



# Complete removal of carbon monoxide by functional nanoparticles for hydrogen fuel cell application



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## HIGHLIGHTS

- Complete oxidation of CO was achieved at low temperature with Cu/Ce<sub>0.8</sub>Zr<sub>0.2</sub>O<sub>2</sub> catalysts.
- Complete CO oxidation at low temperature was attributed to high oxygen storage capacity of the catalysts.
- The contribution of oxygen species in achieving the complete conversion was investigated and explained.

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## ABSTRACT

A bi-functional catalyst containing a stable cubic cerium-zirconium oxide phase was prepared and used for CO preferential oxidation. Pure ceria was observed to achieve the highest CO conversion of over 95% at >300 °C. A bi-functional ceria-zirconia successfully reduced the reaction temperature to 200 °C but at the expense of lower conversion of 85%. The bi-functional catalyst containing copper species at 5 wt% of the metal precursor demonstrated the ability to oxidize CO completely at 115 °C. This was made possible by the high oxygen storage capacity (OSC) of the catalyst which was measured to be 707.7 μmol O<sub>2</sub>/g.

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## 1. Introduction

Hydrogen (H<sub>2</sub>) has been used as fuel to power rocket for decades. However, its application in a wider range that encompasses communal transportation and infrastructure has not been far-reaching. An effort to spur growth based on a hydrogen economy and hydrogen powered society began in Japan in 2014 with the announcement on the strategic road map for hydrogen and fuel cells (Kamiya et al., 2015). It was followed by another announcement recently to designate \$350 million to subsidize and invest in 6000-unit Olympic village that shall function exclusively on fuel cell power in order to catalyze a transition to hydrogen powered society (Spector, 2016). The objective from this initiative is two-fold; reducing an ecological footprint and placing Japan on the world map as a role model for the implementation of large-scale hydrogen technology. By doing so, the economy of scale can be

achieved and the important component in this initiative - the proton exchange or polymer electrolyte membrane fuel cell (PEMFC) can be made more affordable. This fuel cell system can be used to exploit the stored hydrogen from renewable or fossil sources to generate electricity.

Despite the promising prospect of hydrogen production from renewable sources, about 95% of the current hydrogen is produced commercially by steam reforming (SR) of natural gas (Chaubey et al., 2013). This is due to the economic feasibility and mature technology for producing H<sub>2</sub> in an industrial scale by SR. The synthetic gas from SR which normally contains H<sub>2</sub>, carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO) can be supplied directly into a molten carbonate fuel cell (MCFC) to generate electricity (Nguyen et al., 2012, 2013). However, this cannot be done for PEMFC system because the CO, although present in a minute scale, can potentially poison the electrode catalyst and lead to rapid degradation of PEMFC performance (Gottesfeld and Pafford, 1988; Rosli et al., 2017). Thus, complete CO removal is desirable before the synthetic gas can be used for PEMFC.

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