SIIC092

CO_2 METHANATION OVER SUPPORTED MONOMETALLIC AND BIMETALLIC OXIDE CATALYST: A REVIEW

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Abstract:
Rapid industrialization occurred during the 19th century caused a large quantity of CO_2 to be emitted from different sources into the atmosphere. In order to reduce CO_2 emission across the globe, various kinds of discoveries have been reported by researchers to convert CO_2 into less hazardous substances by using a different combination of metal and support materials. Therefore, this research work aims to provide an informative review regarding the role of metals, supports and addition of secondary metal (promoters) to produce high-performance CO_2 methanation metal catalyst. Specific emphasis is placed on the role of metals as well as on the role of supports as these are the most important factors which could contribute to the enhancement of CO_2 methanation metal catalysts. In this research work, recent findings within the related scope from various researchers are thoroughly reviewed and the important data gathered are presented in the form of tables. Next, any significant trends obtained from the data are explained with reasonable scientific justifications. From the research conducted, Ni was chosen as the best material mainly due to its high methanation activity, wide usage in commercial applications and exhibit a high prospect for catalytic improvement. Next, the addition of secondary metal to existing metal catalyst especially Ce not only modify and reconstruct the catalyst structure but promote the reducibility of active species thus producing new catalyst with enhanced catalytic properties. From the findings, it can be clearly seen that the bimetallic catalyst has much higher catalytic performance compared to the monometallic catalyst because of the benefits offered by the second metal. From this research, conventional metal oxide support (Al_2O_3 & CeO_2) was determined to exhibit better catalytic performance compared to other support materials due to its high specific surface area and high hydrogen storage ability.

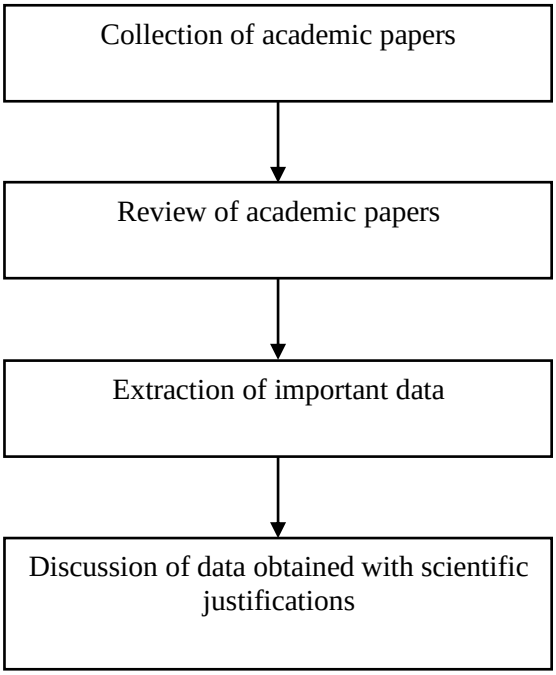
***Keywords*:**
Monometallic; Bimetallic; Catalyst supports; CO_2 methanation; Promoters

Objectives:

- To conduct a review on research papers within the scope of metal catalyst used in CO_2 methanation process by extracting important data and provide relevant scientific reasons.
- To determine whether monometallic or bimetallic catalyst will be a better choice and determine the best combination of metal and support material which would give the

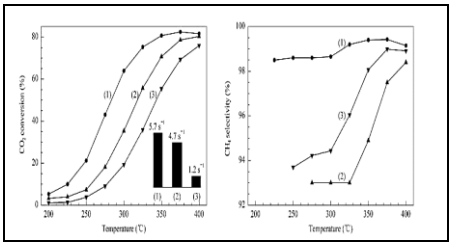
highest catalytic performance in CO_2 methanation by comparing various options of metal and support materials.

Methodology:



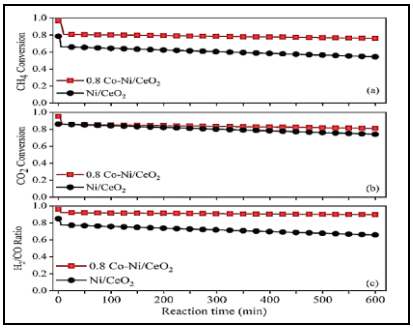
Results:

Ni based catalyst- CO_2 conversion and CH_4 selectivity



Catalyst	Active metal (wt%)	Pressure (bar)	Temp (℃)	X_{CO_2}(%)	S_{CH_4}(%)	Ref.
Ni-Al_2O_3-HT (1)	78	1	350	80	99	[32]
Ni/Al_2O_3-IMP (2)	20	1	350	70	95	[32]
Ni/Al_2O_3-IMP (3)	78	1	350	54	98	[32]

Ni-Co catalyst- CO_2 conversion and CH_4 conversion



Catalyst	Active metal (wt%)	Pressure (bar)	Temp (℃)	X_{CO_2}(%)	X_{CH_4}(%)	Ref.
Ni/CeO_2	10	1	800	80	60	[39]
0.8 Co-Ni/CeO_2	10	1	800	90	80	[39]

Conclusion:

The CO_2 hydrogenation reaction to transform CO_2 into CH_4 were first discovered by the French chemists Paul Sabatier and Jean-Baptiste Senderens in 1897 and has been a topic of main research attraction until to the present day. Each of the metal catalyst previously reviewed in the monometallic and bimetallic section has their own respective advantages and disadvantages when participating in the CO_2 methanation reaction. Noble metal catalysts for example Ru are well recognized to be the most active metal for CO_2 methanation, but the high cost, as well as limited availability, makes them less attractive to be incorporated in practical applications. Hence, researchers have changed their attention on metal such as Ni and Co which are relatively cheaper than noble metals because these metals have the potential to be modified to produce a high-performance catalyst. For metallic catalysts, Ni was chosen as the best material mainly due to its high methanation activity, wide usage in commercial applications and exhibit a high prospect for catalytic improvement. Next, the addition of secondary metal (promoter) to existing metal catalyst not only modify and reconstruct the catalyst structure but promote the reducibility of active species thus producing new catalyst with enhanced catalytic properties for instance high CO_2, high CH_4 selectivity and high catalyst stability. Ni catalyst doped with Ce promoter yield the highest CO_2 conversion and CH_4 selectivity compared to other promoters. From the research conducted, it can be clearly seen that the bimetallic catalyst has much higher catalytic performance compared to the monometallic catalyst because of the benefits offered by the second metal such as higher metal dispersion and inhibition of RWGS reaction. Besides, the choice for support materials plays a vital part in the catalytic performance of a heterogeneous catalyst. From this research, conventional metal oxide support (Al_2O_3 & CeO_2) and carbon support (CNT) was determined to exhibit better catalytic performance compared to other support materials due to its high specific surface area and high hydrogen storage ability. In addition, low temperature and high-pressure condition was determined as the favourable conditions for better CO_2 methanation process. Even so, more research needs to be conducted to determine the suitable H_2/CO_2 reactant gas ratio which would give highest CO_2 conversion. From my personal recommendation, it would be safe to assume that Ni metal doped with Ce and supported on Al_2O_3 will be the best combination to produce high-performance CO_2 methanation metal oxide catalysts. This can be explained via the contribution of alumina support which promotes better dispersion of Ni metal particles, reducing their size and increasing the number of active sites while the addition of Ce into Ni catalyst increased the Ni-alumina support interaction, minimize Ni particles sintering and carbon deposition [105]. My assumption is supported by a research conducted by Gonzalez et al [105] and the result they obtained is in agreement with my assumption.