Hydrogen from methane without CO2 emissions

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Production of hydrogen from methane without carbon dioxide emissions is the objective of a project in which KIT is a major partner. At KALLA, the Karlsruhe Liquid-metal Laboratory, researchers are setting up a novel liquid-metal bubble column reactor, in which methane is decomposed into hydrogen and elemental carbon at high temperature. In this project, KIT cooperates with the Institute for Advanced Sustainability Studies (IASS). Today, the initiator of the project and scientific director of IASS, Nobel Prize laureate Professor Carlo Rubbia, met KIT scientists working at KALLA, the Institute for Pulsed Power and Microwave Technology (IHM), and the Institute for Applied Materials - Material Process Technology (IAM-WPT).

Energy production from fossil fuels without emissions of climate-affecting carbon dioxide – this vision might come true through the research program "Combustion of Methane without CO2 Emissions". Since late 2012, KIT has been partner in the program that is part of the Earth, Energy, and Environment (E3) Cluster of the Institute for Advanced Sustainability Studies (IASS), Potsdam. "This is the truly pioneering experiment with the ambition of using fossils without CO2 emissions," said the scientific director of IASS and physics Nobel Prize laureate Professor Carlo Rubbia when visiting KIT today.

Hydrogen represents a promising medium for the storage and transport of energy in the future. However, it is bound in water (H2O) or hydrocarbons, such as petroleum, natural gas or coal. Consequently, the hydrogen has to be separated first. In the course of conventional

separation processes, the climate-affecting greenhouse gas carbon dioxide is formed. Today's worldwide hydrogen production causes about 5% of the global CO2 emissions.

CO2-free hydrogen production at KIT will be achieved by thermal decomposition of methane in a high-temperature bubble column reactor. KIT researchers enter entirely new ground. "With this project, we have the opportunity to participate in the development of fundamentals for a completely new energy technology," explains the head of KALLA, Professor Thomas Wetzel. "If feasibility can be confirmed, sustainable production and use of hydrogen from fossil sources that would have affected the climate if they were used conventionally will be possible."

The liquid-metal bubble column reactor to be built up at KALLA in the next months is a vertical column of about half a meter in height and a few centimeters in diameter. The column is filled with liquid metal that is heated up to 1000°C. Fine methane bubbles enter the column through a porous filling at the bottom. These bubbles rise up to the surface. "At such high temperatures, the ascending methane bubbles are increasingly decomposed into hydrogen and carbon," explains Professor Thomas Wetzel. "We will study how much hydrogen can be produced by a smart process conduct."

The KIT liquid-metal bubble column reactor is based on previous work of Professor Carlo Rubbia and Professor Alberto Abánades from IASS. They studied thermal decomposition of methane in a gas-phase reactor. During this gas-phase reaction, however, the carbon formed deposited on the reactor walls. As a result, gas channels were plugged after a short time and no continuous process was possible. "In the reactor planned to be built in cooperation with the IASS colleagues, the shell of the bubbles assumes the role of the wall," explains Thomas Wetzel. "Only when the bubbles burst at the surface of the liquid metal, is carbon released. The reactor wall is constantly renewed." A similar approach was described by

researchers in the team of Manuela Serban from the Argonne National Lab, USA, about ten years ago. Since then, however, this process has not been developed any further.

Following the setup of the test reactor, KIT scientists will study various parameters influencing process conduct and potential hydrogen yield this year. Work at KIT will also focus on fundamental scientific aspects, for example, on the identification of reaction paths influencing the composition of the product gas flow and on possibilities of removing carbon from the reactor. In parallel, the scientists will select materials for potential future industrial reactors, study filter technology, and develop probes for a later continuous process conduct.

Karlsruhe Institute of Technology (KIT) is one of Europe's leading energy research establishments. Research, education, and innovation at KIT foster the energy turnaround and reorganization of the energy system in Germany. KIT links excellent competences in engineering and science with know-how in economics, the humanities, and social science as well as law. The activities of the KIT Energy Center are organized in seven topics: Energy conversion, renewable energies, energy storage and distribution, efficient energy use, fusion technology, nuclear power and safety, and energy systems analysis. Clear priorities lie in the areas of energy efficiency and renewable energies, energy storage technologies and grids, electromobility, and enhanced international cooperation in research.

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