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Recent innovations in membrane electrode assembly fabrication for polymer electrolyte fuel cells

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Polymer electrolyte fuel cells (PEFCs) are sustainable energy converters capable of generating electrical energy directly and highly efficiently from the chemical energy bound in hydrogen through electrochemical reactions. The heart of the PEFC, which determines performance and lifetime, is the membrane electrode assembly (MEA), which consists of an ion-conducting membrane between two electrodes (anode and cathode catalyst layers), as shown in Fig. 1 in a three-layer structure (gas diffusion layers are added on both sides). The cost-effective production of long-life, high-performance MEAs by optimising electrode configuration and fabrication is key to the global commercialisation of PEFCs [1]. In addition to the materials used, the interaction between the carbon supports, the pore structure, the mass transport and the accessibility of the catalysts, the production technology also has a significant influence on the achievable power density of the cell and the mass activities of the catalyst systems used. The production techniques considered include slot die coating, ultrasonic coating, reactive spray coating, electrospinning and inkjet printing.
In addition to the industrially highly relevant slot die coating, electrospinning is being developed as an innovative method for depositing a mat of ultrafine nanofibres as an electrode. In contrast to ultrasonic spray coating, this technique is very sensitive to small changes in the composition of the catalyst ink, the dispersion of the catalyst particles, the ion-conducting binder (e.g. Nafion) and the solvent. The nanofibre mat has unique properties, in particular exceptional mass transport properties. Among other things, the effect of the thickness of the catalyst layer produced by ultrasonic coating on performance and resistivity is discussed. Electrochemical impedance spectroscopy shows that the mass transport resistance increases with increasing layer thickness, while the membrane resistance decreases, which can be attributed to an increased water retention resistance [2]. The durability of catalyser inks, which is crucial for the large-scale production of MEA, has been investigated. In terms of dispersion stability, the catalyst ink should be used immediately after mixing, as the catalyst particles tend to sediment quickly, in contrast to zeta potential analysis. Acetone, which impairs the pore structure of the catalyst layer, was detected as an oxidation product in the catalyst ink [3]. Catalyst ink for MEA production can be stored for up to a maximum of four weeks without any significant loss of performance for the fuel cell. Finally, an outlook on research activities to improve MEA production is presented.

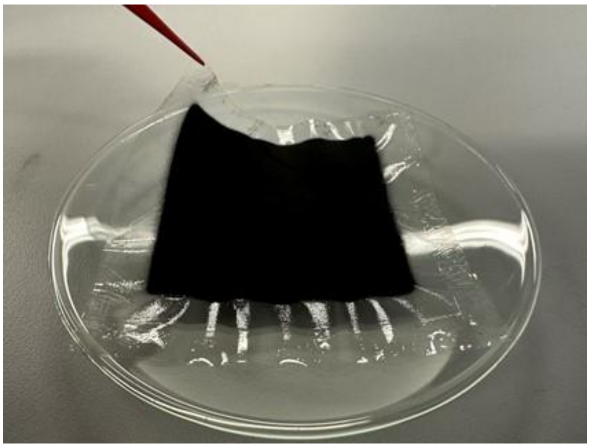

Figure 1. Catalyst coated membrane (CCM) for polymer electrolyte fuel cell (source: Kircher@TUGraz)

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