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OPTIMIZATION OF CATALYST ELEMENTAL COMPOSITION AND REACTION PARAMETERS FOR METHANOL SYNTHESIS ON Cu/Zn/Al/Zr CATALYST

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Abstract:

Catalytic hydrogenation of methanol involved metal catalyst with its operating reaction parameters such as temperature, pressure, and space velocity. The experimental of methanol synthesis were carried out to characterize a different composition of multi – metallic catalysts consists of Cu/Zn/Al/Zr and also to optimize the catalyst elemental composition as well as reaction parameters via CO_2 hydrogenation. The catalyst is synthesized from its metal nitrate with its ratio by co – precipitation (CP) method. CP method included the stages of precipitation, drying, and calcination process to get metal solid catalyst. The catalyst then characterized with BET surface area and Temperature Programme Reducibility (TPR) techniques. Response Surface Methodology (RSM) using Minitab software analyzed the multiple data in order to obtained one set optimum parameter of methanol synthesis. The parameter involved were temperature of 200°C – 300°C, with a pressure ranged of 10bar – 50bar and the conversions of carbon dioxide at 10% - 30%. The data were collected at $10,000h^{-1}$ of gas hourly space velocity. This kind of technique is to ensure that all parameter and values covered the boundary of sample. The best catalytic performance of the reaction parameters for methanol synthesis were optimized at the temperature and pressure of 281.11°C and 45.56bar with appropriated conversions at 0.2857 and 0.2661 respectively. The optimum graph has been expressed from the Response Optimizer.
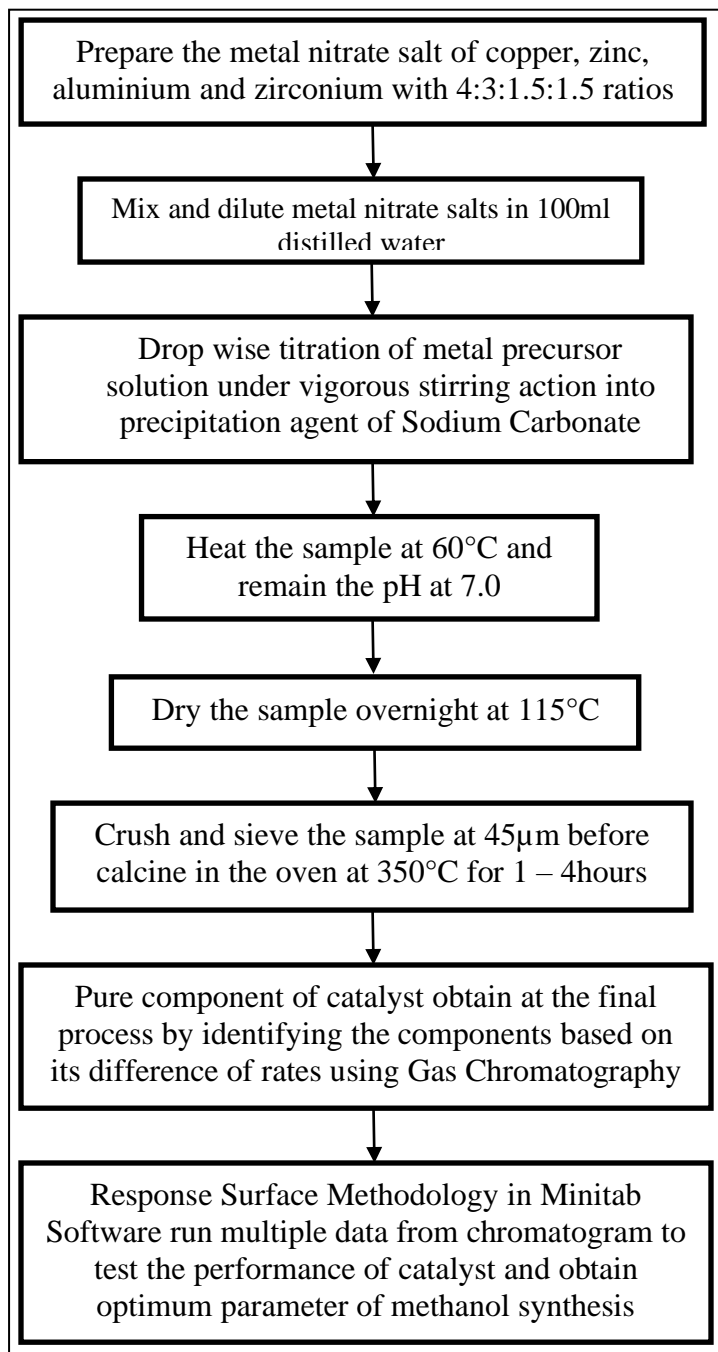
***Keywords*:**
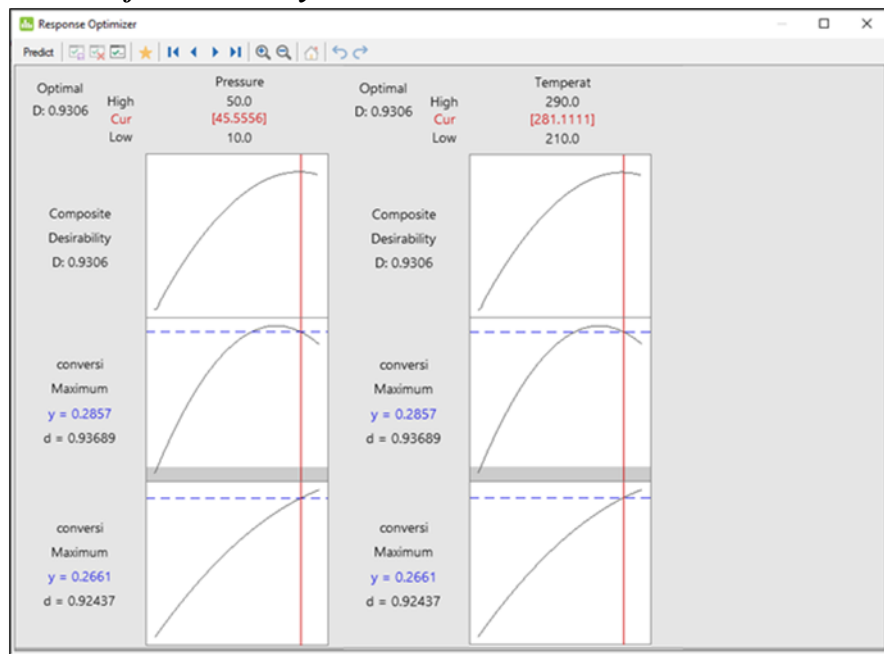Optimization, Methanol synthesis, CO_2 conversion, Response Surface Method, Minitab Software

