamimah Tukirin

Nuklear Malaysia, Bangi

Great potential for diversity of supply is an important reason why hydrogen is such a potential solution to our energy security needs. Hydrogen can be produced using abundant and diverse domestic resources, including fossil sources, biological methods, nuclear energy and renewable energy sources (lternatives, C. O. et. al 2004, Andreas Zuttel et. al 2008, Hans Larsen et al. 2004, John Andrews & Bahman Shabani 2012). Hydrogen can be converted to water, generating energy without releasing harmful emissions, thus reducing greenhouse gas emissions, pollutants and our dependence on fossil fuels.

Large-scale hydrogen utilisation encounters a constraint in terms of safe, dependable and cost-effective hydrogen storage. Hydrogen storage is a critical enabler for the transition to a hydrogen and fuel cell economy. Although hydrogen has approximately three times greater chemical energy density per unit mass (120 MJ kg^{-1}) of any chemical fuel (e.g., on average the equivalent value for liquid hydrocarbons is 43 MJ kg^{-1}), it also has a low energy density per unit volume (Von Colbe et al., 2019). For example, 1 L of gasoline (31.7 MJ/L, 8.8 kWh/L) contains approximately six times as much energy as a litre of hydrogen compressed to 70 MPa (4.7 MJ/L, 1.3 kWh/L). Hence, in order for the hydrogen to be successfully utilized, it must be compressed, liquefied, or other various ways before it can be used in the industry, such as automobiles or wearable technologies, like a mobile phone (Kayfeci & Keçebaş, 2019).

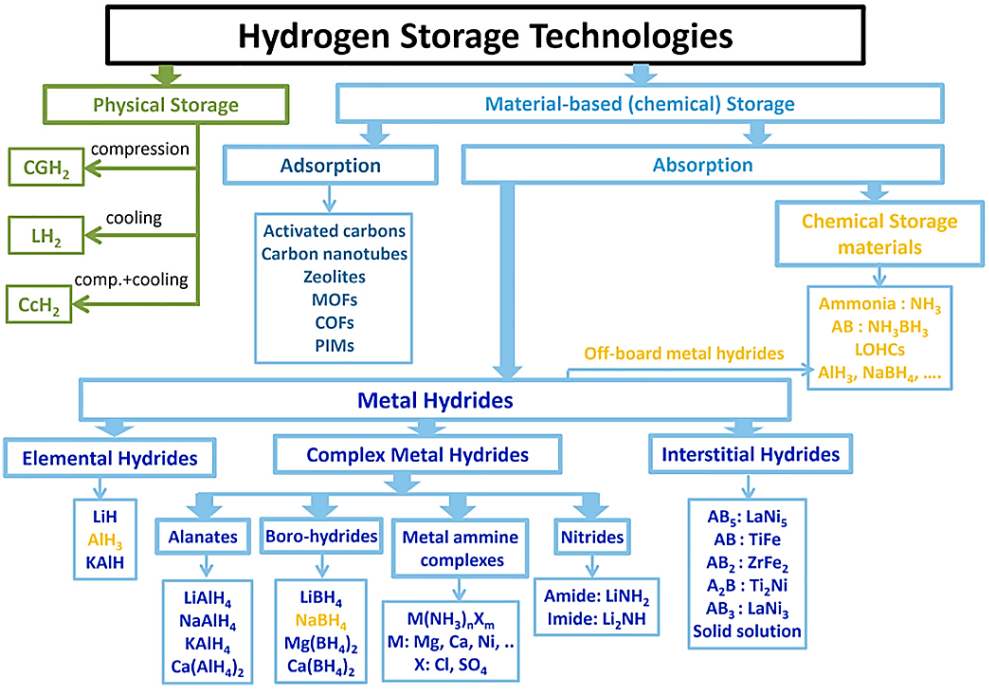

Figure 1. Hydrogen storage techniques (Hassan et al., 2021).

There are a few ways of storing hydrogen, and it can be classified into two categories, which are physical-based and material-based (Moradi & Groth, 2019) as shown in Figure 1. For each physical-based and material-based of storing hydrogen, they have a different of volumetric and energy density, as illustrated in Figure 2.

