## my email signature

henning zoz

CEO, Father of Five & Nanotechnologist, Doctoral Degree in Advanced Technology CIITEC/IPN, Professor in Mexico & Japan till 2014, Manager of the Year in SW/Germany, Patents & Innovation Awards.

# no trash on this planet but material make more with less

photo 2023-01-24 Stockhütte



D 57482 Wenden · Germany

HKP nanomaterials / nanostructures in non-religious clean- green- & hightech for transportation, energy & economy, from super-concrete to nuclear.

Zoz Group, D-57482 Wenden, Germany









#### 15<sup>th</sup> Int. Symposium Hydrogen & Energy

22.-27.01.2023, Emmetten, Switzerland contact: Prof. Dr. Andreas Züttel

#### H2-Barbeque & H2-Cremation, bypassing fuel-cell conversion on route to stand-alone & subsidies free Hydrogen Energy Economy.

Henning Zoz<sup>1</sup>, Shengyu Lai<sup>2</sup>, Albert Hesse<sup>3</sup>

<sup>1</sup>Zoz Group, Wenden, Germany, <sup>2</sup>Zhongshan Guanjian Metal Products Co., Ltd, Zhongshan City, China, <sup>3</sup>Albert Hesse Familienstiftung, Wenden, Germany 15<sup>th</sup> INT. SYMPOSIUM HYDROGEN & ENERGY

MPOSIUM STEERING COMMITEE & ENERGY Craig JENSEN, Hawaii, USA Shin-Ichi ORIMO, Japan Min 7HU. China

22. - 27. January 2023 Seeblick Höhenhotel, Emmetten, Switzerland



INVITED SPEAKERS Henning ZOZ, Germany Noris GALLANDAT, Switzerland Shin-Ichi ORIMO, Japan Klaus LACKNER, USA Jihye PARK, S. Korea Allan WALTON, England Heena YANG, S. Korea Bidrariu Hikoarsson Sweden

Jingiu ZHANG, China

Andreas ZÜTTEL, Switzerland

http://hesymposium.ch/



#### todays`content

What is Stockhütte ? (video, 2min) What is Zoz ?

#### upfront relevance:

- (a) HT & HT/nuclear materials Zoz-PM2000, PM2017, PM2018 (19YAT, 20YAI, 14YWT)
- (b) H2T Hydrolium<sup>®</sup>, H2Tank2Go<sup>®</sup>, IronBird|Stromkoffer, P2G2F<sup>®</sup>, P2H<sup>®</sup>
- (c) present cremation process, not so totally advanced

#### discussion:

- (d1) H2-Cremation (H2F2Go), substantial improvements & innovation, why cash printer.
- (d2) H2-Barbeque (H2Grill2Go), heats your home and drives your vehicle, not just grill.

#### call for feedback:

- (all) patrons & multipliers politics, society & economy green innovation from Germany
- (d1+d2) H2-Burner
- (d2) cost effective energy low-intensive O2-storage without compression
- (d2) cost-effective electrolyser 0.5-1kg H2 DLY
- (e) alternative natural rubber from banana skin, Fraunhofer-IME+Zoz

## appreciation & invitation

15th HES & OZ-24



www.zoz.de - high kinetic processing & nanostructured materials





## a very Welcome ZTC Olpe R/D Division@Zoz

Zoz Technology Center

Raiffeisenstrasse 17 | D-57462 Olpe





10 11 ji

## D 57482 Wenden · Germany

TOZ.de

Wuppertal

Hilden

Köln

Zoz Technology Center

HH

Z ZTC

🔁 нон

Siege

ZCS

Z ZCO





## Zoz manufactures

Simoloyer<sup>®</sup> up to 900l vessel vol.



DRM and other up to 20.000l vessel vol.



RSM up to 80.000I vessel vol.



But also lab-scale/table top equipment e.g. latest delivery to Switzerland:



## latest delivery to Switzerland – December 2022, 4x RM1







## latest business unit added to Zoz Group





## Zoz Center Siegen (ZCS), Tuesday-Excursion Nanostructure Symposium (last OZ-20)





12th German-International Symposium on Nanostructures March 4-6, 2024 Olpe, Gorwany





FuturBeton golden color

Zoz-FuturBeton-Eag	16
--------------------	----

green nanotechnology for foyer/garden/park and/or your building high strength 🔅 CO2-low 🌣 super durability 🌣 super surface



FuturBeton natural

dimensions

152 kg of "nanostructure"

Sales and Options		
FuturBeton golden color	EUR 999,00 + VAT	
FuturBeton natural	EUR 649,00 + VAT	
sales and distribution via Frank Lessmann Co.		

Technical Data, Dimensions		
L x B x H	990 x 1135 x 1030 mm	
net weight	152 kg	
material	FuturBeton C.1 (> 100 MPa)	
curing time	< 15 h	
CO <sub>2</sub> -saving*	3 kg(*compared to OPCC)	

After the set-up of the public bridge Rosenthal and the establishment of the balustrade, the Zoz-Eagle represents the first on-shelf available product and clearly demonstrates the possibilities of FuturBeton in complex structures at high requirements on surface quality.



the bridge "Rosenthal" at Olpe / Germany established on 14.11.2012





Zoz DeutscheFarber old Spray Coating



12 ton balustrade, Villa ZCS at Siegen / EuroNano Award 2013, Germany established on June 21, 2013 Zentallium<sup>®</sup> & FuturBeton nanoTruck (2014)





## Santuario a la Virgin de Guadalupe, Columbario Monumental Sanctuary of the Virgin of Guadalupe, Monumental Columbarium





2018: Mexican delegation @ OZ-18 at Wenden 2021: LIDER-cover 2022: start on ground at Zacatecas/Guadalupe 10 years "after" the Rosenthal Bridge !

burial chamber	20m
rising statue	60m
total height	80m

skin structure: high-strength, extremely durable and CO2-low **FuturZement|FuturBeton**,

green Zoz Technology from Wenden/Germany.



## Simoloyer<sup>®</sup> | present applications & products



VDA Verband der Automobilindustrie
Matthias Wissmann
President VDA



333 33 3333 333 8 88 8 3333 333 33 3

ready to market				
technologically	>!! public bridge in Germany			
economically	>!! +7 € / ton as of 43.000 tons p. a.			
ecologically	>!! 2	>!! 20 % CO2 savings		
		Automotive	FuturBeton	
additionally saved CO2		678 €/ton-CO2	354 €/ton-CO2	
vantage FuturBeton vs. OPCC		cost relevance	CO2 savings relev.	

