Magnetocaloric hydrogen liquefaction – From materials to prototypes

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Magnetic cooling can be utilized to construct environmentally friendly cooling devices, air conditioners, and heat pumps [1]. Originally, magnetic refrigeration was used to achieve ultra-low temperatures by adiabatic demagnetization of magnetic salts. Recently, low temperatures have once again become the focus of attention as an area of application for magnetocaloric cooling namely for hydrogen liquefaction [2,3].

Hydrogen is light, energy dense and clean. If produced from sustainable resources, it represents the ultimate energy carrier for many of our needs. Liquid hydrogen has more than twice the energy density of the gas at 700 bars. What is more, it can be transported in conventional, unpressurised dewars. However, conventional liquefaction means we use up to 40 % of the lower heating value of the gas we are compressing, just to liquefy it! Magnetocaloric materials enable an alternative and more efficient approach. A large number of compounds are already known that show magnetocaloric effects in the desired temperature range and new candidates are constantly being added. In this work, we would like to discuss our current progress for the creation of a materials library for cryogenic applications. The basis for this is our characterization infrastructure for materials research at TU Darmstadt and the Dresden High Magnetic Field Laboratory in static and pulsed magnetic fields [4,5]. Figure 1 shows an example of this using various cobalt-based Laves phase materials [6]. Furthermore, we also provide an overview of the recent results in the demonstrator development of a magnetic hydrogen liquefier within the framework of the European project HyLICAL [7].

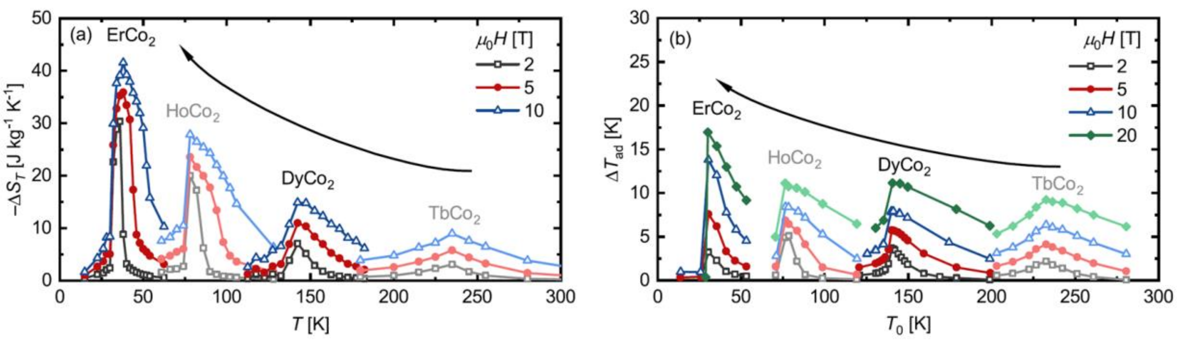

Figure 1. Isothermal entropy change (a) and adiabatic temperature change (b) in different $R\mathrm{Co}_2$ Laves phases in magnetic-fields of 2T (open black and gray squares), 5T (red circles), 10T (open blue triangles), and 20T (green diamonds) [6].

References

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