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# Matched Wetting Behaviour of Material Pairings for Optical In-Situ Measurements in PEM Fuel Cells

**Sebastian Blessing[1], Moritz Kippenberger[1], Alexander Stroh[1], Jochen Kriegseis[1]**
[1]Institute of Fluid Mechanics, Karlsruhe Institute of Technology (KIT)
Kaiserstraße 10, 76131 Karlsruhe, Germany
sebastian.blessing@kit.edu; moritz.kippenberger@student.kit.edu; alexander.stroh@kit.edu; kriegseis@kit.edu

## Extended Abstract

The Proton Exchange Membrane (PEM) fuel cell (FC) is one of the most attractive options in renewable energy conversion systems for automotive application, where PEM FCs are operated at lower temperature as compared to other fuel cell types. One of the major difficulties to date in PEM FCs is that the water created in the fuel cell reaction will often condense into liquid form, blocking parts of the air supply channels and porous layers. This leads to a significant power-density drop in the presence of liquid water [1].

Various experiments have been conducted in optically accessible fuel cells [2, 3]. In most cases, the conductive plate in which the air-flow channels are located is replaced by a transparent plate for optical access, which significantly alters current and heat fluxes in the whole fuel cell. A promising strategy to resolve this limited comparability to real PEM FCs is the application of conductive plates with sufficiently small transparent windows to simultaneously ensure optical access and retain the electrical properties of the device. Recent publications [4] emphasize the significance of the surface tension forces in droplet movement within the gas channels. Therefore, close similarity of the dynamic contact angles between the chosen transparent and conductive materials is of utmost importance for successful flow investigations inside the channels of such hybrid plates. Consequently, the present study aims to identify material pairings that adhere to this condition. The plate materials are chosen to include present state-of-research metals with different coatings that are also interesting for industrial applications. Furthermore, graphite, commonly used in research fuel cells, is considered. The investigated transparent materials were chosen to endure the adverse fuel-cell conditions (temperatures up to 80°C, acidic environment) [5] and moreover also provide sufficiently accurate optical properties to ensure laser-based measurements. The selection includes thermoplastics and glasses.

A test rig for the wettability investigations builds upon shadowgraph method [6] to record the time resolved shape of water droplets during impact onto the solid substrates, which allows the determination of the dynamic contact angles for the given materials. A high-speed camera is used to record 400 images of the drop impact at 4.000 fps (15μs exposure time), where sufficient intensity of back lightning is provided by a high-power LED system such that a spatial resolution of 130 px/mm is possible at reasonable signal-to-noise ratios. A light barrier-based camera trigger and an automized drop dispenser system allow for maximal reproducibility between experiments, which in turn ensures statistical significance of the obtained data.

The raw images are processed to extract the desired contact-angle information from either recorded contact line for each frame. Plotting the contact angles over their corresponding Capillary number ($Ca$) yields the Hoffman diagram. It is hypothesized that similarity of Hoffman diagrams between the conductive plate material and the transparent corollary indicates a material pairing for the fabrication of the afore-mentioned hybrid fuel-cell plate. Emphasis is placed on the comparison of advancing and receding contact angles at zero $Ca$ as well as their difference, i.e., the contact angle hysteresis. The measurement uncertainty in contact angle is found to lie below ±2° and uncertainty of the contact line detection was below 0.5 px. The conference talk will provide clear recommendations regarding material pairings for optical measurements in operated fuel cells.

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