Hrein Energy

Hrein Energy Inc.
Head office : Sapporo city, Hokkaido
Laboratory: Otaru city
Experiment Site : Ishikari city
Capital : 32.1 million yen
Establishment : April 2001(company name has been changed in September 2004)
President : Akira Koikeda (Mr)
Member: 9 employees including contract employees

Liquid Organic Hydrogen Carrier (LOHC)

LOHC's Principle

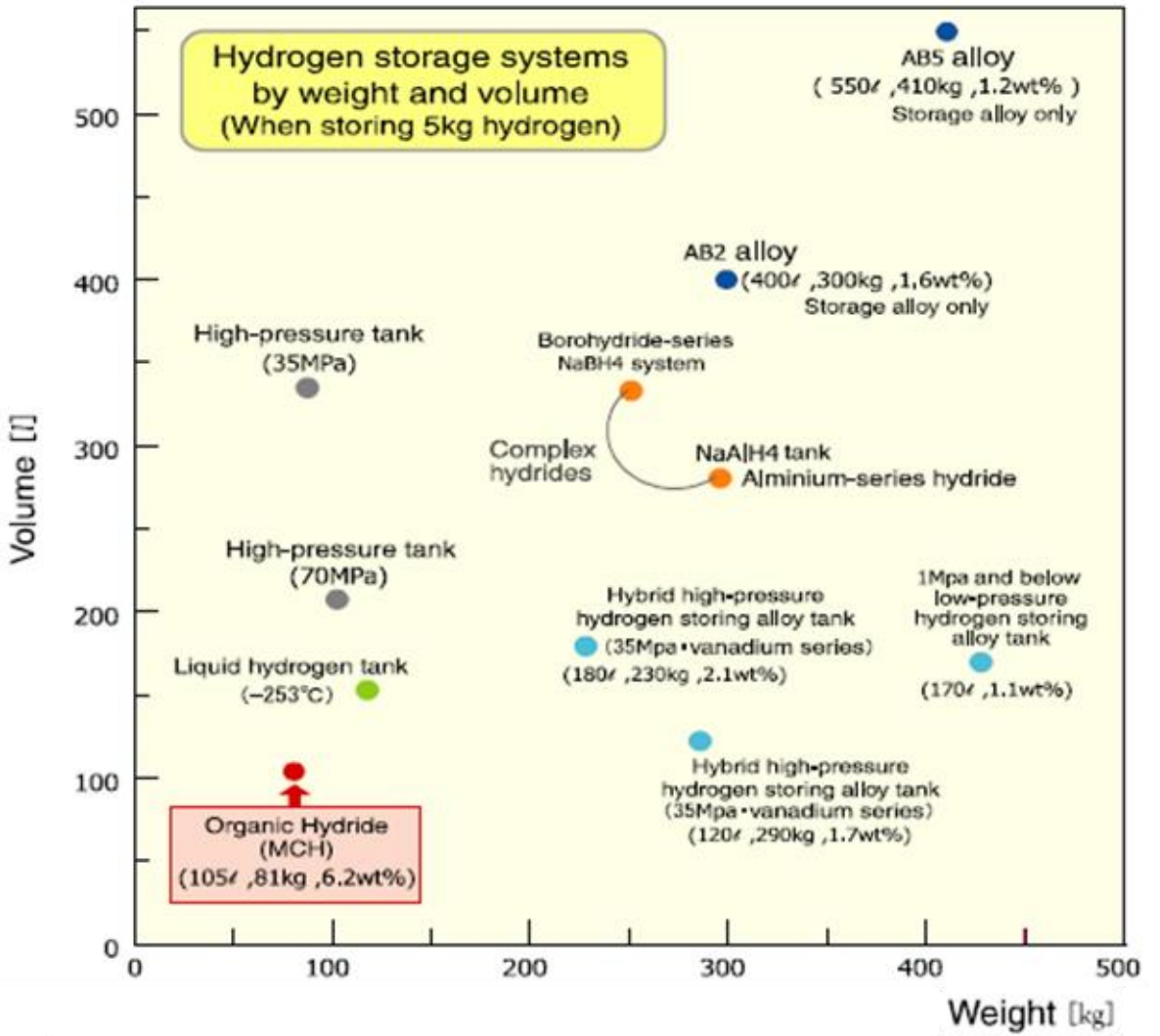
Hydrogen is stored as a liquid Hydride (Methylcyclohexane : MCH) through a catalytic reaction with a carrier (Toluene). Hydrogen is extracted from the carrier when it is used, and the carrier is recycled for reuse .

