This project is supported by: The NATO Science for Peace and Security Programme

SPS Information Day in Kyiv, Ukraine, 21 November 2019

PORTABLE ENERGY SUPPLY

(Project no G5233)

SPS Key Priority Area: 1. b) *Energy Security.* Innovative energy solutions for the military; battlefield energy solutions; renewable energy solutions for military applications

Participating Institutes: NATO country: Institute for Energy and Technology, Kjeller, Norway; partners from Ukraine - Karpenko Physico-Mechanical Institute of the NAS of Ukraine; Frantsevich Institute for Problems of Materials Science, NAS of Ukraine; Vernadskii Institute of General & Inorganic Chemistry, NAS of Ukraine

NPD – Prof. Volodymyr Yartys (volodymyr.yartys@ife.no); PPD – Prof. Ihor Zavaliy (zavaliy@ipm.lviv.ua); CPDs- Prof. Yurij Solonin (solonin@ipms.kiev.ua); Dr. Yurij Pirsky (pirsky@ionc.kiev.ua).

PROJECT OUTLINE: METAL/HYDRIDE+H_2O→H_2+FUEL CELL→ PORTABLE POWER (30 W / 7 kg / 3 days of operation)

The project is focused on the development of hydrogen fuelled portable energy systems integrating hydrogen generation and storage units based on use of light metals or metal hydride materials and portable fuel cells. The weight efficient hydrogen storage devices will be constructed using the selected and performance-optimised materials. The pilot unit (Hydrogen Supply + portable FC) will be tested.

- A better understanding the nature of the interaction between hydrogen and materials will be obtained during the development of inexpensive, light, effective materials for hydrogen storage and generation.
- Application of innovative nanostructured complex and light metal hydrides for portable devices will contribute the technology advancement.
- Obtained knowledge of the hydrogen technology will allow to create different applications with low weight, volume and high energy storage capacity

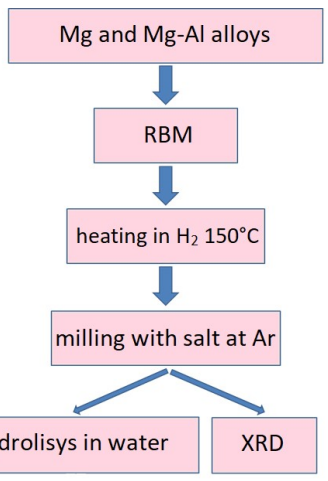
MOTIVATION

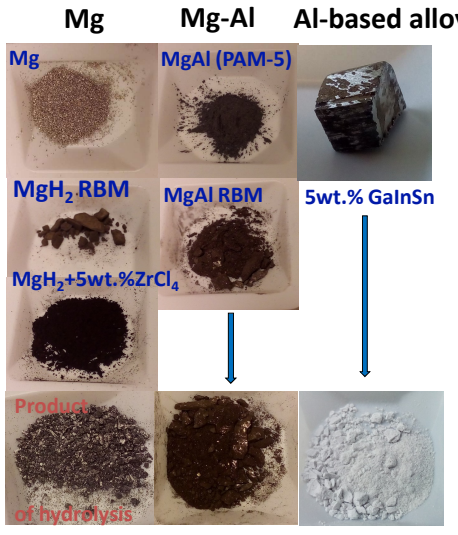
Hydrogen energy arouses great interest as an environmentally friendly and safe in use technology, being particularly important for autonomous and mobile energy systems applications. This includes the development of portable energy supply systems where hydrogen is used to power a fuel cell (FC). The report will provide a review of the works dedicated to effective hydrogen storage materials that can be used in hydrogen supply devices. Advantages and disadvantages of different classes of materials and different delivery methods will be analyzed. Main attention will be focused on the metallic / intermetallic hydrogen storage materials. Such material class as hydrides of Mg and Mg-based intermetallic compounds will be characterized from the perspectives of practical application.

OBJECTIVES

Milestones 1-2. Enhance the kinetics of the processes of hydrolysis of MgH_2, Mg-Al and Al-based alloys. Study the effect of the catalyzing salts (NaCl, $MgCl_2$, $AlCl_3$, and $ZrCl_4$) on the efficiency of hydrolysis in pure water for the mixtures containing 2-20 wt.% salt.

