Mg and Al based hydrides and alloys for efficient hydrogen generation by hydrolysis process

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MOTIVATION

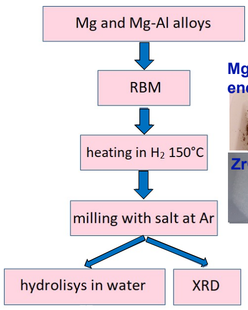
Hydrogen is a convenient and environment friendly energy carrier which is integrated with renewables in energy storage cycle. Activated Mg and Al alloys and hydrides attract interest because of their high chemical reactivity, affordable price and absence of pollution to the environment. Both Mg and Al show a high thermodynamic driving force to release hydrogen from water. However, because of the presence of passive surface layers, hydrogen generation rate could be limited or even completely stopped.

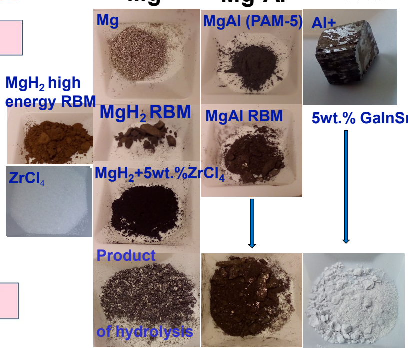
Ball milling process in hydrogen is an effective technique allowing to improve the reactivity of the alloys and to obtain materials with high surface to volume ratio. During milling of Mg, MgH_2 which allows to double the productivity of the hydrolysis process.

OBJECTIVES

Enhance the kinetics of the processes of hydrolysis of MgH_2,Mg-Al and Al alloys. Study the effect of the catalyzing salts (KCl, NaCl, $MgCl_2$, $AlCl_3$, and $ZrCl_4$) on the efficiency of hydrolysis in pure water for the mixtures containing 2-10 wt.% salt.

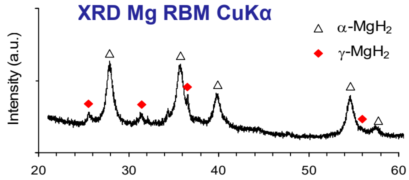
PREPARATION

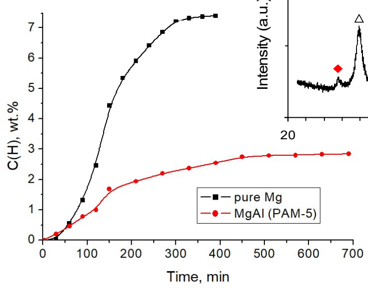




RESULTS

Mg-based composites for hydrolysis were prepared by ball milling in hydrogen gas @ 20 bar H_2 (RBM) of the Mg containing materials. XRD proved that mechanochemical hydrogenation results in a complete transformation of Mg into a mixture of α- and γ-MgH_2.



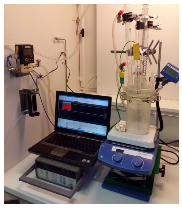


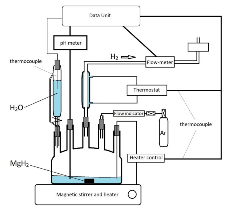
Hydrogenation RBM of Mg and MgAl alloy (Mg50Al50)

The resulting mixture was converted to α-MgH_2 by heating in a H_2 medium at 150 °C for 2 h. Analysis of hydride profile parameters indicates that the size of crystallites is <10 nm.

HYDROLYSIS PROCESS

All investigated specimens were subjected to hydrolysis at pseudo-isothermal conditions in the temp. range 25-70° C using specially designed setup. The hydrolysis setup consists of a glass vessel with a flat flanged lid and five necks placed on a magnetic stirrer allowing its heating. The reacting powder and water were added under inert conditions (in a flow of Ar gas). The setup contains: - a droplet funnel with a pressure compensator; - flow-meter with a data logger; - the temperature was monitored for both starting materials and reaction medium.



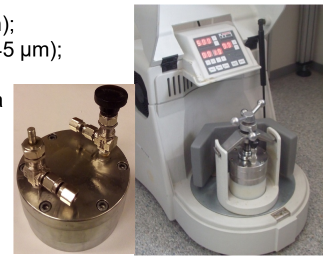


EXPERIMENTAL DETAILS

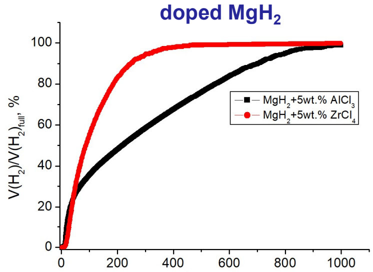
<u>Materials:</u>
Mg (99.8 %, grit 50-150 mesh);
Commercial MgAl (powder ~45 μm);
Intermetallic alloy $Mg_{17}Al_{12}$.
Al eutectic alloy with In/Sn/Ga

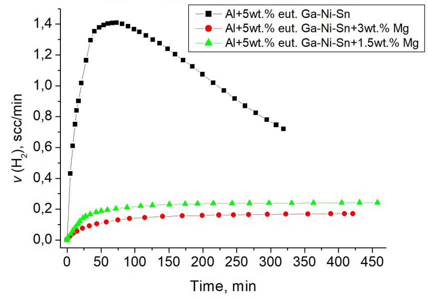
<u>Reactive ball milling:</u>
Fritsch 6 Pulverisette mill.
milling conditions: 20 bar H_2;
500 rpm; BPR = 60:1

<u>Phase-structural analysis:</u>
powder XRD (Cu-Kα),
FULLPROF software



Hydrogen production rate during hydrolysis of doped MgH_2





Hydrogen production rate during hydrolysis of doped Al

CONCLUSIONS

- ❑ Aluminum activated by Ga-In-Sn eutectic shows excellent performance in hydrogen generation by hydrolysis and can be used in a pelleted form to achieve a continuous supply of hydrogen over a long period of time.
- ❑ The magnesium hydride composites with chloride salts were tested and demonstrated their suitability for the effective hydrolysis reaction, showing a much better improved performance compared to the pristine materials.
- ❑ Further work should be focused on achieving improved surface activity of the Mg- and Al-based reactive composites.

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ACKNOWLEDGEMENTS

The work was supported by the NATO Science for Peace Program

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