FuturBeton C.1

nanostructured cement/concrete

high strength 🔆 CO2-low 🔆 super durability

FUCHS



the world's first public bridge made of

Futur High Performance Cement/Concrete

project-no. 03X0068A, BMBF

faster | sleeker | higher | cost-effective | durable | environmentally friendly

Zoz Group

Straßen.NRW

FuturBeton can build more

100 % а b С

cost of

- 3-4x stronger (140 MPa)
- superior durability (95% GP)
- · 20% CO2-emission saving
- > all advantages for € 7,00 / ton





		GER	World
CO2-savings-potential (by FuturZement/Beton)	[Mt]	4.95	158.4
CO2-savings-potential (ditto relative)	[-]	0.6 %	<b>0.5</b> %







#### 15<sup>th</sup> Int. Symposium Hydrogen & Energy

22.-27.01.2023, Emmetten, Switzerland contact: Prof. Dr. Andreas Züttel

#### H2-Barbeque & H2-Cremation, bypassing fuel-cell conversion on route to stand-alone & subsidies free Hydrogen Energy Economy.

Henning Zoz<sup>1</sup>, Shengyu Lai<sup>2</sup>, Albert Hesse<sup>3</sup>

<sup>1</sup>Zoz Group, Wenden, Germany, <sup>2</sup>Zhongshan Guanjian Metal Products Co., Ltd, Zhongshan City, China, <sup>3</sup>Albert Hesse Familienstiftung, Wenden, Germany



STEERING COMMITEE Craig JENSEN, Hawaii, USA Shin-Ichi ORIMO, Japan Min ZHU, China

22. - 27. January 2023 Seeblick Höhenhotel, **Emmetten**, Switzerland



http://hesymposium.ch/

INVITED SPEAKERS Henning ZOZ, Germany Noris GALLANDAT, Switzerland Berend SMIT, Switzerland Shin-Ichi ORIMO, Japan Klaus LACKNER, USA Jihye PARK, S. Korea

Allan WALTON, England Heena YANG, S. Korea Björgvin Hjörvarsson, Sweden

Sabrina Sartori, Norway Robert SCHLÖGEL, Germany

Andreas ZÜTTEL, Switzerland

Jinqiu ZHANG, China

todays`content

#### upfront relevance:

HT & HT/nuclear materials - Zoz-PM2000, PM2017, PM2018 (19YAT, 20YAI, 14YWT) (a)



## 2022-03 knightly accolade in nuclear fusion



This is to confirm and acknowledge that the Zoz GmbH in Wenden, Germany, has been involved already since many years in the European Nuclear Fusion Programme. Within the current EURATOM Framework Programme, i.e., Horizon Europe 2021-2025, the Zoz company participates as an industrial subcontractor in the EUROfusion project. Its contributions include R&D work and services in the area of materials development for extremely loaded components, such as the first wall of components facing the plasma in future fusion reactors, i.e., the breeding blankets. The current contributions comprise:

- Development of a cost-effective large-scale mechanical alloying route for reduced activation oxide-dispersion-strengthened (ODS) steel powders in the several tons range.
- Development of a scalable industrial processing route for tungsten alloy powders as semifinished products towards self-passivating "smart alloys".
- Provider of products and services in the field of powder metallurgy, like for example, high energy ball mills, mechanical alloying, design and construction of powder processing facilities.

These services and contributions play an important role in the EUROfusion materials development work package (WPMAT), specifically in the areas of High Heat Flux Materials (HHFM) and Steel Development and Qualification (SDQ).

Yours Sincerely,

Yours Sincerely,



Prof. dr. A.J.H. Donné Programme Manager

EUROfusion Programme Management Unit Boltzmannstr. 2 85748 Garching Germany

www.euro-fusion.org

info@euro-fusion.org

EUROfusion receives funding

ET is a EUROfusion facility, hosted by UKAE







brand	chem. composition (starting mat.)	ID	origin	t. b. on shelf
PM2000	Fe-19Cr-5.5Al-0.5Ti-0.5Y2O3	19YAT	ODS-PM fine-grain/HIP only, D40xL250m	
PM2017	Fe-20Cr-5.5Al-0.5Y2O3	20YAI	ODS-RR	powder only (AM, ALM, MIM)
PM2018	Fe-14Cr-3W-0.4Ti-0.25Y2O3	14YWT NFA-GE powder only, sheets as of 2023		
chemical (basic) compositions for on shelf (a) powder and bulk (b) bulk only (c) powder and bulk				

+SPS, D105xH10-100

## www.zoz.de

 ODS-19YAT (PM2000-Zoz)
 fine-grain/HIP D40x250mm, SPS

 ODS-20YAI (PM2017-AM)
 powder (AM, ALM, MIM)

 NFA-14YWT (PM2018-GE)
 powder only, sheets as of 2023

 ODS-Ti6Al4VSiC (PM2019-EU)
 powder only (AM, SLM)







# Enhanced sink strength: *High density of nanoclusters* compared to typical ODS alloys



 14YWT contains a significantly higher <u>number density</u> and <u>smaller size</u> of Ti-, Y-, and O-rich nanoclusters compared to the YAG oxide particles in PM2000 (and other commercial ODS alloys)



PM2000 – Porsche M-GT4



Al Contraction of the second s

**V727-05c-2h-vac-SPS** 2019-09-27 forging pr. 3 x 5 = 15mm 2s for ea. 5mm def.- step heating temp. 1.100° C





YAT, turbine Zoz-ARCI Center Hyderabad

D. T. Hoelzer, Oak Ridge National Laboratory: On the Development of Nanostructured Ferritic Alloys for Advanced Fuel Clad Applications in Nuclear Reactors, OZ-16, 9th International | 9th German-Japanese Symposium on Nanostructures (2016), Wenden, Germany, proceedings vol. 9 p-no. V02, S02







#### 15<sup>th</sup> Int. Symposium Hydrogen & Energy

22.-27.01.2023, Emmetten, Switzerland contact: Prof. Dr. Andreas Züttel

#### H2-Barbeque & H2-Cremation, bypassing fuel-cell conversion on route to stand-alone & subsidies free Hydrogen Energy Economy.

Henning Zoz<sup>1</sup>, Shengyu Lai<sup>2</sup>, Albert Hesse<sup>3</sup>

<sup>1</sup>Zoz Group, Wenden, Germany, <sup>2</sup>Zhongshan Guanjian Metal Products Co., Ltd, Zhongshan City, China, <sup>3</sup>Albert Hesse Familienstiftung, Wenden, Germany



STEERING COMMITEE **HYDROGEN & ENERGY** Craig JENSEN, Hawaii, USA Shin-Ichi ORIMO, Japan Min ZHU, China

Jinqiu ZHANG, China 22. - 27. January 2023 Andreas ZÜTTEL, Switzerland Seeblick Höhenhotel, **Emmetten**, Switzerland INVITED SPEAKERS



http://hesymposium.ch/

Henning ZOZ, Germany Noris GALLANDAT, Switzerland Berend SMIT, Switzerland Shin-Ichi ORIMO, Japan Klaus LACKNER, USA Jihye PARK, S. Korea Allan WALTON, England Heena YANG, S. Korea Björgvin Hjörvarsson, Sweden Sabrina Sartori, Norway Robert SCHLÖGEL, Germany

todays`content

#### upfront relevance:

- (a)
- H2T Hydrolium<sup>®</sup>, H2Tank2Go<sup>®</sup>, IronBird|Stromkoffer, P2G2F<sup>®</sup>, P2H<sup>®</sup> (b)







## Zoz Energy

- opportune utilization of EEG
- shaping future energy
- · renewable and baseload-able
- Power to Gas to Fuel (P2G2F<sup>®</sup>,P2H<sup>®</sup>)





Zoz Energy is active since 2010 and to date operates seven photovoltaic fields and holds about 12 hectares land for the construction of wind turbines. Assigned are a PEM fuel cell plant in Siegen ZCS for electricity and heat supply (hydrogen reforming from city gas) and an electrolysis plant at ZTC in Olpe to supply hydrogen for vehicle operation on success of the Zoz-ZEV fleet.