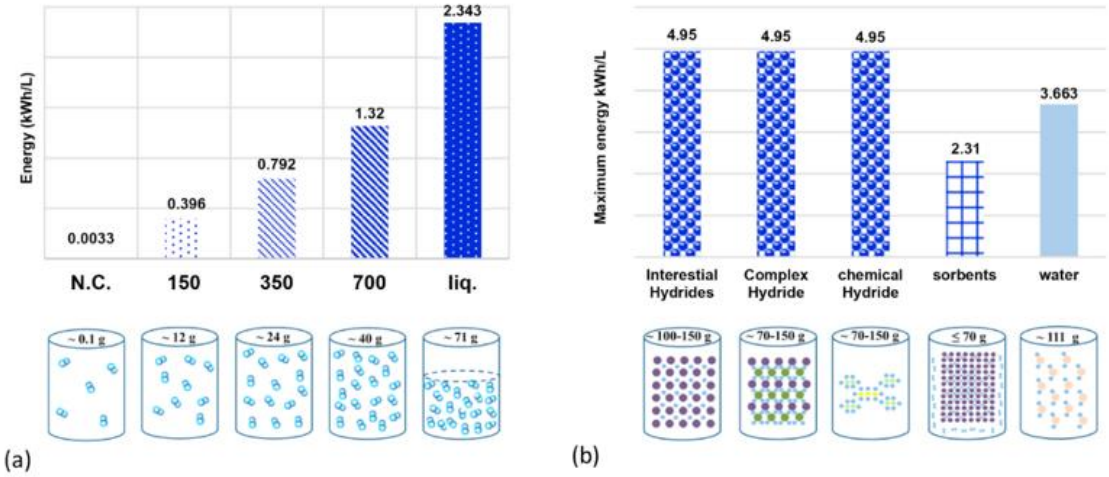

Figure 2. Volumetric capacity and energy density (a) physical-based, and (b) material-based (Hassan et al., 2021).

Physical-based Hydrogen Storage

a) Liquid System

The density of liquid hydrogen (LH_2) is greater than that of CGH_2. At atmospheric pressure or greater, hydrogen liquefies at a temperature of −253°C. LH_2 has sufficient volumetric and gravimetric capabilities. Although LH_2 is an excellent technique, it uses a lot of energy during the liquefaction process. To create 1 kilogram of liquid hydrogen, it takes approximately 4 to 10 kWh supposedly. This accounts for more than a third of the hydrogen's stored combustion energy. During actual usage, this proportion will be much higher. Another negative feature is the boil-off characteristic, which will decrease LH_2 efficiency even further. Approximately 2 to 3% of evaporated hydrogen will be lost each day due to the inevitable heat input into the storage containers. As a result, LH_2 is more popular in high-tech sectors, where performance is more important than cost, such as aeronautics sectors that engage with the production of aircraft vehicles (Yanxing et al., 2019).

The hydrogen is kept at −253°C at atmospheric pressure in relatively well insulated containers in this method. Because hydrogen is a liquid, it holds three times more energy than equal weight gasoline and requires 2.7 times more space to contain the same amount of energy (Kayfeci & Keçebaş, 2019).

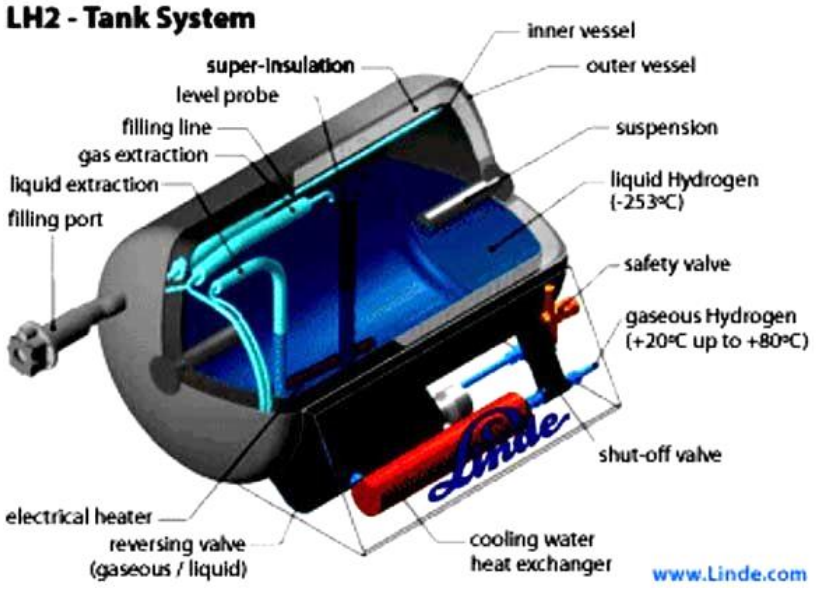

Figure 3. Example of liquid hydrogen storage tank (Suyamburajan et al., 2021).

b) Gaseous System

Compressed gaseous hydrogen storage (CGH_2) is the most established technique that is extensively used in a range of functional applications. In 2010, this technique has been used by approximately 80% of the 215 active hydrogen refueling stations around the world. Though this method is uncomplicated and inexpensive, it has its own flaws. CGH_2 is low volumetric density, which renders it less often used in practice. Although the present hydrogen storage tanks can withstand pressures of up to 70 MPa, their hydrogen density is only 39.1 kg/m^3. Because volumetric density does not rise proportionately to pressure, increasing volumetric density alone via pressurization is very difficult (Yanxing et al., 2019).

