SYNTHESIS AND CHARACTERIZATION OF $CoAl_2O_4$ AND $Co-Al_2O_3-CoAl_2O_4$ CATALYSTS ACTIVITY IN CARBON DIOXIDE REFORMING OF METHANE

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by

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LIST OF ABBREVIATION

Symbol	Description
Al	Aluminium
Al^{3+}	Aluminium (III) ion
Al_2O_3	Aluminium Oxides
$Al(NO_3)_3$	Aluminium Nitrates
Ar	Argon
BaO	Barium Oxide
BET	Brunauer–Emmett–Teller
C	Carbon
C_2H_4	Ethene
C_2H_6	Ethane
$C_6H_8O_7$	Citric acid
CaO_2	Calcium Oxide
Ca_2SiO_4	Calcium Silicate
CETS	Chemical Energy Transmission System
CeO	Cerium Oxide
CH	Methane with 1 hydrogen atom
CH_2	Methane with 2 hydrogen atom
CH_3	Methane with 3 hydrogen atom
CH_4	Methane
CH_x	Methane with different number of hydrogen atom denoted as x
CO	Carbon Monoxide
CO_2	Carbon Dioxide

CO_3^{2-}	Carbonate ion
Co	Cobalt
Co^{3+}	Cobalt (III) ion
$CoAl_2O_4$	Cobalt Aluminium Oxides
$Co_{(x)}Al_{(3-x)}O_4$	Cobalt Aluminium Oxides (with varying cobalt and aluminium content noted as x)
$Co(NO_3)_2$	Cobalt Nitrates
CRM	Carbon Dioxide Reforming of Methane
CrO_3	Chromium Oxides
Dy	Dysprosium
EDX	Energy-dispersive X-ray Spectroscopy
Er	Erbium
Eu	Europium
Fe	Iron
GC	Gas Chromatograph
Gd	Gadolinium
GHGs	Greenhouse Gases
H	Hydrogen atom
H_2	Hydrogen
H_2O	Water
H_2S	Hydrogen Sulfide
HCO_2^-	Hydrogen Carbonate ion
Ho	Holmium
Ir	Iridium
La_2O_3	Lanthanum oxide

M	Metal
$MgAl_2O_4$	Magnesium Aluminium Oxides
$MgCr_2O_4$	Magnesium Chromium Oxides
MgO	Magnesium Oxide
N_2	Nitrogen
Nd	Neodymium
Ni	Nickel
O	Oxygen atom
O_2	Oxygen
OH	Hydroxide
P	Promoter
Pd	Palladium
Pr	Praseodymium
Pt	Platinum
Rd	Rhodium
Ru	Ruthenium
RWGS	Reverse Water Gas Shift
S	Support
SEM	Scanning Electron Microscopy
SiO_2	Silicon Dioxide
Sm	Samarium
Tb	Terbium
TEM	Transmission Electron Microscopy
ThO_2	Thorium Oxide
TGA	Thermo-gravimetric Analysis

Tm	Thulium
TPR	Temperature Programmed Reduction
WHSV	Weight Hour
XRD	X-ray Powder Diffraction
$ZnCr_2O_4$	Zinc Chromium Oxides
ZrO_2	Zirconium Oxides
γ-Al_2O_3	Gamma-Aluminium Oxides

LIST OF SYMBOLS

Symbol	Description	Unit
ΔG	Gibbs Free Energy	kJ K^{-1} mol^{-1}
ΔH	Enthalpy change	kJ mol^{-1}
α	Reduction temperature	°C

SINTESIS, PENCIRIAN $CoAl_2O_4$ DAN Co-Al_2O_3-$CoAl_2O_4$ PEMANGKIN AKTIVITI DALAM KARBON DIOKSIDA PEMBAHARUAN METANA

ABSTRAK

Penghasilan syngas (hidrogen, H_2 dan karbon monoksida, CO) melalui karbon dioksida pembaharuan metana (CRM) merupakan satu proses yang berpotensi. Reaksi ini menggunakan dua gas rumah hijau, iaitu, metana, CH_4 dan karbon dioksida, CO_2. Biogas merupakan bahan mentah yang murah dan sesuai untuk proses CRM kerana mengandungi CH_4 dan CO_2 yang bernisbah 1:1. Walau bagaimanapun, pemangkin yang diperbuat daripada unsur-unsur bumi dan aktif dalam CRM masih dalam permintaan justeru dijadikan objektif penyiasatan dalam projek ini. Dalam kajian ini, aktiviti $Co_{(x)}Al_{(3-x)}O_4$ dan Co-Al_2O_3-$CoAl_2O_4$ telah disiasat. Jumlah kandungan kobalt, Co dalam pemangkin telah diubah dan ditandakan sebagai x%-Co, di mana x adalah diantara 11.11% dan 42.83%. $Co_{(x)}Al_{(3-x)}O_4$ telah disintesis dengan kaedah sol-gel dengan berbagai kandungan Co dan Al manakala Co-Al_2O_3-$CoAl_2O_4$ telah disediakan dengan tindak balas x%-Co yang baru disintesis dengan H_2. 33.33%-Co merupakan pemangkin terbaik yang menghasilkan 90.37 % dan 96.02 % hasil untuk H_2 dan CO pada 900 °C, halaju berat ruang per jam (WHSV) 15000 $mlg^{-1}h^{-1}$ dengan kandungan CH_4:CO_2 bernisbah 1:1. Tiada berlakunya pereputan aktiviti pemangkin dalam tempoh 24 h dan kadar pemendapan karbon adalah pada 3.1×10^{-2} $g\cdot gcat^{-1}\cdot h^{-1}$. 33.33%-Co yang telah bertindak balas dengan H_2 pula dapat menghasilkan penukaran CH_4 dan CO_2 sebanyak 72.89 % dan 79.49 % pada 750 °C dengan kadar pembentukan karbon sebanyak 1.7×10^{-2} $g\cdot gcat^{-1}h^{-1}$. Kajian terhadap kesan kandungan Co dalam x%-Co yang telah bertindak balas