SUCCESS STORY

Polymers4Hydrogen
Decarbonizing of energy infrastructure using novel polymers

Program: COMET – Competence Centers for Excellent Technologies

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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

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NOVEL MATERIALS TO IMPROVE SEALING INTEGRITY

THE DEVELOPMENT OF NOVEL MATERIALS AND CHARACTERIZATION 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

As the ongoing measures to significantly reduce greenhouse gas (GHG) emissions, all the stakeholders around the world are keen to identify alternative fuels while maintaining the energy supply to support economic growth and competitiveness. In general, renewable energy sources such as solar, wind, hydro, geothermal, biomass, etc. are highly dependent on weather conditions and variability over time, making the grid unstable and wasting energy. To overcome these challenges, effective energy storage systems play a pivotal role. Therefore, hydrogen (H_2) is widely identified as a low-cost, large-scale, and long-term energy storage method which can also encourage more renewable energy industries. Hydrogen is generated by an electrolyzer, ideally using green electricity, and stored in different forms depending on the end use. Therefore, hydrogen can replace many current fossil fuel applications, for example, road vehicles, rail, industrial aeronautics, marine, space missions, domestic energy needs, backup energy, etc. H_2 as a transportation fuel, particularly in fuel cell vehicles (FCVs), offers immediate advantages over battery electric vehicles (BEVs). BEVs store electricity in lithium-ion batteries, which can be recharged with external electricity when they are depleted. FCVs, on the other hand, generate electricity on board as needed by the vehicle using stored hydrogen and a fuel cell, releasing water as the only by-product. For the transportation sector, the weight is a limiting factor and, in this case, the weight of hydrogen storage together with fuel cell is much less than the lithium-ion batteries.

Because of its wide applicability, some projections suggest that hydrogen could provide 24% of Europe's energy needs by 2050. However, this will require

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improvements and advancements in technologies for multi-stage storage and delivery between production and end-use. Polymer grades with their unique properties play a crucial role in many components that make the hydrogen economy a reality. Elastomeric grades in sealing applications are a weak link which are exposed to high pressure H_2 gas and a wide range of temperatures, therefore the development of novel materials is a critical step to meet future demands. Addressing this, the COMET module "Polymers4Hydrogen" at the Polymer Competence Center Leoben GmbH is developing novel polymer materials and advanced characterization techniques for high-pressure hydrogen systems.

Novel filler strategies to widen the application range

This novel research is focused on extending the limits of sealing materials used in high-pressure H_2 gas systems, pushing the current limits to meet future requirements. Therefore, several elastomeric grades were developed to use up to ~100 MPa and wide temperature ranges (-40 to 85 °C). Further, these materials were optimized to resist the failure modes, for example, rapid gas decompression (RGD), property degradations in cyclic loading conditions, and aging in high-pressure H_2. The best material formulation, a nitrile rubber grade, was further filled with 2D fillers (high-aspect ratio) in addition to the carbon black, in the expectation of creating a tortuous path for gas molecules, resulting in less gas permeation through the material. To achieve this, the 2D fillers had to have a good distribution and orientation, which was achieved through modification steps in the in-house lab facilities. Figure 1 shows the results of industrial scale grades incorporating Struktosil 45AM as a 2D filler. As these grades meet all the requirements in real-world applications and expand working conditions, they add great value to meet future needs in realizing the hydrogen economy.

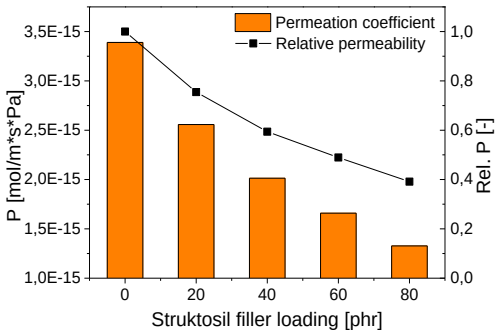

Figure 1: Improvement of barrier properties as a result of incorporation of 2D filler.

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- SKF Sealing Solutions Austria, AT
- Bundesanstalt für Material-forschung und -prüfung, DE
- Politecnico di Milano, IT
- Montanuniversität Leoben, AT

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