Computational Modelling of Droplet Dynamics Behaviour in Polymer Electrolyte Membrane Fuel Cells: A Review

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Abstract

Polymer Electrolyte Membrane Fuel Cells (PEMFC) is one of the leading advanced energy conversion technology for the use in transport. It generates water droplets through the catalytic processes and dispenses the water through the gas-flowed microchannels. The droplets in the dispensing microchannel experience g-forces from different directions during the operation in transport. Therefore, this paper reviews the computational modelling topics of droplet dynamics behaviour specifically for three categories, i.e. (i) the droplet sliding down a surface, (ii) the droplet moving in a gas-flowed microchannel, and (iii) the droplet jumping upon coalescence on superhydrophobic surface; in particular for the parameters like hydrophobicity surfaces, droplet sizes, numerical methods, channel sizes, wall conditions, popular references and boundary conditions.

Keywords: Droplet Sliding, PEMFC, Jumping, CFD, Hydrophilic, Hydrophobic, Superhydrophobic Surfaces

1. Introduction

In PEMFC assembly, it consists of the dielectric membrane-Nafion, gas diffusion layers, electrolyte, electrodes, catalyst and gas sources (i.e. hydrogen and oxygen gases). The membrane requires sufficient liquid water in operation. Thus, the usual operation temperature is below 90°C which preventing a high evaporation rate in the system. In a complete electrical circuit, the electrons move from anode to cathode through the wires and electrical resistances. Simultaneously, the electrons move within the PEMFC assembly from cathode to anode. Commonly, the working principle of PEMFC is explained from the perspective of ions transport. Herein, this paragraph explains the working principle from the perspective of charge carriers as it requires far less energy for the electrons to move from an ion to another ion. It is a similar concept to explain the movement of charge carriers in a transistor. The motion of electrons relative to the electrolytes (from the cathode to the anode) is as if the protons (hydrogen ions) travel in the opposite direction. During the operation, the anode side, which separated by the layers receives the supply of hydrogen gas [¹]. The hydrogen gas together with an electron (from the cathode) split catalytically into two unit pairs of hydrogen ion and an electron; the electron moves into the electrical circuit around the copper wires. At the cathode, the oxygen gas combines with the hydrogen ions and electrons catalytically to form the water molecules.