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CO_2 METHANATION ON THE EFFECT OF METAL SUPPORTED CATALYST

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Abstract:
Rapid population growth has contributed significantly to the increasing demand for natural resources consumption. An initiative that can be made in conserving the natural resources is by CO_2 methanation that converts CO_2 to the methane gas. Catalyst plays a significant role in promoting the CO_2 methanation in achieving high methane selectivity. The catalytic activity, selectivity, stability and cost must take consideration towards the selection of suitable methanation catalyst in certain reaction conditions. The methanation catalysts that had been reviewed based on their catalytic activity are noble metal such as Rhodium and Ruthenium, Nickel and Cobalt catalyst. The noble metal catalysts such as Ru and Rh are the most active metal in group VIII which possess higher methane selectivity produced at low temperature due to its high resistance for the carbon dioxide, CO_2 oxidized to the atmospheres. Supported Rh/γ-Al_2O_3 catalyst increase the CO_2 adsorption and CO_2 dissociation compared to unsupported Rh catalyst in hydrogenation of CO_2 to methane process. The increase of Rh loading from 1 wt% to 10 wt% resulted higher methane selectivity in the process. The co-precipitated of zirconia dioxide support resulted the greater CO conversion in 20 wt% Ni/ZrO_2 catalyst compared to sol-gel method. The different types of support were used in Ni catalyst such as CeO_2, ZrO_2, TiO_2, SiO_2, and Al_2O_3 to observed the most suitable support in low temperature process. The strong interaction between Ni and Ce support possess the highest catalytic activity based on the percentage of methane yield. The effect of support and metal loading for cobalt catalyst shows that 230 m^2/g of support Co/CeO_2 and increasing from 5 wt% to 10 wt % of Co/CNT catalyst produced higher CO conversion in the CO_2 methanation process. The addition of support and effect of metal loading has influenced the catalytic performance of the catalyst in the reaction. Therefore, the supported Ni with Cerium (IV) oxide, Ni-CeO_2 is the best combination and economical methanation catalyst used in large industrial scale based on their results on the catalytic activity from the research studies.

***Keywords*:**
Carbon dioxide, Methanation, Noble metal catalyst, Ni-based catalyst, Co-based catalyst

Objectives:

- To review the analysis results from several research studies based on the effect of supports, the preparation method, and the metal loading used in the CO2 methanation.
- To determine the best combination of the supported catalyst based on their catalytic performance from the research studies.

Methodology:

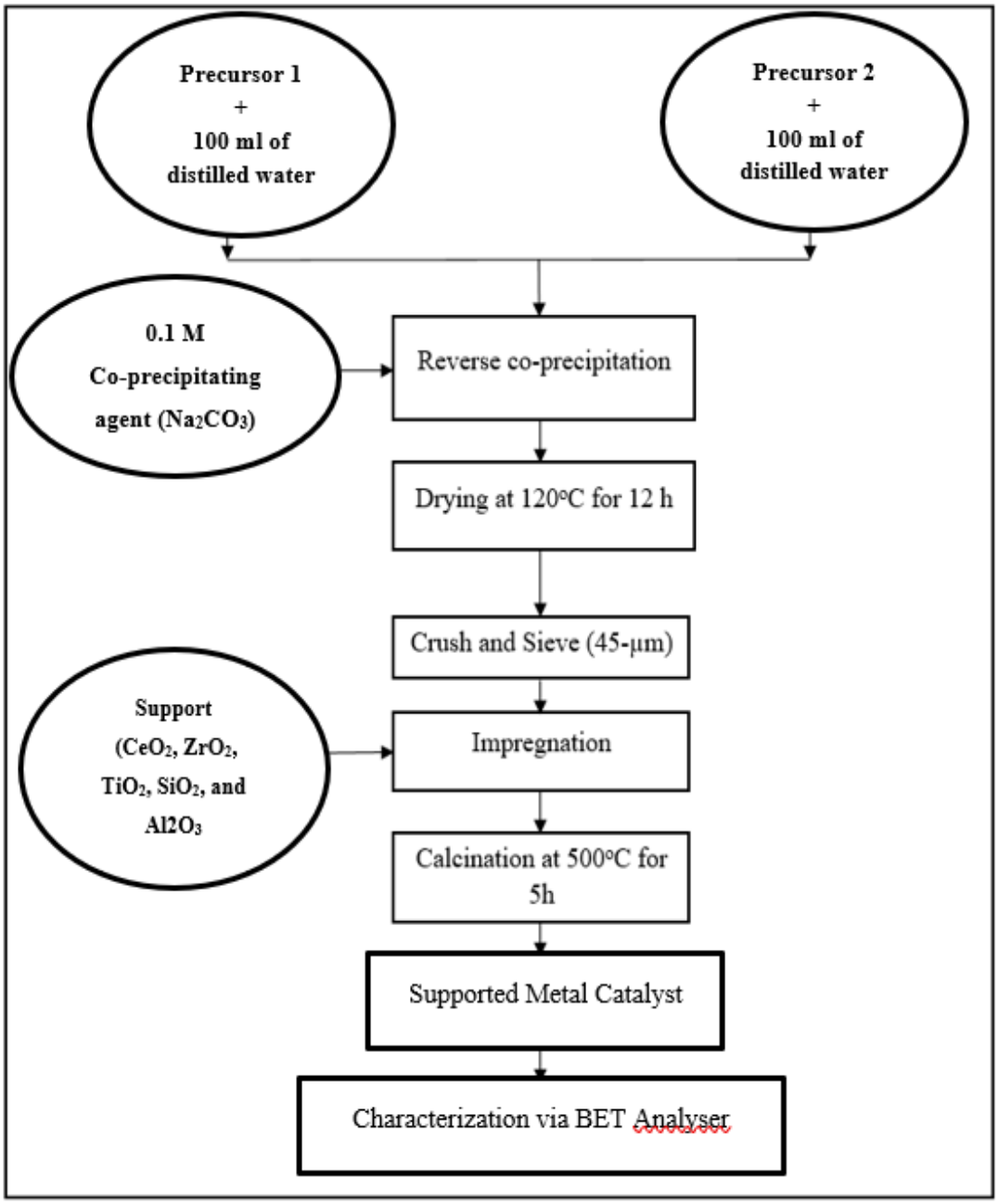
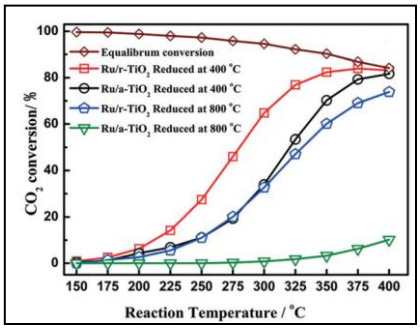
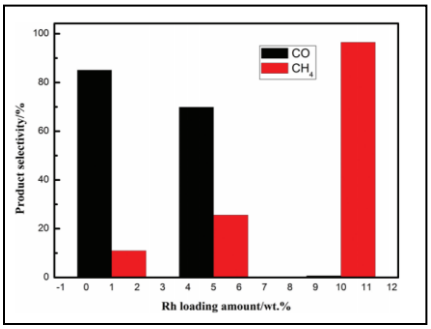
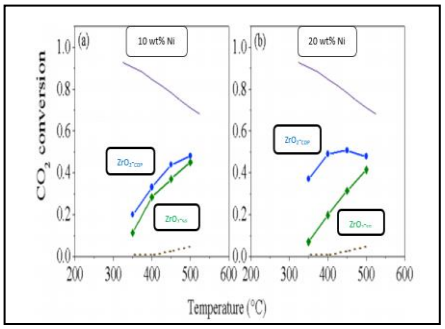