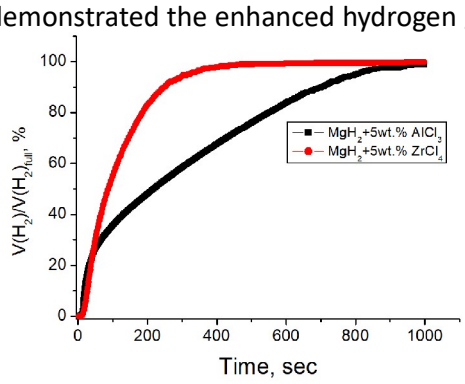
PREPARATION



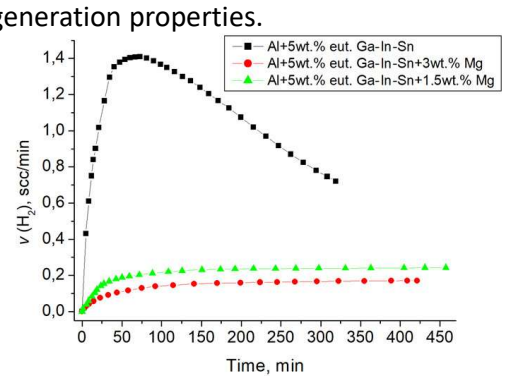


SELECTED RESULTS

Mg-based composites for hydrolysis were prepared by ball milling Mg-containing materials in 20 bar H_2 gas. XRD proved that mechanochemical hydrogenation results in a complete transformation of Mg into a mixture of α- and γ-MgH_2. Mg-based composites and Al-based alloys doped with low-melting metals and alloys demonstrated the enhanced hydrogen generation properties.



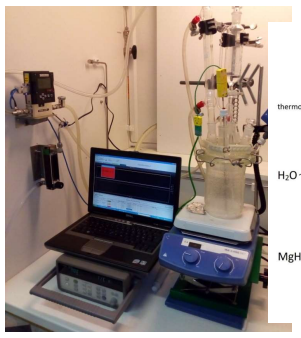
Hydrogen production rate during hydrolysis of doped MgH_2

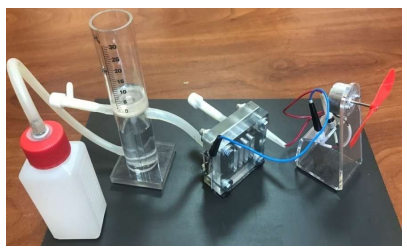


Hydrogen production rate during hydrolysis of doped Al

BUILDING THE LABORATORY FACILITIES FOR SYNTHESIS AND CHARACTERISATION

Hydrolysis devices were constructed at the laboratories of the participants (IET-Norway, PhMI and IPM NASU)





Stand for testing of the activity of H_2-generating substances in an autonomous power supply device

Electrochemical studies of the activity of aluminum alloys and catalysts for the reduction of hydrogen and oxidation of oxygen (based on the C301 Potentiostat/Galvanostat from Stanford Research Systems equipped in the frame of NATO G5233 Project)

other laboratory equipments:

H-30 Fuel Cell Stack

Flow-meter SIERRA M100

Fritsch PULVERISETTE 6

EVENTS

WORKSHOP FOR NATO PROJECT G5233 "PORTABLE ENERGY SUPPLY"
Date and place: 6 September, 2019, Lviv-Shepilske, UKRAINE

Participants:

***Institute for Energy Technology, Norway**:* Prof. Yartys V. (NPD)
***Physico-Mechanical Institute NAS of Ukraine**:* Prof. Zavaliy I. (PPD), Dr. Kytsya A. Dr. Verbovytskyy Yu., Dr. Berezovets V., Dr. Zasadnyy T., Dr. Lyutyy P., Kosarchyn Yu.
***Institute for Problems of Materials Science NAS of Ukraine**:* Prof. Solonin Yu. (PCD), Dr. Korablov D., Bezdorozhev A.
***Institute of General and Inorganic Chemistry NAS of Ukr**aine:* Dr. Pirskyy Yu. (PCD), Dr. Manilevich F., Kutsyi A.

SELECTED PUBLICATIONS

1) V. Berezovets, Yu. Verbovytskyy, I. Zavaliy, D. Korablov, Yu. Solonin, R. Denys, F. Manilevich, A. Kutsyi, V. Yartys. Mg and Al based hydrides for the efficient hydrogen generation by hydrolysis process Col. Abstr. of Int. Symp. on Metal-Hydrogen Systems: Fundamentals and applications. MH-2018, October 28-November 2, 2018 – Guangzhou (China), 2018. – P.286.
2) F. Manilevich, Yu. Pirskyy, B. Danil'tsev, A. Kutsyi , V. Yartys. Studies of hydrolysis of aluminum activated by additions of ga–in–sn eutectic alloy, bismuth or antimony . Physico-chemical mechanics of materials, 4 (2019) 69-80.
3) V. Berezovets, Yu. Verbovytskyy , I. Zavaliy , V. Yartys. Mg-based materials for application in hydrogen supply systems. Abstr. of HighMatTech-2019. 28-30 Oct. - 2019, Kyiv-Ukraine, P.142.
4) Yu. Verbovytskyy, V. Berezovets, A. Kytsya, , I. Zavaliy , V. Yartys. Hydrogen generation by MgH_2 hydrolysis. Physico-chemical mechanics of materials, 2019, In print.