Integrated design for demonstration of efficient liquefaction of hydrogen (IDEALHY)

Fuel Cells and Hydrogen Joint Undertaking (FCH JU)

Grant Agreement Number 278177

Title:	Report on Ortho-Para Developments *(Publishable Summary)*
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Work Package:	Technology Analysis and Conceptual Liquefaction Process Assessment
Deliverable Number:	2.6
Date:	1 August 2013
Report Classification:	Restricted (here: *Publishable Summary*)

Approvals	
WP Leader	✓
Coordinator	✓
FCH JU	**pending**
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Acknowledgements

The research leading to these results has received funding from the European Union's Seventh Framework Program (FP7/2007–2013) for the Fuel Cells and Hydrogen Joint Technology Initiative, under grant agreement number 278177.

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Publishable summary

Hydrogen exists in two spin isomers known as ortho- and para-hydrogen. Hydrogen is always a mixture of both modifications, and the ratio of ortho- to para-hydrogen depends exclusively on temperature. The lower the temperature the more the ratio shifts towards para-hydrogen concentration, and at ambient temperature the ratio of ortho- to para-hydrogen is 3:1. If the temperature is lowered, the mixture is out of balance and aims for a state of equilibrium by converting ortho- to para-hydrogen. Because this is a slow reaction, in the liquefaction process the conversion is accelerated by using a catalyst . Furthermore, the ortho-para-conversion is an exothermic process, and the heat release can cause evaporation and losses in the liquid state. Thermodynamically speaking, it is best if the conversion takes place at the highest possible temperature, i.e. a temperature close to the equilibrium.

This deliverable discusses the ortho-para-conversion, including what possible catalyst bed options exist, how the catalyst is integrated in the liquefaction process and what properties a perfect catalyst needs. Also the NCU (number of conversion units) is introduced, a non-dimensional parameter to evaluate the activity of a catalyst and determine the volume of catalyst required for a given mass flow of fluid. The NCU value found in literature is compared to measurements done at TU Dresden, and a correlation with the reaction rate constant k is given.

It concludes that efficiency improvements are possible by using continuous conversion and that this can be done in the IDEALHY process with a commercially available catalyst. It also concludes that catalyst improvements in the field of reactivity and the ability to package it in narrow spaces would further improve the efficiency of the process.

Key words

Efficient hydrogen liquefaction, ortho-para conversion, catalyst in heat exchanger

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