IEK-14 Report 2022

Research contributions for the energy transition and structural change in the Rhineland

Bernd Emonts (Ed.)

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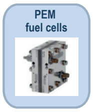
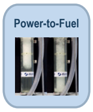
The new subinstitute IEK-14: Electrochemical Process Engineering emerged out of the division of the old IEK-3 subinstitute and the transferring of the activities on solid oxide converters to IEK-9 and safety research to IEK-14. In addition to these structural changes, IEK-14 also had to deal with other challenges in the form of political initiatives concerning the energy transition and structural change in the region. With its new priorities, IEK-14 systematically delivers the solutions expected by energy research to technological issues. The topic of water electrolysis focuses on PEM, AEM, and alkaline electrolyzers of the next generation and beyond. Research on ionic liquids as novel electrolytes for polymer membrane-based fuel cells operated at temperatures exceeding 100 °C is reaching the next development stage with new R&D projects aiming towards functional, technically relevant cells. The topic of fuel synthesis has moved from its initial phase of process and systems analyses to the stage of promising raw materials and process paths and is now additionally focusing on developing catalysts and reactors for alcohol and kerosene synthesis. The new topic of safety research at IEK-14 is developing into a unique area of research contributing to safety analyses, safety concepts, and safety equipment for use in H_2-based energy systems.

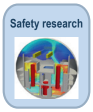
Water electrolysis at temperatures of around 70 °C permits highly dynamic operation with fast start-up and shutdown procedures. The degree of maturity of electrolyzers with polymer electrolyte membranes and/or a potassium hydroxide solution enables large plants to be built on the MW scale. Current and future R&D activities aim to improve performance, increase lifetime, and reduce investment and operating costs. Rolling out large-scale plants for electrochemical H_2 production makes it possible to test integration into the energy system and to test and validate the scalability of the production method.



Operating a PEM fuel cell at temperatures exceeding 100 °C enables more effective cooling and makes the moistering of the gases and water recirculation superfluous. This necessitates new, non-aqueous, proton-conducting electrolytes. The aim is to develop PEM fuel cells based on protic ionic liquids (PILs), suitable for operation at temperatures of 100 – 120 °C. To optimize the interface and bulk properties of PILs, the basic mechanisms of electrochemical reactions and ion transport are being investigated. The PILs are immobilized in a matrix polymer and tested in single cells.



The aviation and shipping industries as well as areas of heavy road transportation will still require liquid fuels with high energy densities. To defossilize this sector, the required fuels could be produced using H_2 and CO_2 sustainably produced from biomass, air separation, and unavoidable process gases. R&D work in this area focuses on process analysis as well as catalyst and reactor development. The scalability of this conversion technology is essential for its integration into the energy system.



In addition to technical and economic challenges, technical safety issues are critical to the acceptance of hydrogen technologies. Hydrogen safety research uses models to analyze the accident-related and unavoidable release of H_2, identify the risks involved, and assess the effectiveness of safety measures. On this basis, safety concepts tailored to specific applications are derived and safety equipment is developed, tested, and characterized to avoid damage and potential acceptance problems.

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