$$3H_2 + C_7H_8\,(\text{Toluene}) \longleftrightarrow C_7H_{14}\,(\text{MCH})$$

LOHC's features

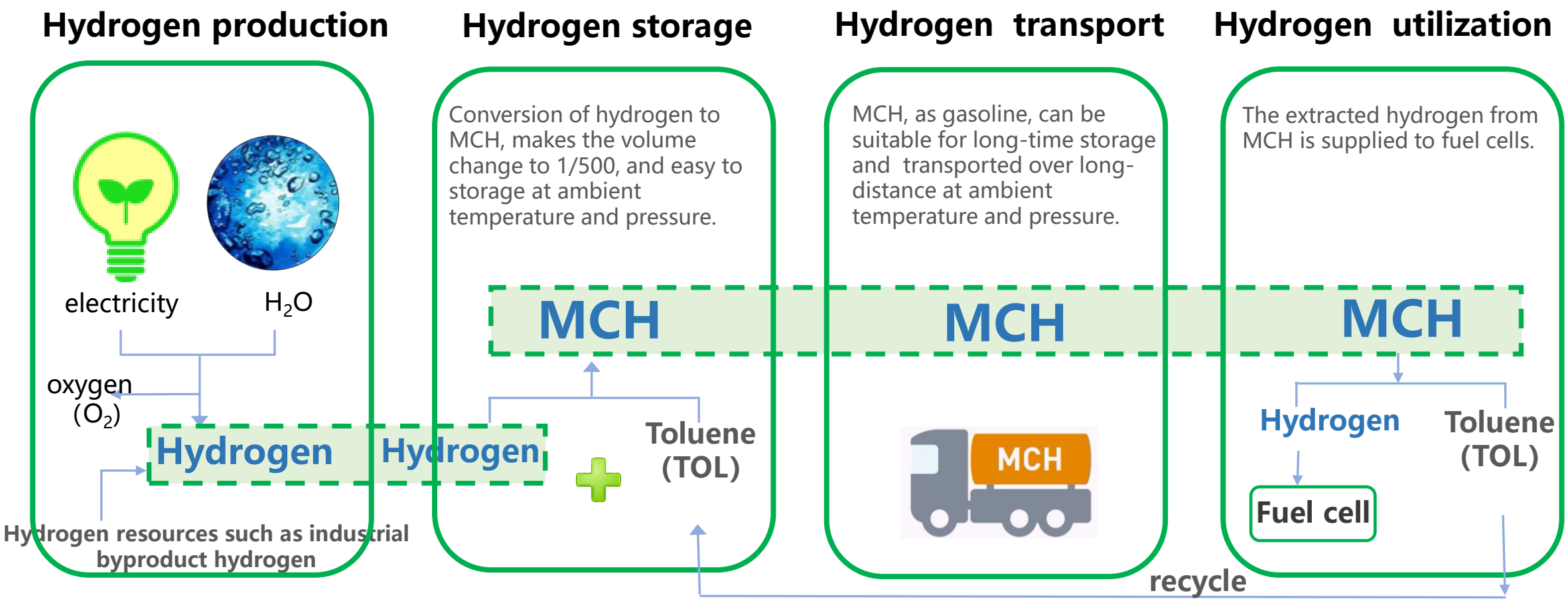
1. The catalytic process is reversible ,the reactants and products can be recycled ,and the Hydrogen storage density is high.
2. As hydrogen carrier, storage ,transport and maintenance is safer and more convenient . It is suitable for long-distance hydrogen transport, since storage equipment is simple.
3. High Hydrogen storage rate. In the closed cycle system consisting of toluene hydrogen storage, the reaction heat of hydrogenation process can be efficiently recovered and the efficiency can reach 98%.
4. It can be stored and transported at ambient temperature and pressure in the same way as petrol and has the advantage of using existing petrol delivery methods and filling stations directly.

LOHC can be stored and transported more efficiently than compressed Hydrogen or liquid Hydrogen.



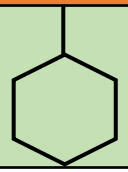
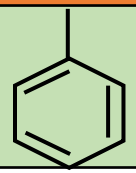
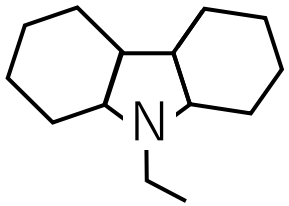
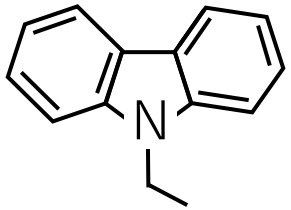
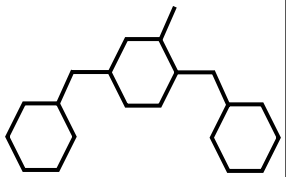
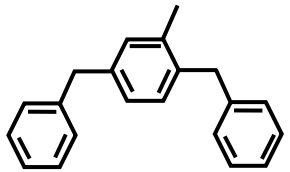
Reference: "Suiso Riyo Gijutsu Shusei" Vol.3, NTS Inc.,arrenged by Hrein Energy Inc.