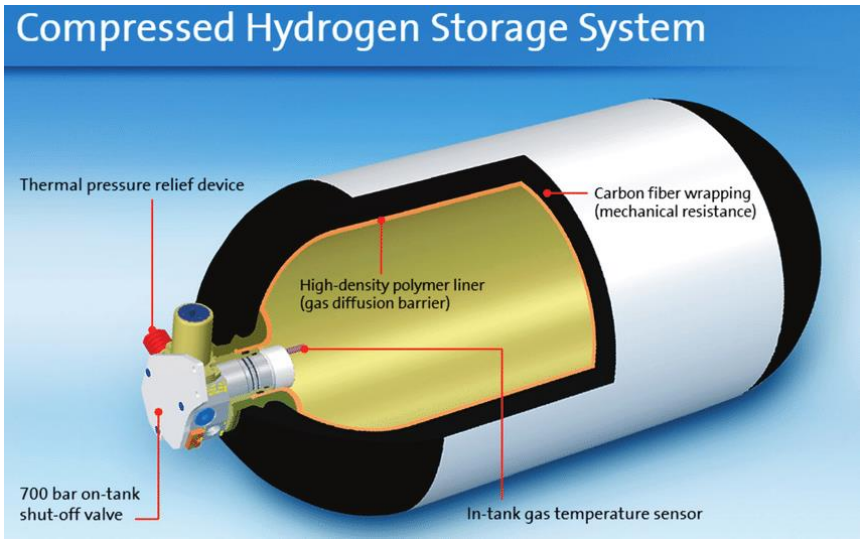

Figure 4. Type IV 70 MPa compressed gaseous hydrogen vessel (Eberle & Helmolt, 2016).

Material-based Hydrogen Storage

Among hydrogen storage techniques, physical-based are found to be closer to commercial feasibility, while materials-based have strong potential. Materials based hydrogen storage has demonstrated the ability to increase the density of hydrogen by a factor of more than twice that of liquid hydrogen, resulting in hydrogen densities of up to 21.1 MJ/L hydrogen (Scott McWhorter et al. 2011). After complete development and commercialization, these materials can accumulate high quantities of hydrogen and can be easily dispense when required.

Although much of research has been performed in this regard, to date, materials with high hydrogen storage capacities under the required conditions set by the United States Department of Energy (USDOE) have not been achieved. The USDOE target is to provide adequate hydrogen storage for onboard light-duty vehicle, material-handling equipment and portable power applications (https://www.energy.gov/eere/fuelcells/hydrogen-storage).

Hydrogen storage materials can be of different types: (i) dissociative material in which molecular hydrogen is dissociated into hydrogen atoms, which occupy interstitial sites (ii) material with chemically bound hydrogen; and (iii) materials that adsorb molecular hydrogen, wherein molecular hydrogen is attached to the surface by weak interactions such as van der Waals force or physisorption.

These materials should be able to store large amounts of hydrogen in gravimetric and/or volumetric manners, dispense hydrogen under mild temperature and pressure conditions, and offer easy handling of hydrogen and should be inexpensive when compared with other techniques (Gurwinder Singh et al. 2023). Materials such as metal hydrides, Pd-based catalysts, ammonia (NH_3) and NH_3 boranes are commonly used chemisorption materials whereas materials including nanoporous carbons, MOFs and porous polymers are generally employed physisorption materials (Gurwinder Singh et al. 2023, El Sayah, Z. et al 2016, Rusman, N. A. A. et al. 2016, D.P. Broom et al. 2019, Dundar Tekkaya et al. 2016). Although porous materials can potentially achieve the targets for hydrogen storage set by the USDOE, most of the studies are conducted at very low temperatures and/or under high pressures. Thus, continuous research and

development of new materials for both chemisorption- and physisorption-based storage of hydrogen is crucial for realizing the full potential of these materials on a commercial scale.

In conclusion, hydrogen storage technology has come a long way. Investigating in all directions need to be continuous in order to find the best system for each application. In the end, the objective to deliver genuinely decarbonized societies will depend on the most appropriate hydrogen storage method for each application. The ability to pick and choose the best hydrogen storage technology will be based not only on technical requirements, but also on its economic feasibility.

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