Power to Gas at Zoz Technology Center (ZTC) + Zoz ZEV-fleet = Power to Gas to Fuel (P2H<sup>®</sup>, P2G2F<sup>®</sup>)



IronBird/power-box remains on vehicle, H2Tank2Go® are replaced at the next tank vending machine or home depot

# Power to Gas to Fuel



Zoz ZEV fleet, OE-OZ-21 through OE-OZ-30





ZTC with 0,2 MW solar power

40 kW Electrolyser at ZTC

P2G2F<sup>®</sup> is a registered trademark of Zoz Group



## Simoloyer<sup>®</sup> | applications & products

## P2G2F<sup>®</sup> Power to Gas to Fuel

DIE FAMILIEN UNTERNEHMER durch

Nominiert für

Deutscher Umweltpreis 2013 Zoz Hydrogen Technology Nanostructures for Zero Emission Future Transportation & Energy



nanostructured H2storage Hydrolium® - environmentally friendly and cost effective



solid-state absorber tanks H2Tank2Go® - virtually pressureless, safe, clean and lasting



click'n'go system H2Tank2Go® - replacing tanks within seconds



exchange at a tank vending machine - refueling e. g. at any home depot



automotive future names Hydrogen - with 20 tanks you can drive your car



Power to Gas to Fuel & Zero Emission Mobility - only makes sense if energy is provided fossil-free

#### Hydrogen-Storage-Tank H2Tank2Go®

Reasonable energy storage for mobile & stationary use, superior safety level, existing infrastructure, brilliantly simple, flexible multi-tank-operation, MOT-approval pending, no one has come so far.

#### Zoz Hydrogen Technology – Power to Gas to Fuel - P2G2F®

Make hydrogen mobility available, create an infrastructure, win new customers, generate energy emission-free, produce & store hydrogen, drive with hydrogen & supply electricity.

isigo®H2.0











## Simoloyer® | applications & products







H2-OnAir<sup>+</sup>

nanostructure in Zoz-Tanks [Hydrolium<sup>®</sup>, H2Tank2Go<sup>®</sup>] and PEMFC's (Zentallium<sup>®</sup>)

# X

## Electric Aircraft with Hydrogen Range Extender project-no. EG 906, EUROGIA+/EUREKA

#### What is new

advanced and environmentally friendly aircraft propulsion by a combination of solar cells, battery and hydrogen fuel cell;

solid state hydrogen storage as well as the physical combination with pressurized hydrogen for aviation;

fuel cell system provides electrical power for all flight phases (not only for cruise);

cost-effective, lightweight fuel cell system;

standardized connectors for all kinds of hydrogen tanks;

same tanks for aviation and ground transportation;

quick replacement of tanks rather than refueling on board (new infrastructure strategy at revolutionary logistics and operative way of refueling);

platform for later High Altitude Pseudo Satellites (HAPS) at combined Battery-Solar-FC-technology for very long term flight missions;



AIRBUS GROUP CROUP CROUP CROUP CONSTRUCT CROUP CONSTRUCT CROUP CONSTRUCT CROUP CONSTRUCT CROUP



#### EADS-Bulletin "UP", No. 6 – November 2012

#### Up To Planet EADS Nr. 6 [11-2012] pp 30-31



The rapid development of alternative energy sources over the last decade is helping solve the question as to how to achieve a similar or better performance without carbon dioxide emissions. With air traffic growing faster than any other transport sector, EADS is examining the long-term potential of electricity and hydrogen as complementary on-board energy sources.

AIRBUS

GROUP

Hydrogen is a clean energy source which is constantly evolving, with 50 million tonnes produced annually and global demand increasing by five to 10% per year. It is primarily used to refine heavy hydrocarbons, but could also be a complementary energy solution for air transport. This potential is the reason why EADS has decided to launch a project based on a fully electric aircraft, partly powered by on-board hydrogen fuel cells devices that transform

the energy contained in hydrogen and three-year programme is being develc of EUROGIA+, a European Union p international partnerships to advance energy technologies.

While this light plane will be equip solar cells in its wings to provide the hydrogen fuel cell system will help e range, allowing it to fly for 40 minut

120 km/h. "The key enabler for such a demonstrator is the development of a solid-state hydrogen storage system," emphasises Dr. Agata Godula-Jopek, Fuel Cells Expert at EADS Innovation Works (IW), the Group's research network. "This system can achieve higher energy densities, meaning more efficient performance and potentially longer runtimes, but currently has a more complex development path," she adds

To overcome these difficulties, the storage system will be based on an innovative technology which improves the kinetics of hydrogen storage by incorporating novel nanostructured materials. Such structures at refined grain size and at the same time enlarged grain boundary surface favour the sorption migration - in and out of hydrogen atoms. This system will be provided by the Zoz Group (see box), along with two fuel cells, while IW will be responsible for integrating the system in the flying platform and testing this in flight. The flying platform itself, known as Icaré II,

ate of Aircraft Design at the Univerect team will also include the French Research (CNRS).

cb of genius

ite of Aircraft Design is also a factor ly designed for full electric flight dessor Voit-Nitschmann (see box). Air-

bus is the main sponsor of this aircraft, which took its first flight in May 2011, while IW is also involved. "The purpose of this project is to better understand electric propulsion, which could become relevant for commercial aircraft," says Nikolai Kresse, manager at Airbus Future Projects. Looking at the long term, the company reaffirmed its commitment to sustainable mobility this September by engaging in the Clean Sky 2 programme from 2014 to 2020, during which €3.6 billion will be invested by the industry and the European Commission.

ing quickly," says Kresse. The eGenius is a two-seat, high-wing aircraft manufactured from fibre composites. The electric motor, integrated in the vertical tail, has a maximum continuous power of about 30 kW and a peak performance up to 72 kW at a weight of just 27 kilograms. And directly behind the pilots are four lithium-ion battery packs integrated in the fuselage. "In the last year, we've learnt that electric propulsion is very efficient: eGenius only needs a few kilowatts for a half-hour flight - you would use more fuel just to power on a conventional aircraft engine! Despite being a prototype, it is flying without a hitch," underlines Kresse.

