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Novel characterization technique for the hydrophilic/hydrophobic properties of a GDL

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The gas diffusion layer (GDL) is a key component for fuel cells, several battery types, and modern electrolysis processes. The main task of the GDL is the homogeneous distribution of the educts over the entire active area and the removal of the formed products to prevent flooding. In addition, the GDL should provide sufficient electrical conductivity resulting in a low resistance for the current transport. In actual fuel cell technology this is maintained by using a carbon paper or carbon fabric which is coated with a mixture of carbon black and PTFE [1]. Hence, an optimum composition of insulating PTFE and conductive carbon black needs to be found. Furthermore, the surface properties and the microporous structure determine the interaction between the hydrophobic media like hydrogen and oxygen and the hydrophilic media such as water.

In this investigation GDLs with different PTFE contents were examined by water vapor adsorption. This analysis method offers the opportunity to determine the quantity of water vapor that can be adsorbed by a certain species under isothermal conditions. In recent reviews by Arvay *et* al. and Harkness *et* al. different characterization techniques were summarized [2,3]. However, this novel method has not been mentioned yet. Fig. 1 shows an example of an adsorption/desorption isotherm. The maximal adsorbable amount of water is reached at relative pressures p/p^0 close to 1. The isotherm shows a strong hysteresis during desorption which indicates the presence of mesopores (2 – 50 nm). Figure 2 reveals that the maximal adsorbed amount decreases with increasing PTFE content until a plateau at approximately 25 wt.-% PTFE is reached. This points out that a PTFE content of 25 wt.-% is sufficient and a further increase of the PTFE content would lead to the decrease of the conductivity, resulting in an overall performance loss.

Since the wettability of the GDLs determines the interaction with the reactants, additional contact angle measurements were performed (Fig. 3). It can be seen that the contact angle of a GDL with a PTFE content of 10 wt.-% is very low, demonstrating strongly hydrophilic properties, which would lead to flooding of the cell since water cannot be removed from the GDL. The contact angle is much higher and remains mainly unaltered with time for higher PTFE contents. It can be expected that the optimal wettability is in a range between 10 and 20 wt.-% PTFE. In future studies the corresponding electric conductivity will be determined by electrochemical impedance spectroscopy.

In conclusion we have shown that water vapor adsorption offers the opportunity to estimate the water uptake of a gas diffusion layer. Thus, the humidification properties of the GDL can be determined which are of great importance for the water balance of the whole system and the resulting overall cell performance.

[1] O'Hayre, R. *et* al., Fuel Cell Fundamentals; Wiley & Sons, New York, 2009.
[2] Arvay, A. *et* al., *J. Power Sources* **2012,** *213*, 317-337.
[3] Harkness, I. R. *et* al., *J. Power Sources* **2009,** *193* (1), 122-129.

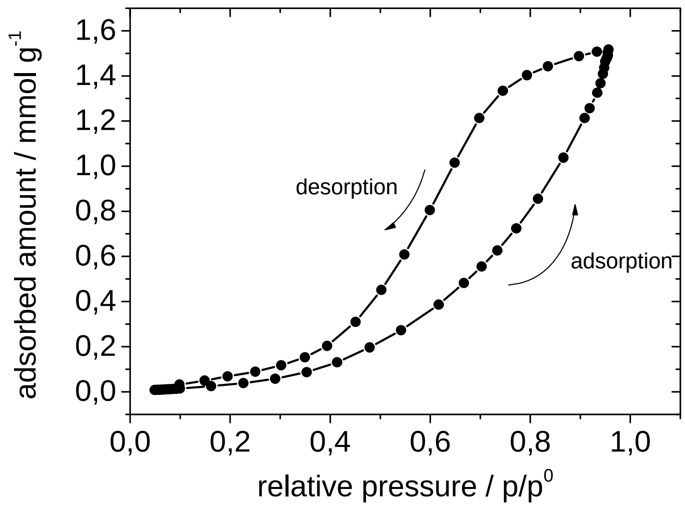

Fig. 1: Water vapor adsorption/desorption isotherm of a GDL with 15 wt.-% PTFE at 10 °C

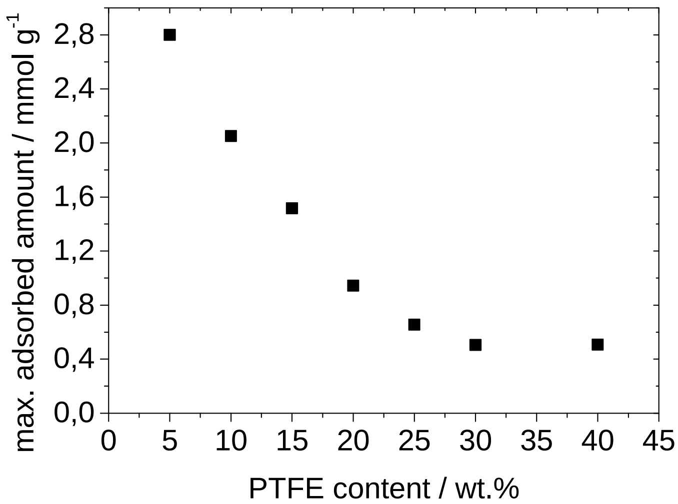

Fig. 2: Dependence of the maximal adsorbed water amount on the PTFE content in GDLs

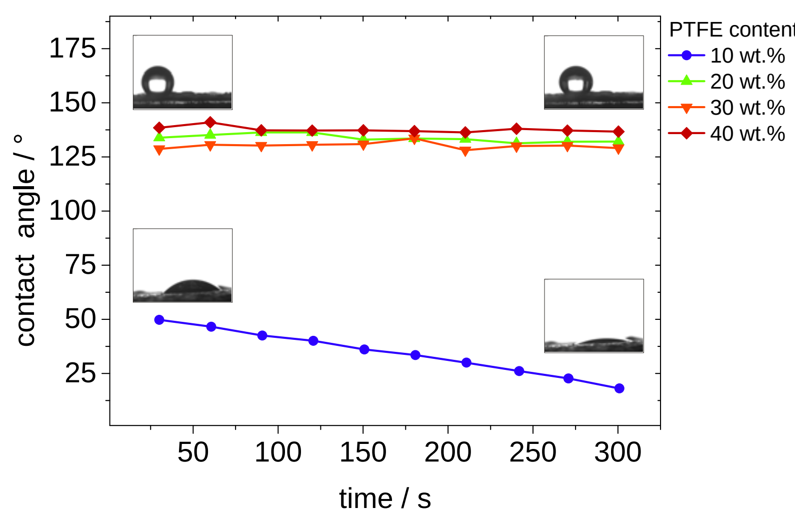

Fig. 3: Development of contact angle of GDLs with varying PTFE as a function of time