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Hydrogen Energy Production and Storage

Module content:

- ***Hydrogen Storage***
  - ***Methods of Storage***

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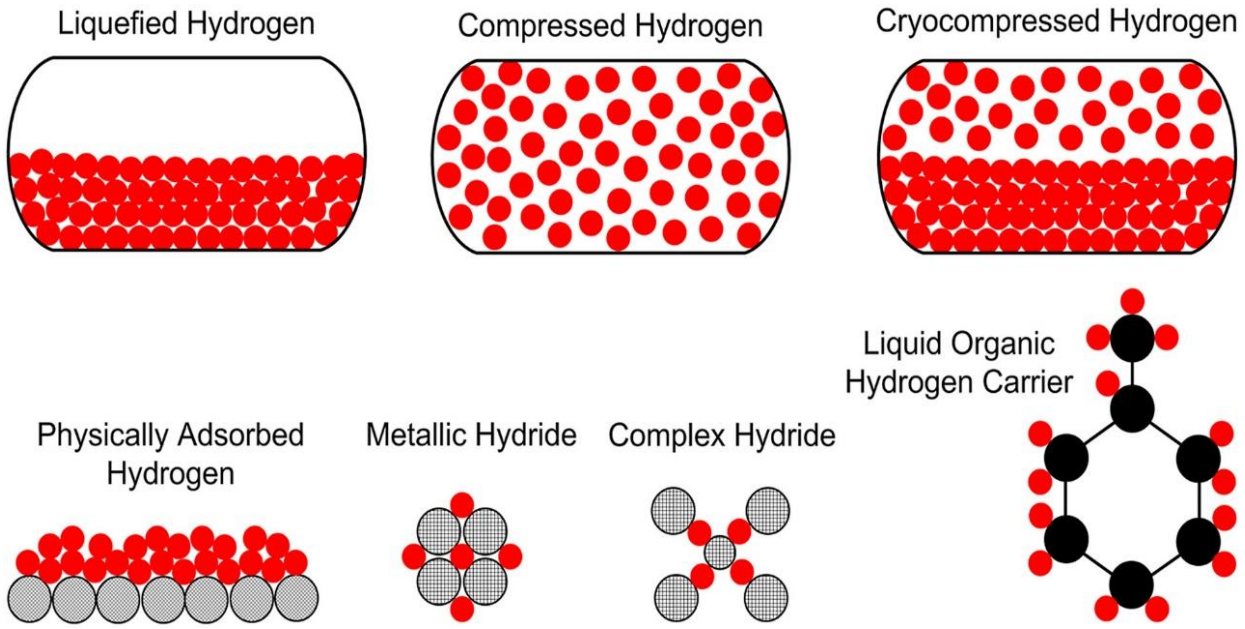
Hydrogen Energy Production and Storage

Hydrogen Energy

- The **Hydrogen storage is crucial** for effective utilization of Hydrogen for its versatile applications.

