Metal hydride — carbon composites: advanced materials for hydrogen energy technologies

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The main priority in advancing environmentally friendly energy technologies is development of efficient materials for energy storage and conversion including metal hydrides (MH). Advantages of MHs include very high energy storage density per unit volume, tunable composition-dependent thermodynamics of the reversible interaction of the parent hydride-forming material with hydrogen, both from the gas phase and electrolyte, technological flexibility in various niche applications, and many other useful features.

At the same time, successful implementation of MH based energy technologies requires solution of a number of challenging problems including improvement of hydrogenation/dehydrogenation kinetics, prolongation of the cycle lifetime, increase of effective thermal (electric) conductivity to improve performances of the upscaled gas phase (electrochemical) systems, mitigation of stresses which appear in the MH bed due to increase of its volume upon hydrogenation, etc.

Many of these problems can be solved by the creation of composite or hybrid materials containing MH filler and additives which combine several useful features (catalysis of H transfer reactions, high electric and thermal conductivity, plasticity, possibility to envelop MH particles thus preventing their oxidation and sintering) with minimal decrease of hydrogen storage capacity.

MH-based composites, powder mixtures or compacts containing various forms of carbon additives prepared from solid or gaseous feedstock and taken in minor (1–3 wt.%) amounts, allow to achieve maximum benefits in gas phase and electrochemical applications (Figure 1).

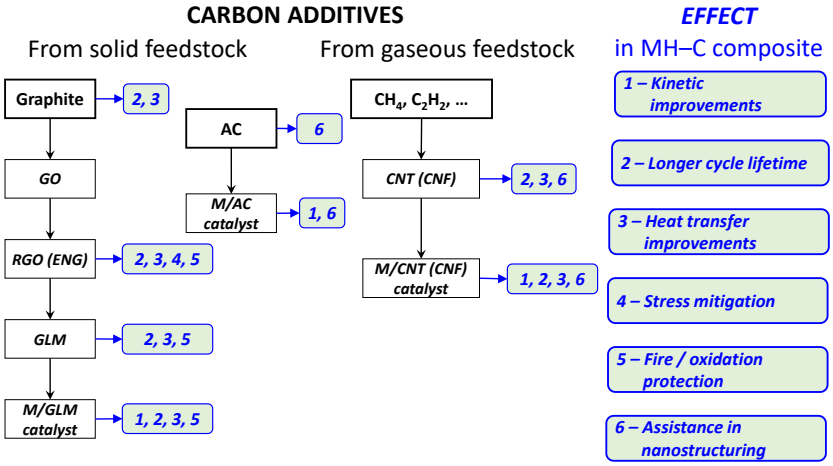

Figure 1. The most frequently used carbon additives in metal hydride – carbon composites and their beneficial effects.

This presentation summarizes results of R&D activities of the research teams from FRC PCP&MC RAS in Russia and HySA Systems in South Africa in the development of advanced MH based composites with carbon additives including activated carbon (AC), graphite, expanded natural graphite (ENG) or reduced graphite oxide (RGO) prepared from graphite oxide (GO), graphene-like materials (GLM), carbon nanotubes (CNT) and nanofibres (CNF), as well as efficient hydrogenation/dehydrogenation catalysts prepared by the deposition of metal nanoparticles (M=Ni, Pd) onto the carbon supports. The developed materials have been integrated in various hydrogen energy storage applications including advanced MH containers for hydrogen storage and compression and MH electrodes for NiMH batteries.

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Dr Mykhaylo Lototskyy is an internationally recognized researcher in hydride materials science and applications of metal hydrides (127 Scopus-indexed publications cited 4019 times since 1985; h=37). Presently, he is a Key Program Manager at HySA Systems Centre of Competence in South Africa and Head of Laboratory of Metal Hydride Energy Technologies at FRC PCP&MC RAS in Russia.

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