CHAPTER I
INTRODUCTION

Hydrogen (H_2) is a clean energy resource to replace polluting fossil fuels because it is readily available, renewable, not harmful when emitted, environment friendly, and fuel efficient. These advantages make it very attractive for using in proton exchange membrane (PEM) fuel cell which converts the chemical reaction between H_2 and O_2 into electricity without combustion. However, the major problem in PEM fuel cells is to supply high-purity of H_2. (Candusso *et al.*, 2006) The preferential CO oxidation (PROX) reaction has been widely used in the purification process of H_2 due to its low cost and ability to reduce CO content to less than 10 ppm without excess hydrogen consumption.

Cerium oxide (CeO_2) or ceria is important oxide and has been widely investigated in the automotive exhaust purification, oxygen storage, and catalysis via conversion between Ce^{3+} and Ce^{4+} oxidation states and the exhibition of oxygen storage and release properties (Ji *et al.*, 2008). The catalytic performance of ceria can be increased by its structural properties, such as surface area and their crystal shape.

The mesoporous (MSP) materials have pore size between 2–50 nm with high surface areas and superior performances in allowing a large reactant to penetrate inside the pores. Thus, they have attracted particular attention in many applications, as adsorption, catalysis, sensor, and hosts for the synthesis of nanomaterials (Idakiev *et al.*, 2006). The first group of MSP materials discovered by Mobil group (M41S family) consists of hexagonal MCM-41, cubic MCM-48, and unstable lamellar MCM-50 mesostructures (Kresge *et al.*, 1992).

MSP ceria with high surface areas has been synthesized by nanocasting method using either soft or hard templates. The hard templates (i.e. silica, carbon) provide more advantages than the soft ones, such as presenting highly crystalline walls leading to prevent a collapse of the structure during the removal of the template and providing well-ordered structure of frameworks leading to high surface areas of replica. The synthesis of MSP cerium dioxide by nanocasting method using a hard template consists of three steps (An-Hui *et al.*, 2010). First, the MSP template is penetrated by a target precursor into the pores. Second, the precursor inside the porous template is converted to the desired substance by thermal treatment. Finally, the hard templates are removed by chemical reaction method. The replica of the MSP template is presented after removing the template. Deeprasertkul *et al.*, (2014) synthesized MSP ceria via nanocasting method using high surface area MCM-48 as a template. The synthesized MSP ceria has strong reduction at lower temperature comparing to commercial one.

However, the pure MSP CeO_2 still has higher reduction temperature and more hydrogen consumption for being used as a catalyst in the PROX reaction. The structure modification of CeO_2 lattice by doping with transition metal oxides may improve the stability and activity of ceria (Trovarelli *et al.*, 1999). Several studies have reported that loading Cu to commercial CeO_2 catalyst support leads to an increase in their catalytic activity and selectivity in many reactions, such as CO oxidation, SO_2 reduction, and methane oxidation (Gorte *et al.*, 2005). The metal loading on a support was prepared by the deposition-precipitation (DP) method which has an advantage over other methods because of the uniform particle distribution with small particle size (Haruta *et al.*, 1993) and a closed interaction between the metal particles and the support (Bond *et al.*, 1999).

In this works, the metal loaded MSP ceria is synthesized by the deposition-precipitation (DP) method, and investigated the effect of the loaded copper on MSP ceria support with different percent of copper (3, 5, 7, and 9 wt%) for the PROX reaction. Moreover, the effect of feeding component on the catalyst activity and selectivity is also studied.