The organic liquid hydride’ s storage and transport technology is composed of 3 processes : hydrogenation reaction of the catalyst, storage and transport of the hydrogen carrier and dehydrogenation reaction of the hydrogen carrier by means of methylcyclohexane (MCH), which is suitable for long-term storage and transport of hydrogen.



LOHC Types

According to internal investigations

Chemical formula after hydrogenation	Hydrogen containing rate (%)	Hydrogen carrier	Chemical formula of hydrogen carrier	At the time of reaction		After the reaction		Remarks
				Hydrogen	Carrier	Carrier	Catalyst influence	
MCH 	6.1	Toluene		gas	gas	liquid	excellent	・easy to get ・stable structure
	5.8	N-Ethlcarbazole		gas	Liquid	solid	?	・solid at ambient temperature, and liquid at the time of reaction ・fragile structure due to containing nitrogen ・irritating to the skin ・possible to produce heavy substances ・still in the research stage
	6.2	Dibenzyltoluene		gas	solid or liquid	solid	?	・high boiling point ・difficult to carry out catalytic reactions because of non-gaseous body ・possible to produce heavy substances

Hydrogen Storage Methods + Engineering

Organic hydride system is an effective technology for hydrogen infrastructure due to their superior storage and transport efficiency compared to compressed and liquid hydrogen.

The most important points to make flexible use of LOCH
"Strengths in dehydrogenation technology"・・・Achieved world's smallest class, highly efficient reactor with high hydrogen purity.

Hrein Energy has developed products that utilize its distinctive technology

- The hydrogenation equipment that can handle variation flexibly.
- Compact high–efficient dehydrogenation equipment

Meeting the needs from small ,medium to large plants with high hydrogen purity derived from renewable energy.

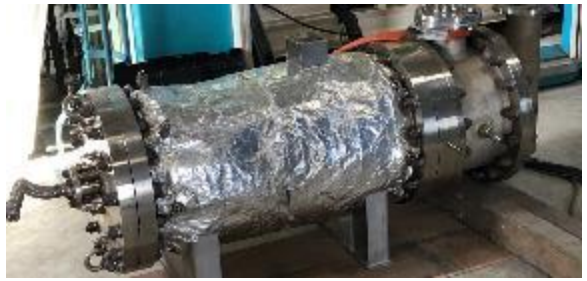
Received recognition by foreign countries and companies as a technology that can be commercialized → "Hrein Technology"

Hrein Energy, is a company that develops catalysts and reactors

International patent “compact and efficient reactor”

LOHC Choose efficient MCH
Catalyst High instant reactivity
Reactor Compact and high thermal conductivity
Hydrogen purity Fewer impurities in by-products

Reactor exterior



Japanese Patents List (organic hydrides)

特許番号	名 称	登録日時	概 要
4254127	水素貯蔵・供給システム	2009/2/6	水素化は無機系材料で担持された金属触媒を、脱水素は炭素系材料で担持された金属触媒を利用するもの
4136396	水素発生・貯蔵装置用の有機ハイドライド又は芳香族炭化水素の気化・凝縮装置	2008/6/13	有機ハイドライドの脱水素より水素を発生し、又は芳香族化合物の水素化反応により水素と貯蔵する装置において、未反応の原料成分をサイクリックに気液変換を行い収量を増加させるもの
4585937	水素貯蔵装置	2010/9/10	水素化反応において、触媒層を複数および水素供給口を複数設けることにより、水素の供給量の変動に対応して高い生成効率で有機ハイドライドを製造するもの
5046359 (PCT)	水素発生装置および水素添加反応装置	2012/7/27	脱水素反応に必要な熱を発生するための燃料を供給する領域に、その燃料の燃焼に利用される燃焼用触媒を有する領域と、脱水素反応に必要な脱水素触媒を有する領域とを、壁を隔てて径方向に隣接して備えた多重管構造の反応器を有する水素発生装置
5122178	水素化/脱水素化反応用応用担時触媒、その製造方法、およびその触媒を用いた水素貯蔵/供給方法	2012/11/2	白金とモリブデンカーバイド若しくはタングステンカーバイドとが、担持の表面の一部または全部を覆う担持触媒を用いて、芳香族化合物への水素化反応または当該芳香族化合物の水素化誘導体の脱水素化反応を行う水素貯蔵/供給方法
5159800 (PCT)	内燃機関用水素供給装置および内燃機関の運転方法	2012/11/22	水素貯蔵体および炭化水素系燃料の少なくともいずれか一方を燃料源とし、水素貯蔵体から水素を生成する脱水素装置を備え、発生した水素を燃料源に添加供給する内燃機関用水素供給装置
3912978	水素貯蔵・供給システムおよび水素貯蔵・供給装置ならびに水素貯蔵・供給触媒	2007/2/9	水素貯蔵体を入れた第1液層または水素供給体を入れた第2液層と水素貯蔵体の水素付加反応または水素供給体の脱水素反応の内、少なくともいずれかのひとつの反応をスプレー供給を利用して行うもの
4657475	水素貯蔵・供給システム	2011/1/7	触媒やノズル噴射する反応層が複数あるもので、所定の供給周期と順次遅延させた供給タイミングでもって、各反応装置に所定量の水素貯蔵体及び／又は水素供給体を供給する
4305899	水素発生・貯蔵装置	2009/5/15	有機ハイドライドを滴下させ、水素又は有機ハイドライド又は芳香族化合物又はそれらの混合物のいずれかの1部を燃焼するもの

