CHAPTER I
INTRODUCTION

In the past decade, porous materials have been widely studied because of their remarkable properties, such as high surface areas, which are attractive in many applications, especially catalyst supports. According to the International Union of Pure and Applied Chemistry (IUPAC), porous materials can be classified into three categories relied on their pore sizes, viz. microporous (pore size <2 nm), mesoporous (2-50 nm), and macroporous (>50 nm) (Lu *et al.*, 2009). Microporous and mesoporous materials are extensively applied as a catalyst supports and adsorbents due to their open structure and high surface area. Mobil researchers, who discovered how to synthesize mesoporous materials, divided the materials into three types; MCM-41 (one dimensional hexagonally), MCM-48 (three dimensional cubic), and MCM-50 (two dimensional unstable lamellar).

Cerium oxide or ceria (CeO_2) is another metal oxide extensively employed for various applications, especially for automotive exhaust catalyst, because it has a redox properties and ability to storage or release oxygen between CeO_2 and Ce_2O_3. Simply, the Ce^{3+}/Ce^{4+} redox cycle provides high catalytic activity of cerium oxide. Furthermore, the catalytic characteristic of cerium oxide can be increased by its structural property, for example, surface area and crystal shape. Cerium oxide is commonly used in oxygen gas sensors, solar cells, fuel cells, and as an additive in the three-way catalyst (TWCs) for automotive exhaust gas treatment.

Zirconium oxide or zirconia (ZrO_2) is the only metal oxide that has acidity and basicity as well as reducing and oxidizing abilities. It has relatively high strength and improved mechanical properties. Zirconia exists in three structural types; cubic, tetragonal, and monoclinic symmetry in which are stable at high (2953–2643 K), intermediate (2643–1223 K), and low (below 1223 K) temperatures. When zirconia is blended with some other oxides, the tetragonal and/or cubic phases are stabilized.

Mesoporous ceria/zirconia oxide with high surface area is synthesized by nanocasting method using either soft or hard templates. The soft template, such as low molecular weight surfactants, block copolymers, indicate some disadvantages relating to the collapse of the mesostructure during the removal of the template. Conversely, the hard template, such as silica, carbon, can control the final properties of the catalyst structure after the removal of the template (Aranda *et al.,* 2010). Thus, the hard templates give well ordered structure of frameworks, leading to high surface areas of replica. The nanocasting method using hard templates consists of three steps. First, the precursor infiltrates inside the mesochannel of the template. Second, the precursor is converted to the desired material inside the pore by thermal treatment. Last, the hard template is removed by using HF or NaOH.

The aim of this study is thus focused on preparation of mesoporous CeO_2-ZrO_2 via nanocasting method using MCM-48 as a hard template which is synthesized from silatrane as a silica precursor. The optimum conditions to obtain high surface area and single phase CeO_2-ZrO_2 are investigated. The morphology and physical properties are characterized using various techniques.