Hydrogen can be stored as

- Liquid
- Gas
- Solid



Physical and material-based methods of storage of Hydrogen

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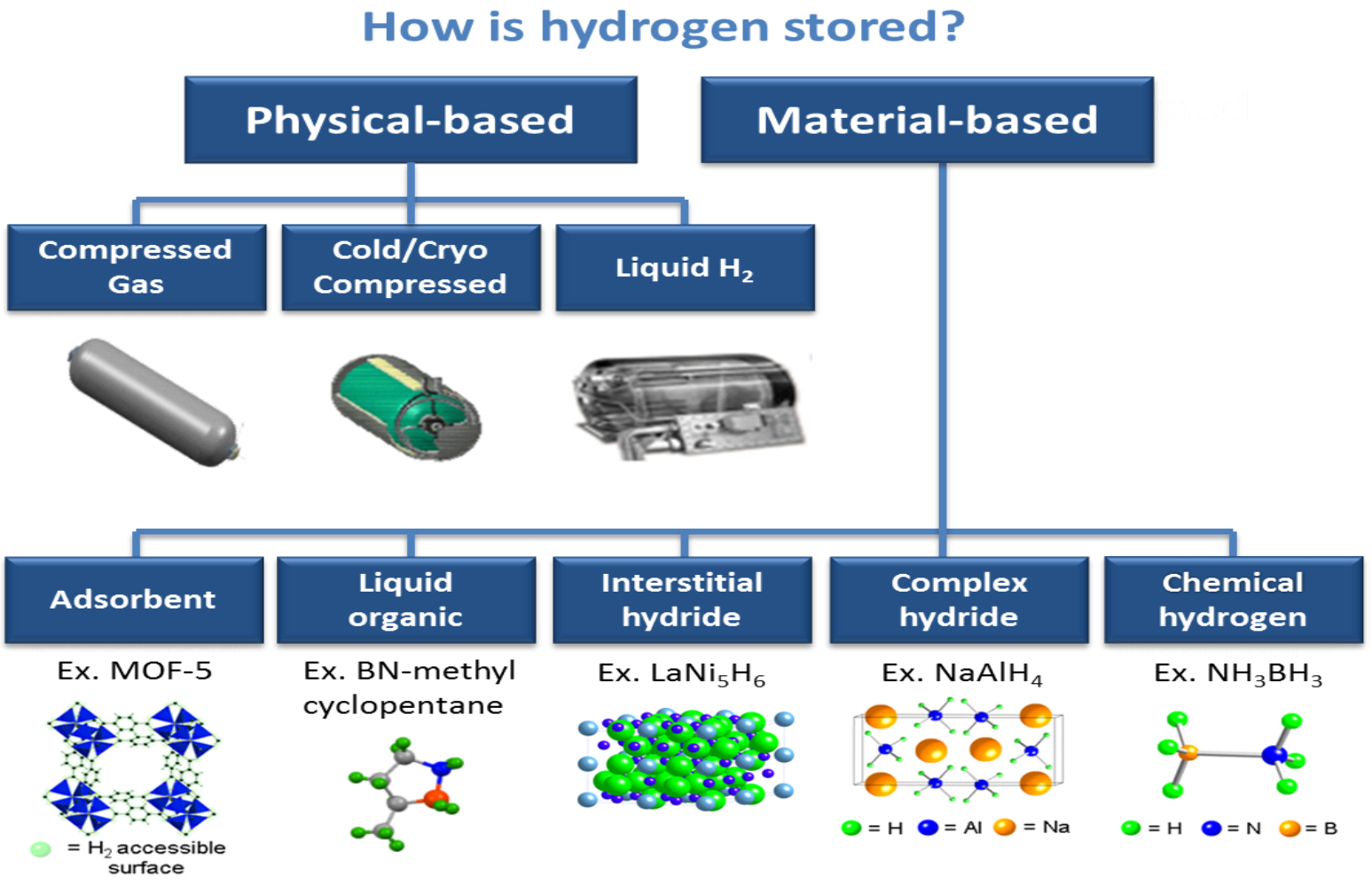

- [Hydrogen Storage in Metal-Organic Frameworks: A Review - research journal (gyanvihar.org)]

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- Storage of hydrogen in **the form of gas** usually requires **high-pressure tanks** (350–700 bar tank pressure)

- Storage of hydrogen **as a liquid** requires **cryogenic temperatures** because the boiling point of hydrogen is −252.8°C at an atmospheric pressure

- Hydrogen can also be stored on the **surfaces of solids (adsorption) or within solids (absorption**)

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Solid state hydrogen storage:

- Depending on the type of hydrogen being stored in host materials, solid-state hydrogen storage can be classified into two categories:
- Absorption of **hydrogen atoms** into the material
- Adsorption of **Hydrogen molecules** onto the surface of adsorbent

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Some of the most prominent materials for Hydrogen Storage are

- Metal organic framework (MOF)
- Liquid organic hydrogen carriers (LOHC)
- Interstitial hydride
- Complex hydride
- Chemical Hydrogen storage

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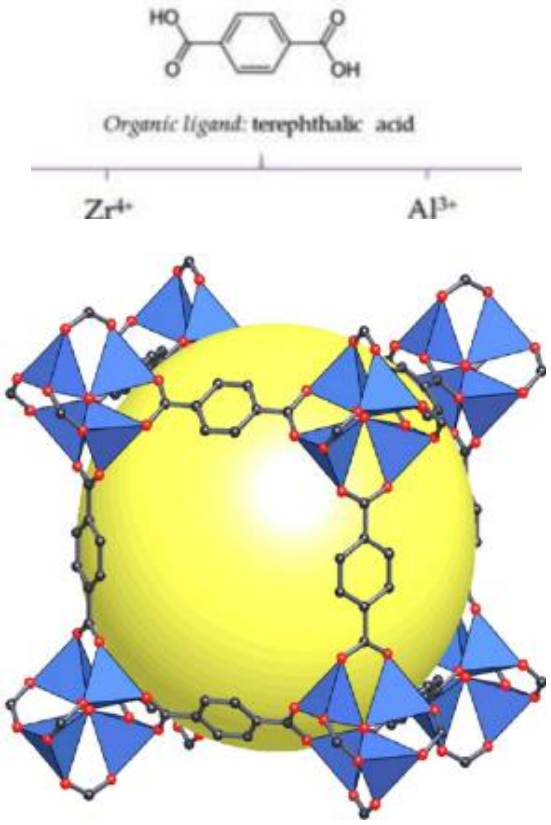
- **Metal Organic Frame as Adsorbent: (MOF)**
- Representing a novel class of porous materials
- Enables high density energy storage of clean fuel gas in MOF adsorbents
- **Zn-MOF (MOF-5)** remains an attractive hydrogen storage material