International Patents List (organic hydrides)

名 称	国名	登録日時	特許番号	その他
水素発生装置および水素添加反応装置	アメリカ	2011/11/15	US8057559	日本はPCT切替し、特許登録済み。 欧州は、英国、ドイツ、フランスで登録済み。
同上	中国	2013/1/23	ZL200780016152.9	
同上	カナダ	2015/2/17	2645114	
同上	欧州	2018/3/7	1995211	
内燃機関用水素供給装置および内燃機関の運転方法	イギリス	2012/5/23	GB2469977	日本はPCT切替し、特許登録済み。
同上	中国	2013/3/27	ZL200880128624.4	

Application of Compact Dehydrogenation Equipment

The vehicle can be used without high-pressure hydrogen cylinder
→ (LOHC tank + dehydrogenation device) + (fuel cell, engine..)

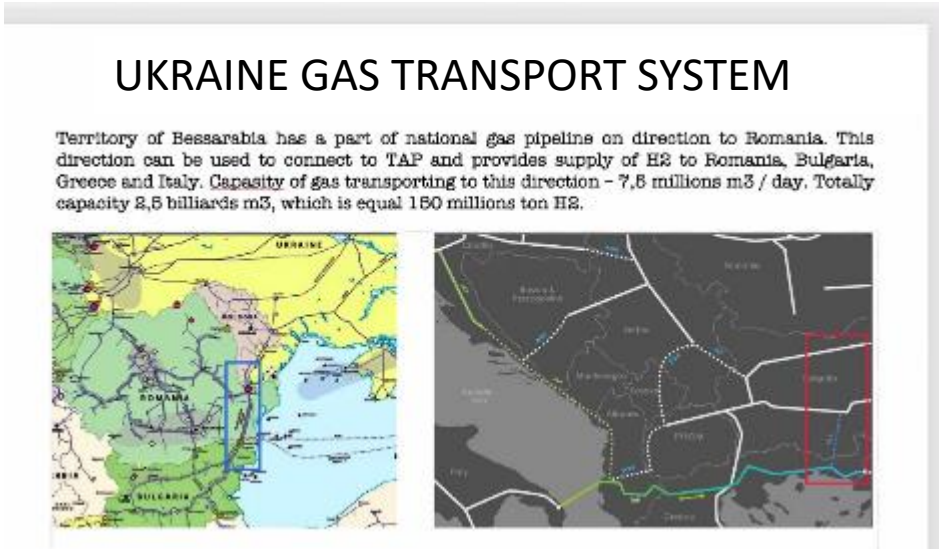
Development achievements

特許番号:第5159800号
英国GB2469977
中国ZL200880128624.4

For vehicles and ships that use mainly batteries ,traveling range can be extended by onboard hydrogen generation and battery charging .
The burden on the infrastructure can also be reduced by omitting the charging stand.
A pilot prototype of the electric vehicle (3KW) has been completed .
Main application : buses , trucks , small ships , railways , etc.

Joint development areas

Business activities outside Japan



Rugao , Nantong City (FCVC2019)

Ningbo City ,Zhejiang Province (International conference on Hydrogen)

Other cooperation with nation , region ,university and company etc.

Scope of business cooperation





Domestic and international transport of hydrogen

Global distribution of Hydrogen

Hydrogen supply overseas

Application fields (㎥/h)

~ 300㎥/h
FCV
facility

300 ~ 3,000㎥/h
FC bus
Hydrogen filling station

Truck ,heavy machinery
Rail-road, ship
Small-scale power generation

1,000 ~ 3,000㎥/h
Public facility
Commercial facility
Airport

1,500,000㎥/h ~
Power station

(Reference material)

Hydrogen Town Energy Diagram

Bringing renewable hydrogen into cities