Objectives:

- To prepare and characterize a different composition of multi – metallic catalysts consist of Cu/Zn/Al/Zr
- To optimize the reaction parameters for methanol synthesis via CO_2 hydrogenation

Methodology:

Prepare the metal nitrate salt of copper, zinc, aluminium and zirconium with 4:3:1.5:1.5 ratios

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Mix and dilute metal nitrate salts in 100ml distilled water

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Drop wise titration of metal precursor solution under vigorous stirring action into precipitation agent of Sodium Carbonate

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Heat the sample at 60°C and remain the pH at 7.0

↓

Dry the sample overnight at 115°C

↓

Crush and sieve the sample at 45µm before calcine in the oven at 350°C for 1 – 4hours

↓

Pure component of catalyst obtain at the final process by identifying the components based on its difference of rates using Gas Chromatography

↓

Response Surface Methodology in Minitab Software run multiple data from chromatogram to test the performance of catalyst and obtain optimum parameter of methanol synthesis

Results:
Optimum Parameter of Methanol Synthesis

Conclusion:

As a conclusion, the catalyst elemental composition and the reaction parameters for methanol synthesis were analysed by Response Surface Methodology (RSM) in Minitab software. RSM is very practical in studying the optimal conditions as the combined effect of the working parameters including temperature and pressure has been studied and their effect towards the conversions of carbon dioxide and methanol selectivity is estimated. Several points of temperature and pressure has been chosen to obtain the optimization conditions which in the range of 200°C to 300°C and 10bar to 50bar. These can be done by analyse the response surface design in order to gain the results of response surface regression before proceeding to plotting the optimum graph from the response optimizer. Therefore, the graph has visualized the optimum condition at 281.11°C and 45.56bar with the conversions of 28.57% and 26.61% respectively.