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C2Or3C-02: Development of a measurement system to measure in-situ the ortho/para concentration of liquid hydrogen

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Molecular hydrogen occurs in two forms, the so-called ortho-hydrogen (parallel alignment of the nuclear spins) and para-hydrogen (antiparallel alignment of the nuclear spins). At a temperature of 293 K and above, hydrogen has 75% of ortho- and 25% para-content. The content of para-hydrogen increases with falling temperature. At a temperature of 20 K almost 100% para hydrogen is present. While hydrogen is cooled down and liquefied the exothermic natural conversion starts, but much slower than the liquefaction itself. However, the conversion can be accelerated by using a catalyst.

To avoid an unintentionally evaporation due to the exothermic ortho to para conversion it is important to verify that the conversion is completed before the liquid hydrogen is stored, transported or used. It is state of the art to accelerate and to ensure a complete conversion by using an oversized ortho/para catalyst. However, the activity of the catalyst decreases over time. Therefore, a continuous in-situ measurement of the ortho/para ratio can contribute to effective use of the catalyst. Furthermore, the amount of catalyst can be reduced and hydrogen losses due to the unintentional evaporation can be prevented by verifying and adjusting the ratio.

The measurement systems which are commercially available do not allow an in-situ measurement of the ortho/para ratio of liquid hydrogen. Therefore, a measurement system based on Raman spectroscopy is currently being developed at the ZEA-1. First tests with the measuring system show promising results for normal hydrogen and 100% para-hydrogen on a laboratory scale.

In a next step, the laboratory set up will be redesigned in a way that a selective mixing of converted and normal hydrogen allows the measurement at any concentration in real time. This enables to optimize the measuring system and, among other things, to characterize catalysts.

The aim of these investigations is to develop a compact measuring system that can be used in research and industrial applications and reliably measures the ortho/para concentration of liquid hydrogen in-situ.

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