Selective CO oxidation over a commercial PROX monolith catalyst for hydrogen fuel cell applications

Qinglin Zhang*, Larry Shore, Robert J. Farrauto
BASF Corporation, 25 Middlesex/Essex Turnpike, Iselin, NJ 08830, USA

A R T I C L E   I N F O

Article history:
Received 2 February 2012
Received in revised form
5 April 2012
Accepted 6 April 2012
Available online 18 May 2012

Keywords:
PROX catalyst
CO oxidation
Cu promoted by Pt
Hydrogen production
Monolith catalyst

A B S T R A C T

Preferential oxidation (PROX) of CO over noble-metal-containing monolith catalysts is one of the most promising approaches for removing CO to generate low temperature fuel cell quality H2. The monolith-supported washcoated catalyst comprising Cu and Fe promoted with Pt is highly effective in reducing the CO in practical reformates to less than 10 ppm over a broad range of feed compositions, inlet temperatures and turn down ratios. It is speculated that Pt dissociates the H2 which then reduces the CuO to its active state. Pt may also act as a cocatalyst for CO adsorption with metal oxides supplying oxygen for PROX reaction. The catalytic system is operated adiabatically with an inlet temperature between roughly 65–120 °C reaching an exit temperature close to 150 °C with no evidence of reverse water gas shift or methanation. The goal was to find the proper operating conditions to achieve <10 ppm CO. Turn down ratios (varying space velocities) at a factor of 4–5 are routinely achieved up to at least 34,000 h⁻¹ with high steam levels of up to 45%. The wide operating window simplifies the control of the PROX reactor and improves the fuel processor’s performance for fast startup and shutdown and responses to transient loads. The catalyst also retains its performance after multiple start and stops modes of operation in reformate.

1. Introduction

The H2-rich gas stream that is fed to the anode of the low temperature PEM membrane fuel cell must have a very low concentration of CO (<10 ppm) to avoid poisoning the Pt electrode [1–7]. Of the many methods of removing CO from the reformer gas, preferential oxidation (PROX) of CO over noble-metal containing catalysts is most frequently practiced [8–15] due to its robust behavior in reformate. A typical fuel processor includes fuel reforming of a hydrocarbon fuel, high and low temperature water gas shift catalysts for converting majority of CO to hydrogen (Fig. 1). The final step is the preferential oxidation of CO (PROX, Fig. 1 and Eq. (1)).

The catalyst for the PROX reactor must be highly active for reduction of CO to less than 10 ppm with minimum catalyst volume.

CO + 1/2O₂ → CO₂

The PROX catalyst must not oxidize any significant quantity of hydrogen (reaction (2)):

H₂ + 1/2O₂ → H₂O

It must also function over a broad range or turn down ratios (SV), inlet temperatures, and CO, H₂, CO₂ and steam concentrations to meet the changing power demands of the fuel cell.

* Corresponding author. Tel.: +1 7322057106.
E-mail address: qinglin.zhang@basf.com (Q. Zhang).
0360-3199/$ – see front matter Copyright © 2012, Hydrogen Energy Publications, LLC. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.ijhydene.2012.04.032