Tailoring magnetocaloric properties of RCo2Hx compounds for natural gas and hydrogen liquefaction

Allan Marciel Döring [1], Imants Dirba [1], Ulysse Rocabert [1], Fernando Maccari [1], Wei Liu [1], Konstatin Skokov [1], Oliver Gutfleisch [1]

[1] *TU - Darmstadt, Germany*

Magnetocaloric | Hydrogen Liquefaction | Hydrogenation | Cryogenic Temperature |

Magnetic cooling technology, based on the magnetocaloric effect, has been developed with a focus on room temperature applications over the past few decades. However, it can also be used to liquefy hydrogen and other gases at cryogenic temperatures, holding a significant role in future green economies and carbon-neutral societies. One possible application of the magnetocaloric cycle for liquefying hydrogen involves pre-cooling gaseous H2 to 77 K using liquid nitrogen, and then, utilizing magnetocaloric refrigeration within the temperature range of 77 to 20 K to liquefy the H2 gas. Since this process occurs at such low temperatures, it is possible to use superconducting magnets that can generate high magnetic fields, which enhances the magnetocaloric effect of the materials, leading to a large cooling power of the liquefier can be achieved. However, efficient production of liquid H2 using magnetic refrigeration requires new materials development. Our research focuses on identifying materials with a Curie temperature (TC) ranging from 20 K to 77 K, coupled with a significant magnetocaloric effect. The RCo2 family, (where R is a rare earth element), displays promise, however, certain compounds have TC higher than 77 K. In our study, we introduce hydrogen as interstitial atoms to adjust the TC of RCo2 alloys to the temperature range from 77 to 20 K, while maintaining a significant magnetocaloric effect. The samples were synthesized through arc melting and subsequently annealed in an inert atmosphere. The sample quality was assessed using X-ray diffraction and scanning electron microscopy. Magnetic response and heat capacity were measured in magnetic fields up to 14 T to ascertain TC and the magnetocaloric effect of the resulting alloys, including magnetic entropy change and adiabatic temperature change. We acknowledge the funding from the Clean Hydrogen Partnership through HyLICAL project, and the German Research Foundation through the CRC 270 project.

References

[1] Wei Liu et al., Applied Materials Today 29 (2022) 101624.

[2] Koichi Matsumoto et al., Cryogenics 51 (2011) 353–357.

[3] Guilherme F. Peixer et al., International Journal of Refrigeration 151(5) 1-13.