

# A hybrid numerical approach for multi-responses optimization of process parameters and catalyst compositions in CO<sub>2</sub> OCM process over CaO-MnO/CeO<sub>2</sub> catalyst

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## Abstract

A new hybrid numerical approach, using Weighted Sum of Squared Objective Functions (WSSOF) algorithm, was developed for multi-responses optimization of carbon dioxide oxidative coupling of methane (CO<sub>2</sub> OCM). The optimization was aimed to obtain optimal process parameters and catalyst compositions with high catalytic performances. The hybrid numerical approach combined the single-response modeling and optimization using Response Surface Methodology (RSM) and WSSOF technique of multi-responses optimization. The hybrid algorithm resulted in Pareto-optimal solutions and an additional criterion was proposed over the solutions to obtain a final unique optimal solution. The simultaneous maximum responses of C<sub>2</sub> selectivity and yield were obtained at the corresponding optimal independent variables. The results of the multi-response optimization could be used to facilitate in recommending the suitable operating conditions and catalyst compositions for the CO<sub>2</sub> OCM process.

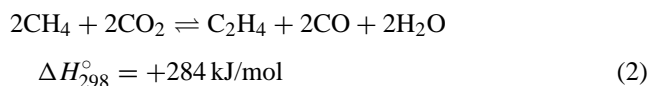
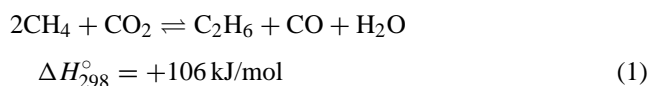
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## 1. Introduction

The high CO<sub>2</sub>/CH<sub>4</sub> ratio in Natuna's natural gas compositions, comprising of up to 71% carbon dioxide and 28% methane [1], should be strategically utilized for the production of higher hydrocarbons, liquid fuels and other important chemicals. Recently, the conversion of methane to C<sub>2</sub> hydrocarbons (ethane and ethylene) using carbon dioxide as an oxidant (carbon dioxide oxidative coupling of methane (CO<sub>2</sub> OCM)) has received considerable attention [2–9]. Eqs. (1) and (2) are the two main CO<sub>2</sub> OCM reaction schemes to produce C<sub>2</sub> hydrocarbons, while carbon monoxide and water are

the by-products.



Catalyst screening of CeO<sub>2</sub>-based catalysts for CO<sub>2</sub> OCM process over binary and ternary metal oxides [9] determined that the 15 wt.% CaO-5 wt.% MnO/CeO<sub>2</sub> catalyst as the most potential. Interestingly, the stability test showed that the 15 wt.% CaO-5 wt.% MnO/CeO<sub>2</sub> catalyst was stable with no obvious coking during 20 h of reaction time on stream. However, the process parameters and the catalyst compositions of the CO<sub>2</sub> OCM process have not been optimized.

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