Carbon materials in fuel cells

Introduction

Fuel cells are direct electrochemical energy conversion devices with high-energy efficiency, by electrochemical combustion without any pollutants. They are classified into various types depending on the temperature of operation, electrolyte etc., Porous carbon materials play a significant role in fuel cell applications especially for polymer electrolyte membrane fuel cells, alkaline fuel cells and phosphoric acid fuel cells, for use in bipolar plates, catalyst supports and for microporous layers for the flow of reactants and products. The properties of carbon with respect to the components play a major role for getting the optimized electrochemical reactions without carbon corrosion.

The main component of a fuel cell is the Membrane Electrode Assembly (MEA). The MEA is formed by a polymer membrane flanked by two electrodes. The membrane acts as the ionic conductor between the two electrodes; the anode, where the fuel is oxidized, and the cathode, where the oxidant is reduced. The electrodes are formed by a porous material named Gas Diffusion Layer (GDL) with a thin layer of an electrocatalyst denominated the Catalyst Layer (CL), The electrocatalyst, responsible of driving the electrochemical reactions that takes place at each electrode, is composed by metal nanoparticles (3–5 nm) dispersed on carbon nanoparticles of bigger size (20–40 nm). The GDL–CL combination is commonly referred as gas diffusion electrode (GDE).

In a single cell the MEA is placed between a pair of Current Collector Plates (CCP) with channels machined on one of its faces that allows the reactants to flow through the MEA surface. A FC stack is formed by intercalating MEAs with plates machined on both faces (bipolar plates-BP) and contained between two end plates. Fig. 1 shows a schematic representation of a fuel cell with its different components.

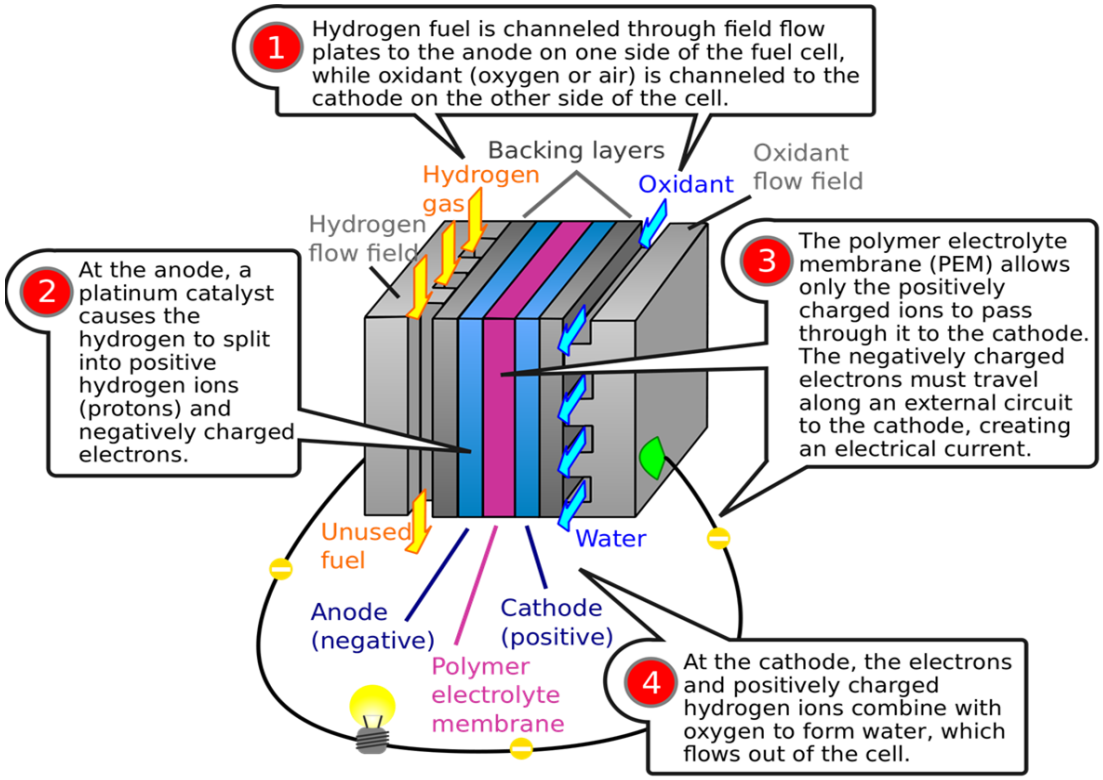

Fig. 1. A schematic representation of a fuel cell

Carbon constitutes the most abundant element of the different FC components. Setting aside the membrane, which is a polymer with a carbon backbone, all the other components, i.e. the CL, GDL and current collector plates (bipolar plates) are made almost entirely of graphitic carbon. The electrocatalyst support of the CL is commonly carbon black in the form of fine

powder. GDLs are thin porous layers formed by carbon fibers interconnected as a web or fabric, while current collector plates are carbon monoliths with low bulk porosity. As explained above each of these components has a particular function within the fuel cell The structure and properties of the carbon in each of the different FC components will determine the whole performance of the cell.

References

1. *Rajagopalan, R., & Balakrishnan, A. (Eds.). (2018). Innovations in Engineered Porous Materials for Energy Generation and Storage Applications (1st ed.). CRC Press.*
2. *Bruno M.M., Viva F.A. (2014) Carbon Materials for Fuel Cells. In: Corti H., Gonzalez E. (eds) Direct Alcohol Fuel Cells. Springer, Dordrecht.*