# Syngas production via methane dry reforming: A novel application of SmCoO₃ perovskite catalyst

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## ARTICLE INFO

## ABSTRACT

In this study, SmCoO₃ perovskite catalyst have been synthesized by the sol-gel citrate method and for the first time, applied as catalyst for the production of syngas (H₂ and CO) via methane dry reforming reaction. The perovskite catalyst was characterized (pre- and post-reaction) to determine its physicochemical properties. Characterization of the calcined perovskite catalyst showed the formation of perovskite structure only. No other crystalline phases were detected. Prior to the catalytic test, the effects of reducing SmCoO₃ perovskite catalyst with H₂ (for activation) in the methane dry reforming reaction were investigated. Results showed no significant effects of H₂ reduction on the activity of the SmCoO₃ perovskite catalyst. This suggests that there was an *in-situ* reduction of SmCoO₃ which was confirmed by XRD analysis of spent catalyst. Subsequently, reactant gases (CO₂ and CH₄) with partial pressure ranged 6.8–60.8 kPa and reaction temperature ranged 973–1073 K were employed for the reaction study. Results from the catalytic activity yielded maximum conversion of 93% for both reactants, at reactants partial pressure of 20.3 kPa (stoichiometric point). In addition, syngas with maximum percentage yield of 67% and 65% for H₂ and CO, respectively, was produced from the methane dry reforming reaction. Used catalyst characterization showed the existence of carbon deposit which could have emanated from methane decomposition.

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## 1. Introduction

Greenhouse gases (CO₂ and CH₄), have been the main causative agents of serious environmental and ecological problems like global warming, thereby presenting a strong case for methane dry reforming (Sutthiumporn and Kawi, 2011). Commercial production of syngas (H₂ and CO) from methane can be obtained via steam reforming. This produces syngas with ratio greater than 3.0 (Khalesi et al., 2008). Recently, focus has been drawn to the conversion of these greenhouse gases, which are arguable the cheapest carbon containing compounds, into more valuable products by catalytic reactions (Khalesi et al., 2008). The resulting product, yields lower H₂: CO ratio which is suitable as precursor for methanol and Fischer-Tropsch synthesis (Ruckenstein and Wang, 2002; Xu and Wang, 2005; Sutthiumporn and Kawi, 2011). The primary reaction for syngas production from methane dry reforming reaction is represented in equation (1):
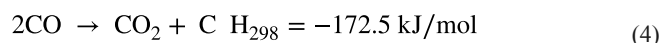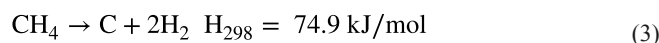
$$CH_4 + CO_2 \leftrightarrow 2H_2 + 2CO, \quad \Delta H_{298} = 246.2 \text{ kJ/mol} \tag{1}$$

This reaction is most often accompanied by simultaneous occurrence of the reverse water –gas shift reaction (RWGS) shown in the following equation (2):

$$CO_2 + H_2 \leftrightarrow CO + H_2O, \quad H_{298} = 46.1 \text{ kJ/mol} \tag{2}$$
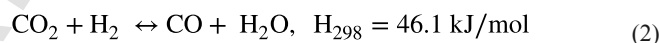
However, methane dry reforming reaction have been reported to proceed with some demerits which include; high endothermicity, slow kinetics and severe carbon engulfment on the catalyst (Luo et al., 2000). Significantly, carbon lay down occurs via two common routes; methane cracking and Boudouard reaction represented in equation (3) and equation (4), respectively.

$$CH_4 \rightarrow C + 2H_2 \quad H_{298} = 74.9 \text{ kJ/mol} \tag{3}$$

$$2CO \rightarrow CO_2 + C \quad H_{298} = -172.5 \text{ kJ/mol} \tag{4}$$

These side reactions and sintering of the metal particles (from catalyst) have been reported to be the main cause of catalyst deactivation (Richardson and Paripatyadar, 1990). Different types of catalyst have been employed for the production of syngas from methane dry reforming. Noble metals catalysts have been reported to be less sensitive to carbon deposition and have more activity in the dry reforming of methane reaction compared to transition metals based catalyst (Hou et al., 2006). However, due to the high cost of noble metals, it is more reasonable and economical to improve the activity and stability of non-noble metal catalyst such as transition metal based catalyst