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Enhanced corrosion tolerance and highly durable ORR activity by low Pt electrocatalyst on unique pore structured CNF in PEM fuel cell

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ABSTRACT

Carbon supports enable Pt electrocatalyst to offer a better electrocatalytic activity and an efficient catalyst utilization in polymer electrolyte membrane fuel cells (PEMFCs). Highly graphitized carbon structure has been regarded as an active and durable catalyst support due to its high electronic conductivity and corrosion tolerant property. However, the graphitized carbon supported Pt nanoparticles may not directly correlate with a high electrochemical surface active area and electrocatalyst utilization due to the collapse of the support pore structure and Pt catalyst agglomeration. To solve this challenge, herein, we apply two different graphitization methods (thermal and catalytic graphitizations) on electrospun carbon nanofibers, which successfully control the pore structure distribution and thereby improve the utilization of Pt electrocatalyst on fibrous graphitized carbon supports. The enhanced performance of our synthesized Pt catalyst on new carbon support was investigated by the activity for oxygen reduction reaction and the corrosion tolerance using a start-up/shut-down accelerated stress test. The influence of the degree of graphitization and the proportion of the controlled meso/macroporous structures have further evaluated in a single cell system where has achieved the maximum power density of 0.85 W cm^{-2} due to its enhanced mass transport at high current density region.

1. Introduction

Due to the ever-increasing demand of realizing clean hydrogen-based technology, fuel cell becomes a major promising hydrogen energy utilization system for the transport sector and distribution infrastructure [1,2]. Of late, hydrogen fueled proton exchange membrane fuel cells (PEMFCs) have been attracted as a decarbonized and sustainable energy conversion system with the advantages of high power density, fast start-up and low operating temperature [3–7]. Among the number of fuel cell applications, fuel cell electric vehicles (FCEVs) have already reached the near-commercialization stage. Since Hyundai has first produced FCVs in a large scale since 2013, several automobile manufacturers including Hyundai, Toyota and Honda have been energetically developing FCEVs with better performance and durability [8–10]. The durability of PEMFCs is one of the essential factors for the next stage of the development in future FCEVs [11,12]. It should be considered that the catalysts in PEMFCs are undergoing degradation due to the dramatic change of operating voltages under an actual driving condition [13].

In PEMFCs, a hydrogen oxidation reaction (HOR) occurs at the anode, and an oxygen reduction reaction (ORR) occurs at the cathode. Due to the sluggish kinetics of ORR, carbon-supported platinum (Pt) has been used as a cathode catalyst [14]. Carbon supports allow Pt catalysts to have a higher surface area with more active sites for ORR [15,16]. At the same time, however, carbon supports can be possibly oxidized and corroded during the long-term fuel cell operation, and such a carbon corrosion behavior may be accelerated under harsh operating conditions such as fuel starvation and repeat start-up/shut-down cycling, leading to a significant degradation of the fuel cell performance [17–20]. Therefore, the challenges for the development of a more durable carbon support is essential to the enhanced FCEVs performance. Graphitized carbon materials have been regarded as durable supports for the ORR in previous studies [18–21]. To explore a durable

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