Airbus is analysing the technical data from the flights together with IW, who also have another team focusing on the performance of the high-energy lithium-ion batteries. "Industrialisation will depend a lot on battery technology, and you can only guess how this will develop 30-40 years from now. But flying up to 500 kilometres with two people on board on a full electric aircraft was only a dream a few years ago. and now it is a reality with eGenius," enthuses Kresse. And while the transition to commercial aircraft is still decades away, these alternative propulsion methods are already making an impact in the aerospace industry. Their use for next-generation UAVs or High Altitude Platforms, for example, is currently being studied, "To understand the real problems you cannot just work on paper, you have to put your feet on the ground. Demonstrators can be an efficient way to mature and promote radical steps in technology, motivating researchers, showing what is possible today and collecting data to learn what may be feasible in the future," concludes Kresse Alvaro Friera

#### "HYDROGEN IS THE ANSWER"

Prof. Dr. Henning Zoz President and CEO of 7oz Groun

Could you explain the hydrogen storage system for the Icaré II flying platform?

With the scooter and car industry in mind, we are developing a simple and conveniently interchangeable system of small tanks of 0.9 litres each, where our goal is that 23 of these H2Tank2Go® bottles could offer 2.25 kilograms of hydrogen This would equal 75 kW/hour, which moves a one-tonne vehicle 300 kilometres. Now at the halfway stage, we can guarantee 50 grams of hydrogen per tank. For the flying platform, however, we will probably supply just six or eight bottles and the fuel cells in a parallel back-up system. Already on the 50g/tank basis, this will be enough to triple aircraft's current range. Our plan is to have around 10 flights in 2013 and 2014 and I wish I could be the pilot on one of these flights.

A kilogram of hydrogen today costs between €6 and €15 and there are only around 200 hydrogen-fuelling stations worldwide. What could be done to make this market more attractive?

My company makes a good part of its profits from third-generation advanced lithium battery technology now, but hydrogen is the answer for humanity's energy problem. We believe we have the solution to revolutionise the hydrogen refuelling infrastructure thanks to our simple and small interchangeable bottle system. Using this, we wouldn't need refuelling stations; we could replace and recycle the bottles in vending machines, bringing the refuelling time almost to zero.

#### "WE'LL SEE ELECTRICAL **BUSINESS AVIATION"**

Prof. Dipl.-Ing. Rudolf Voit-Nitschmann



Institute of Aircraft Design, University of Stuttgart

What can you tell us about progress on electric propulsion?

We started electric flight in 1996, when nobody was doing it. While Icaré II derives from a solar-powered plane designed in 1994, eGenius is a follow-up of an aircraft powered by a fuel cell system. We optimised the whole system for electric propulsion, integrating the electric motor in the vertical tail to further increase energy efficiency. The main advantage is that we have reduced power consumption to 80%, as well as lowering noise and emissions. I think this technology could be available for business aviation in 10 years, while for larger aircraft we will have to wait over three decades.

What are the advantages of collaborating with EADS?

It is important that industry, research institutes and academia partner to drive technological evolution. Airbus won't build an airliner with electric propulsion in the medium term, but will use our findings for further electric systems integration in their aircraft. Moreover, EADS researchers are also interested in transforming this technology into products like UAVs. These vehicles could fly into and out of the target area using a hybrid engine, while fulfilling the mission in electric flight: a very low noise operation with no emissions and no heat, making the UAV virtually undetectable.

Reporting here and above by AF



Shelling Tests of H2Tank2Go<sup>®</sup> at German Armed Forces Nov. 2012, Wehrtechnische Dienststelle für Waffen und Munition 91 (WTD 91), Schießplatz Meppen



Ballistics tested with 12,7mm charge & 44mm hollow charge.

"...bei einer Hochdruck-Tankbatterie hat es die komplette Anlage zerlegt. Mit so einer gewaltigen Explosion hatten wir nicht gerechnet. Sogar Sicherheitsglas wurde durchbrochen und einige Leute erlitten Schnittverletzungen..."

Other H2-tanks were shelled as well during these tests – one of which (high-pressured H2-tank-array) caused an explosion that severe, that even safety glass was pierced by debris and people got injured (details of this incident remain confidential).

no safety issues with the H2Tank2Go® (as expected)







 economic FuelCells (PEM) for tomorrow:

target cost: 1.000 USD / kW electrical power (small scale, air-cooled up to 2 kW)

- goals & requirements
  - precious metal saving
  - prefabricated C-layer
  - high performance CCM (1W/cm<sup>2</sup>)
  - cost effective most simplified BPS
  - automatic manufacturing
  - strategic market impact
- ...this is formed at Wenden !





ref.: SGL Group, "Gas Diffusion Layers", SGL Shanghai, September 2011





Development of low cost gas-diffusion-electrodes on the basis of CNTs/CNFs for application in PEM fuel cells

Die Landesregierung Nordrhein-Westfalen

Investitionen in Wachstum

und Beschäftigung

EFRE







German Federal Ministry of Education and Research project no.: NW-1-1006 // 01.01.2016 // 3 years // total cost: 1.318.977,00 €

Development of low cost gas-diffusion-electrodes on the basis of CNTs/CNFs for application in PEM fuel cells

Entwicklung von Low Cost Gasdiffusionselektroden auf Basis von CNTs/CNFs für den Einsatz in **PEM**-Brennstoffzellen





## 2019-12, LOCOPEM, Zoz membrane forming & assembly device

Hydraulic Hot Press for the manufacturing of *LOw Cost Proton Exchange Membranes (PEM)* 

#### Hot pressing

- semi-automatic
- easy handling (25cm space)
- pressure control
- temperature control
- easy cleaning and maintenance
- pressure range
  - 2-25 bar
- temperature range
  - 20-150° C









#### Funded by the European Union









## H2-tank system B4S-SM/MM

nanostructured reactive complex metal hydride single/multi module • solid-state > 8 wt.%



H2 single-module tank B4S-SM

## high potential energy storage for the future

 $2\text{LiBH}_4 + \text{MgH}_2 \rightarrow 2\text{LiH} + \text{MgB}_2 + 4\text{H}_2$ 

H2-storage: > 8 wt.%, > 80 kg H<sub>2</sub>/m<sup>3</sup> storage material H2-loading completely reversible, H2-release thermally activated only !



consortium: www.bor4store.eu, EU-project FCH JU 303428 [2012-2015]





H2 multi-module tank B4S-MM



complex metal hydride processing unit Simoloyer® CM100-s2; H2-tank system B4S-SM outside ZTC; and inside at HZG - Hydrogen Technology Centre

P2H® | P2G2F® | Hydrolium® | H2Tank2Go® | Zentallium® | Simoloyer<sup>®</sup> | are registered trademarks of Zoz Group



H2Fuel2Go # Zoz-HZG-CEP-NOW-NRW - Hydrogen Fueling Station @ ZTC

Die Landesregierung Nordrhein-Westfalen



Beispiel:

Hydrid A

 $15 \rightarrow 50$ bar Hydrid B

200 bar

Wasserstoffkompressor auf Metallhydridbasis

 $50 \rightarrow$ 

Hydrid C

~450 bar

200 →

# H2Fuel2Go

01.01.2017 // 3,8 years // total cost: 3 M€

vollständige Demonstration einer Wasserstoffkreislaufwirtschaft mit neuartigem, wartungsfreiem und energieeffizientem Feststoffspeicherkompressor

complete demonstration of a hydrogen circulation economy with a novel, maintenancefree and energy-efficient solid-state storage compressor





