**Minimal surfaces in gas diffusion layers**

Mohammad Javad Shojaei\*1, Branko Bijeljic1, Martin J. Blunt1

1Department of Earth Science and Engineering, Imperial College London, London, UK

\*Corresponding Author, m.shojaei@imperial.ac.uk

Gas diffusion layers in fuel cells need to allow the simultaneous flow of gases and water. Empirically this is achieved by coating the naturally hydrophilic carbon fibres with a hydrophobic coating, usually PTFE. We have used high-resolution X-ray imaging to observe the configuration of water within gas diffusion layers with different degrees of PTFE coating, and to quantify curvature and contact angle.

We observe that the fluid menisci form minimal surfaces. These surfaces occur in equilibrium at pinned contact lines at the boundary between hydrophilic and hydrophobic parts of the fibres. Minimal surfaces have two desirable features for multiphase flow. Firstly, the pressure difference between the water and gas is zero, which means that no additional water pressure is required, preventing retention and clogging of the pore space. Secondly, from topological principles, minimal surfaces ensure well-connected phases: the water clusters contain many redundant loops which helps maintain the continuity of flow under operando conditions.

In our work we found minimal surfaces for gas diffusion layers with 5, 20 and 40% coating with PTFE. The layer with a 60% coating had a markedly lower porosity and was more characteristically hydrophobic with higher average contact angles and a negative capillary pressure – that is the water pressure was higher than the surrounding air. The presence of minimal surfaces suggests that the water and gas pressures are equal, allowing water to flow readily without a pressure build-up. From topological principles, the negative Gaussian curvature of the menisci implies that the fluid phases are well connected. The implication of the design of porous materials where the simultaneous flow of two phases over a wide saturation range is explored.

**Reference**

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