

Abstract

Direct formic acid fuel cells (DFAFC) offer a potentially sustainable alternative to the batteries in portable devices due to their higher charge capacity, high efficiency, and smaller size. However, due to the two-phase flow in the anode catalyst layer and the small pore size between agglomerates in the catalyst layer (~20 nm), mass transport limitations plague the performance of the DFAFC. To maximize the performance, the two-phase transport of the reactant (formic acid) and the product (carbon dioxide) must be optimized. The incorporation of a pore forming template during catalyst layer fabrication and subsequent removal can increase the porosity between catalyst/ionomer agglomerates and enhance mass transport into and out of the anode catalyst layer.

In 2002, a 3.4x enhancement in current density at 60°C of 3.4x was reported due to pretreatment with 1M methanol.[1] The methanol swelled the anode catalyst layer thereby enhancing mass transport. This methanol pretreatment was found to be only temporal. In 2012, the addition of the pore forming template lithium carbonate (Li_2CO_3) has been shown to form ~10 mm voids through the thickness of the ~10 mm catalyst layer after acid leaching out the Li_2CO_3 . [2] The formic acid electrooxidation charge transfer resistance was reduced for 17.5 wt% pore former additions, at the detriment of the catalyst layer's triple-phase boundaries.

The present study aims to increase the nano-range porosity of the anode catalyst layer to enhance two-phase flow, while maintaining the integrity of the triple-phase boundaries. The alternative templating agent is magnesium oxide (MgO) with an average size of only ~50 nanometers. MgO has been shown to increase mass transport of methanol.[3] The current work shows improved catalytic activity due to the increase in the porosity.