Helmholtz-Zentrum Geesthacht

Centre for Materials and Coastal Research

Zoz Technology Center





H<sub>2</sub> MOBILITY



## D 57482 Wenden · Germany

CEP







Bundesministerium für Wirtschaft und Energie

Wasserstoffregion Burgenlandkreis

Power-to-Gas-to-Fuel **P2G2F**<sup>®</sup>, H2-Circular-Energy-Economy **H2C2E**, **P2H**<sup>®</sup>









Naumburg (Saale) Sachsen-Anhalt, Germany brown-coal region, wine & beauty



Dr. Young-Lib Kim (KAMI CEO), Dr.-Ing. InSung Chang Hyundai VP, Prof. Zoz, 21.01.2019



# **CO2-Scenario of IPCC**

# Why do we need green religion if we can have green science !



#### ENF # 12.-14.06.2019, Bucharest, Romania





"...what you have showed us, if I understand correctly, confirms what I claimed here 2 days ago, that **mankind** for the next very many years in all transportation, **cannot drive more economic and more ecologic, than with a diesel**." H. Zoz, EuroNanoForum 2019 (Prof. Schlögel confirmed/agreed non-verbally).





Hydrogen transportation sector, even after decades, does not see any significant products that can stand without permanent subsidies and/or political market interventions, **which is not acceptable**.





Hydrogen transportation sector, even after decades, does not see any significant products that can stand without permanent subsidies and/or political market interventions, **which is not acceptable**.

No matter if the CO2-scenario is true or fairytale, fossils are too costly and too valuable to just burn away.





If reconversion (**FuelCell**) is still too costly, for the time being, technologies where this is <u>not</u> required, are most attractive.

In result, the inventions Power Plant and H2F2Go describing CO2-free Hydrogen cremation, were claimed where Hydrogen is **replacing fossil gas** in a burner **to producing heat**.

Patent- und Markenamt \*08.09.2022 Patent- und Markenamt \*08,09,2022 power plant 10 2022 122 862.2 H<sub>2</sub> F<sub>2</sub> Go 10 2022 122 863.0 GERMAN PATENT APPLICATION **GERMAN PATENT APPLICATION** radiant tube Thermoprocessing plant Incinerator with with а а 75 pages, hydrogen-powered heating device, arranged inside the combustion 34 claims chamber, modern cremation. sustainable cremation, CO2-free. - (Ô) | Ô)+ ğ ğ ğ ğ () () Albert Hesse Albert Hesse Zoz Zoz Groui Groute Familienstiftung **Familienstiftung** 

strategic division











#### 15<sup>th</sup> Int. Symposium Hydrogen & Energy

22.-27.01.2023, Emmetten, Switzerland contact: Prof. Dr. Andreas Züttel

#### H2-Barbeque & H2-Cremation, bypassing fuel-cell conversion on route to stand-alone & subsidies free Hydrogen Energy Economy.

Henning Zoz<sup>1</sup>, Shengyu Lai<sup>2</sup>, Albert Hesse<sup>3</sup>

<sup>1</sup>Zoz Group, Wenden, Germany, <sup>2</sup>Zhongshan Guanjian Metal Products Co., Ltd, Zhongshan City, China, <sup>3</sup>Albert Hesse Familienstiftung, Wenden, Germany



STEERING COMMITEE **HYDROGEN & ENERGY** Craig JENSEN, Hawaii, USA Shin-Ichi ORIMO, Japan Min ZHU, China

Jinqiu ZHANG, China 22. - 27. January 2023 Andreas ZÜTTEL, Switzerland Seeblick Höhenhotel, **Emmetten**, Switzerland INVITED SPEAKERS



Klaus LACKNER, USA Jihye PARK, S. Korea Allan WALTON, England Heena YANG, S. Korea Björgvin Hjörvarsson, Sweden Sabrina Sartori, Norway Robert SCHLÖGEL, Germany

Henning ZOZ, Germany

Shin-Ichi ORIMO, Japan

Noris GALLANDAT, Switzerland Berend SMIT, Switzerland

http://hesymposium.ch/

#### todays`content

#### upfront relevance:

- (a)
- (b)
- (c) present cremation process, not so totally advanced



## critical issues towards cost & technology

- No. 1 exhaust air purification
- No. 2 thermoprocess (discontinuous)



## critical regulations (a) & (t)

No. 1 crematorium flame ban ! No cremation without wooden coffin !

No. 2 temperatures main-cc min 650°C, afterburner-cc 850°C for 2-3s min.

combustion chamber, authority, temp.

processing times (main-cc) reported from 1.5-4 to 6 h







#### 15<sup>th</sup> Int. Symposium Hydrogen & Energy

22.-27.01.2023, Emmetten, Switzerland contact: Prof. Dr. Andreas Züttel

#### H2-Barbeque & H2-Cremation, bypassing fuel-cell conversion on route to stand-alone & subsidies free Hydrogen Energy Economy.

Henning Zoz<sup>1</sup>, Shengyu Lai<sup>2</sup>, Albert Hesse<sup>3</sup>

<sup>1</sup>Zoz Group, Wenden, Germany, <sup>2</sup>Zhongshan Guanjian Metal Products Co., Ltd, Zhongshan City, China, <sup>3</sup>Albert Hesse Familienstiftung, Wenden, Germany



STEERING COMMITEE Craig JENSEN, Hawaii, USA Shin-Ichi ORIMO, Japan Min ZHU, China

22. - 27. January 2023 Seeblick Höhenhotel, **Emmetten**, Switzerland



http://hesymposium.ch/

Henning ZOZ, Germany Noris GALLANDAT, Switzerland Berend SMIT, Switzerland Shin-Ichi ORIMO, Japan Klaus LACKNER, USA Jihye PARK, S. Korea Allan WALTON, England Heena YANG, S. Korea Björgvin Hjörvarsson, Sweden Sabrina Sartori, Norway

Robert SCHLÖGEL, Germany

Jinqiu ZHANG, China

INVITED SPEAKERS

Andreas ZÜTTEL, Switzerland

#### todays`content

#### upfront relevance

- (a)
- (b)
- (c)

#### discussion:

(d1) H2-Cremation (H2F2Go), substantial improvements & innovation, why cash printer.



## over-mortality

(no matter if caused by Covid or Corona-politics)

Statistisches Bundesamt, Germany, October 2022: over-mortality +20% (slight under-mortality in 2020).

unfortunately further rising of over-mortality is expected worldwide.

## political ban of fossils also in cremation

Netherland as of 2030 expected, other nations to follow.

## most frequently government technology

not so innovative, Clean-/GreenTech to come.

cemeteries at critical occupation

coffin-burial might come to an end.