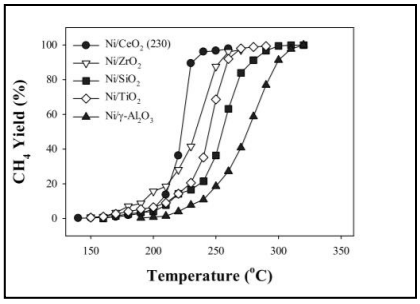
Figure 1.Preparation of Supported Metal Based Catalyst

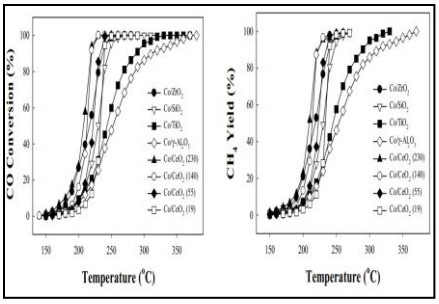
Results:











Catalyst (wt/wt)%	%$CO_{Conv.}$	CO_2%	CH_4%	C_2-C_4%	C_{5+}%
Co5/CNT.A.T	45.5	0.5	19.0	10.2	70.3
Co10/CNT.A.T	58.7	0.5	9.5	6.8	83.2
Co15/CNT.A.T	50.6	0.5	18.2	15.6	65.7
Co20/CNT.A.T	40.3	0.5	23.0	19.1	57.4

The particle size of metal retained after reduction is one of the factors attributed to the percentage rate of CO conversion and CH4 yield. Cerium (IV) oxide, CeO_2 support possess smallest Ni and Co size retained in the reaction. Therefore, in this review study the Ni-CeO2 catalyst is chosen as the best combination supported catalyst in the methanation process due to its higher catalytic performance besides low cost and energy consumption in the reaction.

Conclusion:

The methanation catalysts such as ruthenium, rhodium, nickel and cobalt play a vital role in CO_2 methanation by increase the reaction rate in achieving high yield and selectivity. The supported metal catalyst has been commonly used in industrial application towards CO_2 methanation process because of its catalytic properties and high catalytic performance producing yield and selectivity at low-temperature reaction. The effect of preparation method, metal loading and the presence of support gives significant result towards the catalytic activity in achieving high CO conversion and methane yield in the process. In addition, the larger the surface area of the support were attributed to the high metal dispersion and strong interaction inside the catalyst surface to enhance the performance during reduction at higher temperature. The metal loading of the supported catalyst affected the metal particle size and surface area of the support that will affect to the CO conversion and CH_4 yield over the temperature reaction. Cerium (IV) oxide has been observed has most potential support used in Ni and Co catalyst due to high stability and catalytic performance achieving high methane yield at low-temperature CO_2 methanation reaction compared to Al_2O_3, TiO_2, SiO_2 and ZrO_2.Since the nickel metal provides low cost compared to other metals, supported Ni with Cerium (IV) oxide support is the most suitable and economical methanation catalyst used in large industrial scale based on their results on the catalytic activity from the research studies.