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Determination of Viscosity and Degree of Hydrogenation of Liquid Organic Hydrogen Carriers by Cavity Based Permittivity Measurement

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Abstract : A very promising alternative to compression or cryogenics is the chemical storage of hydrogen by liquid organic hydrogen carriers (LOHC). These carriers enable high energy density and allow, at the same time, efficient and safe storage under ambient conditions without leakage losses. Another benefit of this storage medium is the possibility of transporting it using already available infrastructure for the transport of fossil fuels. Efficient use of LOHC is related to precise process control, which requires a number of sensors in order to measure all relevant process parameters, for example, to measure the level of hydrogen loading of the carrier. The degree of loading is relevant for the energy content of the storage carrier and simultaneously represents the modification in the chemical structure of the carrier molecules. This variation can be detected in different physical properties like permittivity, viscosity, or density. E.g., each degree of loading corresponds to different viscosity values. Conventional measurements currently use invasive viscosity measurements or near-line measurements to obtain quantitative information. This study investigates permittivity changes resulting from changes in hydrogenation degree (chemical structure) and temperature. Based on calibration measurements, the degree of loading and temperature of LOHC can thus be determined by comparatively simple permittivity measurements in a cavity resonator. Subsequently, viscosity and density can be calculated. An experimental setup with a heating device and flow test bench was designed. By varying temperature in the range of 293,15 K -393,15 K and flow velocity up to 140 mm/s, corresponding changes in the resonation frequency were determined in the hundredths of the GHz range. This approach allows inline process monitoring of hydrogenation of the liquid organic hydrogen carrier (LOHC).

Keywords : hydrogen loading, LOHC, measurement, permittivity, viscosity
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