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- **Liquid organic hydrogen carriers (LOHC)**
  - LOHC technology has shown great potential for efficient and stable hydrogen storage and transport
  - This technology allows for safe and economical large-scale transoceanic transportation and long-cycle hydrogen storage
  - LOHCs can be used as storage media for hydrogen
- Organic compounds that can absorb and release hydrogen through chemical reactions
  - **Methyl cyclopentane**
  - **Dibenzyl toluene**

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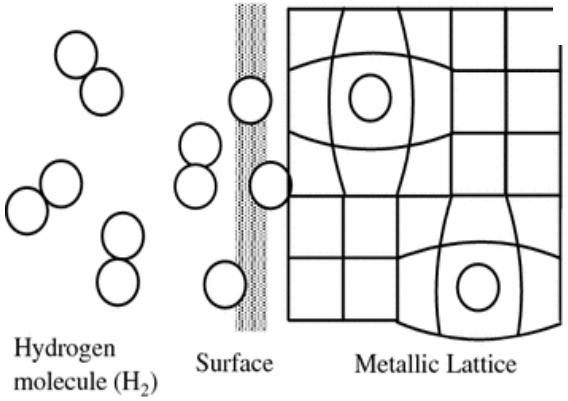
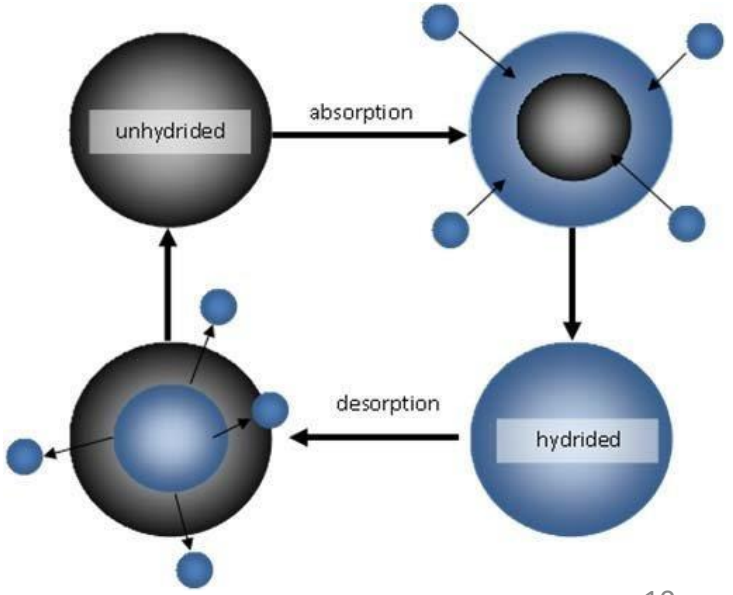
Interstitial hydride

- Contain a larger quantity of hydrogen than the same volume of liquid hydrogen
- Have advantage in the amount of hydrogen on a weight basis
- Certain interstitial hydrides are very suitable for hydrogen storage and transportation
- Example: $LaNi_5H_6$



Solid Hydrogen Storage Materials: Interstitial Hydrides | SpringerLink



Nanomaterials for Hydrogen Storage Applications: A Review (researchgate.net)

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- **Complex hydrides**
  - Composed of metal cations (such as Li, Mg, Na, etc.) and hydrogen-containing coordination anions (such as AlH_4^-, NH_2^-, BH_4^-)
  - On heating, the metallic hydride decomposes to hydrogen and finely divided metal

    Example: Sodium alanate can release up to 7.4% of Hydrogen when heated at 200^oC

    $$3\ NaAlH_4 \rightarrow Na_3AlH_6 + 2Al + 3H_2$$

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Chemical Hydrogen

- Hydrogen is released from a material through a chemical reaction
- Hydrogen is restored through a chemical reaction when the material is being recharged
- Ammonia Borane **(NH_3-BH_3)** has exceptional properties for chemical hydrogen gas storage
- Hydrolysis of NH_3-BH_3 releases hydrogen stored in it in presence of catalyst

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	Advantages	Disadvantages
• Liquid	• Liquid H_2 exist at low temperature 20K (-253K) • Stored in cryogenic tanks • Low volume compared gaseous H_2	• Reinforced & insulated storage tank required • Cooling and compression process consume energy (net loss about 30%)
• Gas	• It involves less infrastructure • More cost effective • Can be compressed into high pressure in gas form	• Needs extra energy • Space occupied is large • Leak proof tanks needed
• Solid	• hydrogen can be released whenever required by thermal stimulation or any other technique • Ease of handling • Safety	• Under R & D trials

THANK YOU

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