## H2F2Go Pilot-CC No. III [37]





## 37 H2F2Go Pilot-CC No. III







## firing temp., electrodes & heat radiation tubes





## Power Plant + Hydrogen = H2F2Go = human, efficient and environmentally friendly cremation

Dignity piety respect | ideal hydrogen combustion | CO2-free | thermodynamics | isolated heating circuit | gas equation | ideal convection | no cross-contamination in the gas phase | no hazardous waste disposal | vacuum/turbine technology | high-temperature materials from nuclear fusion | graphite electrodes and silicon nitride | lime water conversion | double wall vs. afterburner chamber | energetically ideal HT-operation | mechano-chemical mercury vapor absorption | high-kinetic thermal process | exhaust gas minimization through EG-recirculation | lightweight design | mobile HT-sensors | enormous energy and time saving | green hydrogen | circular energy economy.

ODS-19YAT (Zoz PM2000) and ODS-19YAI (PM2017)

#### Power-to-Gas-to-Power (P2G2P)

#### Cremation as a by-product of temporary storage of so-called renewable energy.



P2H<sup>®</sup> and P2G2F<sup>®</sup> are registered trademarks of Zoz Group



































#### 15<sup>th</sup> Int. Symposium Hydrogen & Energy

22.-27.01.2023, Emmetten, Switzerland contact: Prof. Dr. Andreas Züttel

#### H2-Barbeque & H2-Cremation, bypassing fuel-cell conversion on route to stand-alone & subsidies free Hydrogen Energy Economy.

Henning Zoz<sup>1</sup>, Shengyu Lai<sup>2</sup>, Albert Hesse<sup>3</sup>

<sup>1</sup>Zoz Group, Wenden, Germany, <sup>2</sup>Zhongshan Guanjian Metal Products Co., Ltd, Zhongshan City, China, <sup>3</sup>Albert Hesse Familienstiftung, Wenden, Germany



22. - 27. January 2023

Seeblick Höhenhotel, **Emmetten**, Switzerland

http://hesymposium.ch/

STEERING COMMITEE

Craig JENSEN, Hawaii, USA Shin-Ichi ORIMO, Japan Min ZHU, China Jinqiu ZHANG, China Andreas ZÜTTEL, Switzerland

#### INVITED SPEAKERS

Henning ZOZ, Germany Noris GALLANDAT, Switzerland Berend SMIT, Switzerland Shin-Ichi ORIMO, Japan Klaus LACKNER, USA Jihye PARK, S. Korea Allan WALTON, England Heena YANG, S. Korea Björgvin Hjörvarsson, Sweden Sabrina Sartori, Norway Robert SCHLÖGEL, Germany

#### todays`content

#### upfront relevance

- (a)
- (b)
- (c)

#### discussion:

- (d1)
- (d2) H2-Barbeque (H2Grill2Go), heats your home and drives your vehicle, not just grill.



## H2Grill2Go [37] – state of the art, just grill





Materials Energy Research Laboratory in nanoscale

https://www.heatlie.com.au/hydrogen-bbq



https://merlin-h2.com/energyh/h2





## just GRILL ?

## NOT just GRILL !

H2Grill2Go does charge your mobile and heats your home, all you need is sun, wind and rain (and beef). no more carrying gas-bottles, do I have enough gas ?



HydrogenGasgrill + Electrolyser + H2Tank2Go<sup>®</sup> = Power to Gas to Heat + Power







If industrial countries such as Germany are worried about "getting through winter", this also describes an unprecedented high demand for **energy self-sufficient** systems for all areas of life.

## HydrogenGasgrill + Electrolyser + H2Tank2Go<sup>®</sup> = Power to Gas to Heat + Power



H2Grill2Go







#### 01a Gasgrill, energy requirement & capacity



5kg C<sub>3</sub>H<sub>8</sub> (propane) bottle vol. 21 liter D230 x H505 mm net-weight 5,6 kg **65 kWh** approx. good for 25GS (grill-session)



## 01b H2Grill2Go, energy requirement & capacity



required good for 5GS/week > 13 kWh/week > **1,9 kWh DLY** 

1 week / 268 h, 30 sunny-hours

## 01c Grill Expert<sup>3</sup> claims

propane consumption at Grill: 750g/h > 5kg propane-bottle fires gasgrill for 6,6h. At 25GS, 25min/GS remain. Bratwurst burned in 10min, Steak well done after 15min. Match !





## 02 Energy generation onboard

H2Grill2Go carries a small wind-turbine under each of the 2 tables. Total max. power is about 100W, at 30% performance, this results in 0,7 kWh DLY. Both tables are covered with sandwich-element Ceran/solar-foil/Ceran, total surface is about 0,4 m<sup>2</sup> resulting in max. another 100W. At 10% performance, this provides 0,25 kWh DLY. Resulting total onboard generation is max. 1 kWh DLY representing half of the net-requirement !



2x sandwich Ceran/solar-foil/Ceran on tables. Total surface 0,4 m<sup>2</sup> > max. 100W x 10% performance > 0,25 kWh DLY

2 small wind-turbines underneath tables. 2x 50W = 100W x 30% performance > 0,7 kWh DLY

Resulting total onboard generation is max.

## 1 kWh DLY

representing half of the net-requirement !



## 03 Energy generation adapted

Portable wind- and solar energy devices for adaptation via socket to buffer-battery. Helixrotorturbine at rotor-dimension D700xH900xhight on a 1,6 m support provides 800 W max. At 30% performance, this results in 5,7 kWh DLY. A foldable solar system with an effective area of 1 square meter delivers a maximum of 250 W. At 10% performance, that would be 0.6 kWh per day. In total, a maximum of 6.3 kWh DLY could be generated onboard, thus three times the net requirement.





## 04 Result Grill Energy

(02) + (03) provide up to 7,3 kWh DLY at estimated net-requirement of 2 kWh DLY. At total energy losses of 60%, still 4,4 kWh DLY remain, covering the requirement twice. Okay.



adapted generation 6,3 kWh DLY

onboard + adapted > 7,3 kWh DLY

./. 60 % energy losses

> 4,4 kWh DLY at 2 kWh requirement  $\checkmark$ 



## 05 Hydrogen storage capacity (10x H2Tank2Go®)

1 kg Hydrogen provides 33,33 kWh which equals to about 3kg/4l gasoline. Acc. to (01), net-storage requirement is estimated at 13 kWh. Resulting gross 21 kWh. Thus 630g Hydrogen needs to be stored. H2Tank2Go<sup>®</sup> (0,95l at 4,3 kg) stored a theoretical value of 100g, achieved today about 65g Hydrogen. Thus the capacity of 10x H2Tank2Go<sup>®</sup> is required, in total 10 liter at about 35 kg.





1 kg H2 → 33,33 kWh (≈ 3kg/4l gasoline) net storage required 13 kWh → gross 21 kWh →
630g Hydrogen needs to be stored.
H2Tank2Go<sup>®</sup> (0,95l/4,3kg) stores 65g H2 (100th) →
10 x H2Tank2Go<sup>®</sup> required,
650g H2, total vol. 10 liter adds 35 kg to Grill.



