SUCCESS STORY

Polymers4Hydrogen
Decarbonizing of energy infrastructure using novel polymers

Program: COMET – Competence Centers for Excellent Technologies

Line of Funding: COMET-Modul

Single Project: New approaches and characterization techniques towards reinforced polymers with tailored filler matrix interface for high pressure environments, 01/2020-12/2023, multi-firm

SEALING ENHANCEMENTS FOR H_2 GAS ATMOSPHERES

THE DEVELOPMENT OF NOVEL MATERIALS AND CHARACTERISATION TECHNIQUES TO IMPROVE THE GAS SEALING PROPERTIES AND SEALING INTEGRITY FULFILLING THE FUTURE DEMANDS OF HIGH-PRESSURE H_2 GAS ENERGY SYSTEMS

Polymers for high-pressure hydrogen gas storage

In a response to the climate crisis the world is facing, the European Union presented a Green Deal in 2019/20 to reduce the net emissions of greenhouse gases by at least 55% by 2030 compared to 1990 levels, and to reach a climate-neutral continent by 2050. These ambitious targets encourage all the stakeholders to utilize viable alternative resources. Therefore, hydrogen receives great attention as a clean energy carrier as well as a feasible and cost-effective renewable energy storage solution. However, this emphasizes the importance of the improvement of technologies and materials involved in these systems. Energy storage in the form of pressurized H_2 gas is favored due to its high efficiency, convenience, and matured technology compared with other H_2 storage methods. Nonetheless, developing systems to accommodate onboard storage tanks with higher mileage and quick refueling possibilities in filling stations demands materials that work up at high pressure (up to ~100 MPa) and within wide temperature ranges (-40 to 85 °C) in order to fulfil the near future requirements. Leakage through sealings as a result of permeation and possible mechanical damage under prevailing harsh conditions is a major concern from an economical and safety point of view. The dissolved gas influences the degradation and possible mechanical damage under cyclic loading/exposure conditions. Therefore, developing grades for sealing applications, especially, elastomeric grades or thermoplastic elastomeric grades, that work in a wide temperature range, remain intact after pressure cycles and retain the sealing function is of great interest.

Therefore, novel polymer materials and advanced characterization techniques for high-pressure hydrogen systems are being developed in the COMET module "Polymers4Hydrogen" at the Polymer Competence Center Leoben GmbH.

Novel filler strategies to enhance the barrier properties

The gas intake into the sealing material, dissolution, and diffusion through the material can be controlled by introducing fillers into the matrix material. This effect can be pronounced if two-dimensional fillers with a high aspect ratio are incorporated to create a tortuous path to the gas diffusion direction. However, this needs to enhance the filler-rubber interaction and homogeneous distribution of the fillers. One approach used within this module is shown in Figure 1, in which the exfoliation of the micrometer-sized filler stack, surface modification, and successful incorporation into the matrix is considered.

Development of novel sealing materials and characterization techniques

Tailored elastomeric materials to withstand a wide temperature range, high-pressure, and cyclic loading conditions were developed within this COMET module. The test setups were developed within the consortium to expose these grades up to 100 MPa of H_2 gas at different temperatures. The possible degradation of components under application-relevant conditions was assessed. The results revealed a significant improvement of the developed grades with respect to damage modes and chemical/mechanical degradation. Further, advanced material characterization techniques were developed to mimic the near service conditions, for example, the complex loading behaviors in cyclic exposure conditions and sudden gas releasing atmospheres. This reveals the relevance of certain mechanical/fracture mechanical properties on possible damage modes, and is helpful in material development and process optimization. The outcomes of this module will advance the state of the art in sealing solutions for high-pressure H_2 gas systems.

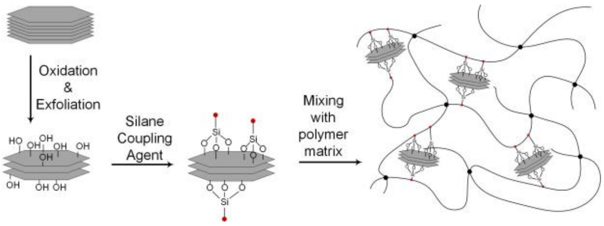

Figure 1: 2D filler exfoliation, surface modification, and subsequent incorporation in to the matrix.

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- Polytecnico di Milano, IT
- Montanuniversität Leoben, AT

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