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Degradation mechanisms in PEM fuel cells: A brief review

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ABSTRACT

One of the most important features of polymer electrolyte membrane (PEM) fuel cells is durability. Improving fuel cell life and membrane electrode assemblies (MEA) durability translates to significant cost savings for fuel cells. This review is about the study of the degradation mechanisms of PEM fuel cells. The Degradation mechanisms include chemical, mechanical, catalyst, and thermal degradation. The reason for degradation also may be due to the presence or formation of contaminants during dynamic conditions. From the review, it has been observed that Pt catalysts made of Pt or Pt-alloy catalyst value superior to those required for complete Pt oxide.

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1. Introduction

Energy sustainability is a critical challenge due to the depletion of fossil fuels and the release of large amounts of CO_2 into the air which causes global warming. So alternatively, fuel cells are among the most essential energy devices because they can directly transfer chemical energy from fuel (such as methanol, hydrogen, etc.) to electrical energy with great efficiency and zero carbon emission in the case of hydrogen fuel. Depending on the electrolytes and fuels employed, there are many distinct types of fuel cells such as polymer electrolyte membrane fuel cells (PEMFC), direct methanol fuel cells (DMFC), solid oxide fuel cells (SOFC), molten carbonate fuel cells (MCFC), phosphoric acid fuel cells (PAFC), alkaline fuel cells (AFC), and alkaline anion exchange membrane fuel cells (AEMF) [1–4]. Among all, PEMFCs are the most sustainable with a variety of applications [5] in particular, for automotive applications [6]. The main benefit of PEMFC is that it operates at low temperatures below 100 degrees Celsius.

The PEMFC's key component is the MEA. A PEM fuel module is composed of two catalyst layers and two gas diffusion layers (GDL): because of their superior proton conductivity, mechanical and chemical stability nafion membranes are the most used electrolytes.

One of the most serious obstacles to the commercial use of PEMFCs is the high cost of electro-catalyst platinum (Pt) and fabrication process. One technique to reduce the cost is to expand the surface area of the Pt catalyst and use it more efficiently without sacrificing cell performance. It will assist in reducing the fuel cell's size, and its high cost. The factors which reduce the PEM fuel cell performances are temperature control and water control capabilities, ohmic resistance, and rate of long-term performance deterioration of PEMFCs which are all determined by the membrane, catalyst degradation, and efficiency. The performance is impacted by a variety of input factors and output factors of a PEM fuel cell which encompass both design and construction of fuel cells, material deterioration, impurities or pollutants, and operating situations. The long-term endurance of PEM fuel cells is a major roadblock to their commercialization in stationery and transportation applications. Improved fuel cell component durability is required for commercial viability. Individual components must be thoroughly described to determine and quantify deterioration mechanisms to expand fuel cell durability. In this review, we summarise some of the progress made in identifying chemical, mechanical and thermal degradation mechanisms in PEM fuel cells over the years, as well as a solution to the degradation due to contaminants.

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