## 06 Hydrogen Storage, pressure vessel vs. solid state absorber

Storage in a gas pressure tank fails due to low outlet pressure of the electrolyser <100bar. Hydrogen has a density of 0.0899 g/l or kg/m<sup>3</sup> at 0°C and 1.01325bar (1013hPa, ICAO standard). If a gas pressure tank could be loaded at 100 bar with an electrolyser and if hydrogen gas would behave ideally up to 100bar, a 1-liter pressure tank would contain approx. 9g of Hydrogen, which is around 7.2 times less than the H2Tank2Go<sup>®</sup> solid state storage tank . Acc. to the state of the art, available small electrolyser as suitable for a grill, deliver an output pressure of 30-50bar where the achievable pressure in the vessel in daily operation is another 10bar lower. In result, a maximum of 3g of Hydrogen could be stored in a 1-litre pressure vessel, which is 20 times less. In order to store 630g, a pressure vessel volume of about 200l would be required, which exceeds the space available for a grill. Gravimetric, a 200l gas pressure tank would weight less than a comparable 10l solid state storage tank, however volumetric, the gas pressure tank presents no alternative. In contrast to the compressed gas tank, the solid state storage tank requires a significant supply of heat for discharge, which is available as waste heat from the combustion process (barbecuing/heating).

#### Electrolyser

outlet pressure <100bar, available 30-50bar, at vessel 10bar lower



Hydrogen

density ( $\rho$ ) 0.0899 g/l or kg/m<sup>3</sup> at 0°C/1013hPa ~ 1.01325bar (ICAO standard).



H2-pressure tank (11) 100bar  $\rightarrow \sim$  9g H2 20-40bar  $\rightarrow \sim$  3g H2 630g H2  $\rightarrow \sim$  2001 vol.



H2Tank2Go<sup>®</sup> 0,95I/4,3kg → 65g H2 10 x H2Tank2Go<sup>®</sup> 650g H2, 10I/35kg





#### 07 H2Grill2Go, capabilities

(02) + (03) provide up to 7,3 kWh DLY at estimated net-requirement of 2 kWh DLY. At total energy losses of 60%, still 4,4 kWh DLY remain, covering the requirement twice. Okay.

charge your mobile (at buffer battery) heat your home (at ideal H2-combustion) power to your ZEV (power any via IronBird)





## 08 cost add on, initial estimate

at mass production

unit	net cost [€]
	mass production
water filter	10
electrolysis, gross 150g DLY cost is 250 Euro	175
operation management electrolysis	20
10x H2Tank2Go <sup>®</sup>	800
generators onboard	100
buffer battery	30
rectifier	40
H2-burner	60
combustion ignition via buffer battery	10
water tank max 51 or 2 tanks underneath tables	15
total	1.260
total with only 1x H2Tank2Go®	540





Hydrogen

## **Barbecuing with** Hydrogen Gas

Walt Pyle, John Dabritz, Reynaldo Cortez, and Jim Healv

@1994 Walt Pyle, John Dabritz, Reynaldo Cortez, and Jim Healy arbecuing with hydrogen is cleaner than using charcoal or propane because there's no carbon in hydrogen. When hydrogen burns, it emits only water vapor and traces of nitrogen oxide. No toxic pollutants, smoke, or particulates are released by a hydrogen flame. When hydrogen is produced by renewable energy, the water-to-fuel-to-water cycle can be sustained virtually forever!

For generations.

barbecue fires

have been made

Though we also

have natural gas

and electricity for

cooking, these

largely based on

fossil fuels and are

Home Power #43 · October / November 1994

are

resources

from charcoal



not sustainable. PV produced hydrogen Above: The propane gas is sustainable. (See barbecue before modification

HP #39 to see how PV electrolysis is accomplished. Cooking with hydrogen also appeared in HP #33.) Air pollution from barbecues is becoming objectionable in densely populated areas. Outdoor cooking is very popular on hot summer days. Unfortunately, that's also when air quality is usually at its worst. Legislation regulating barbecuing has even been enacted in some areas.

#### Propage Barbecues

24

Propane barbecues are more convenient and produce less emissions than charcoal models. Propane also eliminates waiting while the coals get hot.



Above: By removing the cooking grill and lava rock support, you can see the stainless steel propane burner



Above: The propane gas supply valves, burner, and pre-mix tubes, and pressure regulator.

The propane burner is ignited by turning on the gas and pressing the piezo-electric igniter button. A spark ignites the fuel-air mixture escaping from the burner The flame heats lava rocks, distributing the heat to the grill. Liquids that drip onto the lava will vaporize and burn, shielding the burner from contamination. After cooking is finished, the gas is turned off and the heat stops. The lava cools guickly to ambient temperature.

Gaseous fuel is safer than charcoal in some respects For instance, there's no need to supervise the fire after cooking. You're less likely to start a fire when a gust of wind comes up and rekindles "dead" coals! There's also much less ash residue. Though propane flames emit carbon oxides and hydrocarbons, amounts are less than from charcoal. Better fuel-air mixing results in less smoke. Cooking time is also shorter with propane.

The propane flow to each burner is controlled by a valve and delivered to an orifice. The orifice limits the gas flow and produces a high velocity jet, which aids fuel-air mixing. The high velocity gas enters the premixer, drawing air through ports on each side of the burner delivery tube.



Above: The propane burners installed in our barbecue use fuel-air pre-mixers.

Conversion of a Propane Barbecue to Hydrogen We started with a two-burner Kenmore propane barbecue. It has 1451 square centimeters (225 square inches) of cooking area and is rated at 24,000 Btu (82 kW) per hour. Sears had it on sale for under \$100.

We converted our barbecue by changing the burners and gas delivery tubes to prevent pre-mixing of the hydrogen fuel and air. Other parts of the barbecue were usable without modification. The covers, grill plates, gas supply line, control valves, pressure regulator, and piezo-electric igniter all worked as purchased. We will use the propane tank in a future hydrogen storage experiment.

#### Step 1. Feeding Hydrogen to the Pressure Regulator

Remove the pressure regulator from the propane tank. Attach 0.64 cm (0.25 inch) Swage lock stainless steel tubing to a 1/4 NPT fitting. This will replace the original pipe fitting on the "INLET" side of the regulator. We used stainless tubing, but copper or brass tubing and fittings can be used as well. They may also be easier to obtain at your local hardware store.

Set the hydrogen gas supply pressure to about 1 bar (14.5 PSIG) at the pressure regulator "INLET". Most propane-type regulators are rated for 17 bar (250 PSIG) maximum inlet pressure. Do not exceed the rated value. Use safety relief-valves in the piping and storage tank so excessive pressure cannot cause an unsafe condition. A welding-type compressed hydrogen cylinder with two-stage regulator can be used to supply the pressure regulator. For safety, include a shutoff valve to isolate the hydrogen supply from the pressure regulator during idle periods.

Before we continued our hydrogen conversion, we wanted to try the barbecue on hydrogen in its



Above: The gas pressure regulator with Swage lock tubing INLET pipe fitting.

"propane" configuration. We supplied the pressure regulator inlet with 1 bar (14.5 PSIG) pressure from the hydrogen tank and checked for leaks. Donning safety glasses, we turned on the control valve and pushed the igniter button. The fuel-air mixture in the burner and supply line promptly lit with a loud "BANG" that resembled a firecracker! We weren't surprised. The pre-mixed gas and air was flammable. The velocity of a hydrogen flame is much higher than that of propane The flame moved backwards against the hydrogen flow. It traveled from the igniter at the burner pre-mix outlets to the orifice at the mixer. The flame burned freely on the open jet of hydrogen coming out of the orifice, heating the pre-mix tube instead of the burner.

The hydrogen diffusion burner and gas distribution plate are designed to prevent the pre-mixing of hydrogen with air. In a gas diffusion burner, fuel is burned without premixing the fuel (hydrogen) with air.

Below A close-up of Hydrogen Burner Showing Gas Diffusion Ring, By coating the surface of the burner pores with a catalyst nitrogen oxide emissions can be reduced



Home Power #43 · October / November 1994

Highlighting open-pored HT metal-foam, here Ta (tantalum), for flame stabilization preventing premature fuel gas mixing, Pt-coated (platinum) to avoid/reduce NOx. Highly interesting approach for an H2 grill ! Note: (unfortunately) does not apply to H2Grill2Go, currently expected to operate with a "detached" flame pattern due to the required heat output.









#### 15<sup>th</sup> Int. Symposium Hydrogen & Energy

22.-27.01.2023, Emmetten, Switzerland contact: Prof. Dr. Andreas Züttel

#### H2-Barbeque & H2-Cremation, bypassing fuel-cell conversion on route to stand-alone & subsidies free Hydrogen Energy Economy.

Henning Zoz<sup>1</sup>, Shengyu Lai<sup>2</sup>, Albert Hesse<sup>3</sup>

<sup>1</sup>Zoz Group, Wenden, Germany, <sup>2</sup>Zhongshan Guanjian Metal Products Co., Ltd, Zhongshan City, China, <sup>3</sup>Albert Hesse Familienstiftung, Wenden, Germany



STEERING COMMITEE Craig JENSEN, Hawaii, USA Shin-Ichi ORIMO, Japan Min ZHU, China

22. - 27. January 2023 Seeblick Höhenhotel, **Emmetten**, Switzerland



INVITED SPEAKERS Henning ZOZ, Germany Noris GALLANDAT, Switzerland Berend SMIT, Switzerland Shin-Ichi ORIMO, Japan Klaus LACKNER, USA Jihye PARK, S. Korea Allan WALTON, England Heena YANG, S. Korea Björgvin Hjörvarsson, Sweden Sabrina Sartori, Norway

Robert SCHLÖGEL, Germany

Jinqiu ZHANG, China

Andreas ZÜTTEL, Switzerland

http://hesymposium.ch/

#### todays`content

#### upfront relevance

- (a)
- (b)
- (C)

#### discussion

- (d1)
- (d2)

#### call for feedback:

- (d1+d2) H2-Burner
- cost effective energy low-intensive O2-storage without compression (d2)
- (d2) cost-effective electrolyser 0.5-1kg H2 DLY
- alternative natural rubber from banana skin, Fraunhofer-IME+Zoz (e)



H2-Barbeque (d2) & H2-Cremation (d1), bypassing fuel-cell conversion on route to stand-alone & subsidies free Hydrogen Energy Economy.

## call for feedback:

(all) patrons & multipliers - politics, society & economy – green innovation from Germany(d1+d2) H2-Burner

- (d2) cost effective energy low-intensive O2-storage without compression
- (d2) cost-effective electrolyser 0.5-1kg H2 DLY
- (e) alternative natural rubber (ANR) from banana skin, Fraunhofer-IME+Zoz







## Taraxa Gum

from dandelion roots to high performance tires



"green" tires made by 100% natural raw materials

- rubber substitution by use of dandelion roots -

cooperative development Continental, Fraunhofer & Zoz

























## Taraxa Gum

from dandelion roots to high performance tires



"green" tires made by 100% natural raw materials

- rubber substitution by use of dandelion roots -

cooperative development Continental, Fraunhofer & Zoz









27.11.2017, ZTC



#### Alternative Natural Rubber







## Continental launches bike tyre made from sustainable dandelion rubber - Cycling Weekly

Continental reveals its first ever bicycle tyre made from dandelion rubber and will make it available in time for the Tour de France

#### 🐜 www.cyclingweekly.com

2019-08-01@TDC https://chan-bike.com/continentallaunches-bike-tyre-made-dandelions





## **Alternative Natural Rubber**

dandelion<sup>©</sup> successful, next comes banana<sup>©©</sup> Zoz/Fraunhofer IME joint technology initiative - sustainable biorefinery route for banana peels processing -

green<sup>+</sup> rubber from dandelion, green<sup>++</sup> from waste-peels

#### (a) Natural Rubber (NR) from Hevea Brasiliensis, background

NR is obtained from rubber trees (Hevea brasiliensis) providing latex, growing within the "green belt" of the planet can technically not for 100% be replaced by synthetic rubber;

- market cost strongly fluctuating at increasing demand;
- from alternative resources known and challenging since WW-II.

#### (b) Alternative NR (ANR) from dandelion roots

Russian dandelion, resource for Continental Taraxagum™ agrarian robust and undemanding, grows practically everywhere; results in high quality natural rubber in one step;

- no latex coagulation required environmentally friendly (green) rubber !
- FHG-IME increased the rubber yield crop massively, comparable to rubber tree.
- 2015 Fraunhofer IME Dandelion Rubber Extraction Facility was set up at the Zoz Technology Center (ZTC) at Olpe/Germany [4].
- 2017 Continental took over the dandelion unit at ZTC and
- **2018** opens the Taraxagum<sup>™</sup> Lab at Anklam, Germany [5].
- 2018, Zoz designed a continuous processing unit in pilot scale for the above
- ⇒ In 5-10 years, Continental wants to be able to produce tires with ANR commercially. The goal is a more sustainable tyre production more independent from traditional NR sources.

#### (c1) next step - continuous processing

Zoz designed, manufactured and in first years also operated the batch processing plant for rubber-extraction from dandelion roots in preindustrial scale successfully. Converting such process into continuous operation for commercial industrial product volumes is the next step.

#### (c2) next resources - banana peels (BP)

- availability of (c1) can open a new world in green<sup>++</sup> biorefinery offering a wide range of industrial utilization of quickly renewable natural resources;
- first flora candidate at high rubber content + available in large scale are banana peels;
- worldwide, about 135mio tons of bananas are cultivated, DE imports 1mio tons p.a.
- BP-waste at high volumes even in DE, as much as 30-40%wt (crop dry) of fresh fruit;
- BP degrades very slowly in composting, contains numerous pollutants from pesticides;
- including BP into product processing, prior or post transport, offers protection of the environment and value adding.



















12th German-International Symposium on Nanostructures March 4-6, 2024 Olpe, Germany

