PROJECT 14: METHANOL PRODUCTION FROM CO_2 HYDROGENATION

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cleaner energy for a sustainable future

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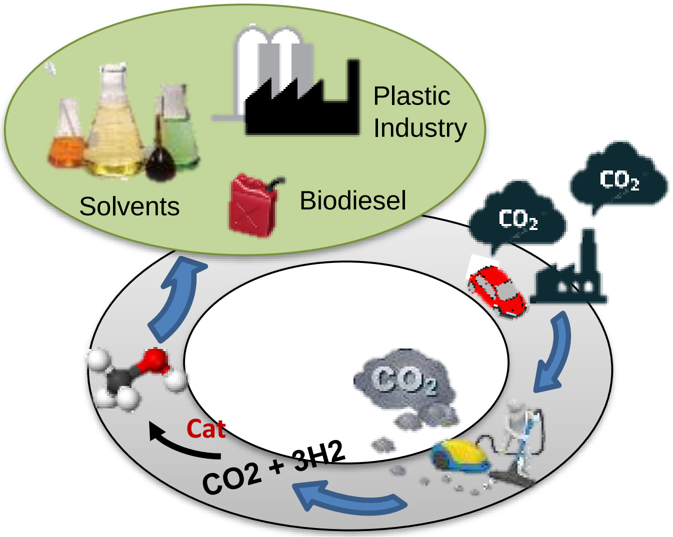
Introduction

Why CO2?

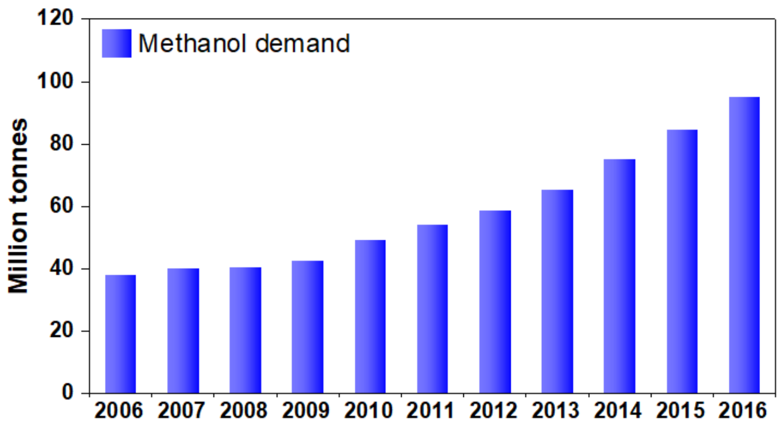
- CO_2 is the main pollutant of the Earth's atmosphere and one of the great villains of the greenhouse effect and global warming;
- CO_2 is also an abundant C1 feedstock for making chemicals, materials and fuels;



CO2 to methanol

- Global demand for methanol is increasing every year and it has a great importance for industry, being an important solvent used in large scale in the plastics industry and as precursor in the synthesis of several chemical intermediates. It is also widely used in the transesterification reaction of triglycerides for the production of biodiesel;

- The hydrogenation of CO_2 to methanol is a promising strategy to CO_2 abatement from CCUS (Carbon Capture Utilization and Storage) and to clean production of methanol;



Introduction

Actual process → $CO + 2H_2 \leftrightarrows CH_3OH$

Cu-Zn/Al_2O_3 catalyst

Syngas
50 – 100 bar

Alternative process → $CO_2 + 3H_2 \rightleftarrows CH_3OH + H_2O$

CO_2 abatement

$CO_2 + H_2 \rightleftarrows \mathbf{CO} + H_2O$ RWGS

$CO_2 + 4H_2 \rightarrow \mathbf{CH_4} + 2\,H_2O$

Ni-Ga catalyst

CO_2 abatement
1-10 bar

Challenges

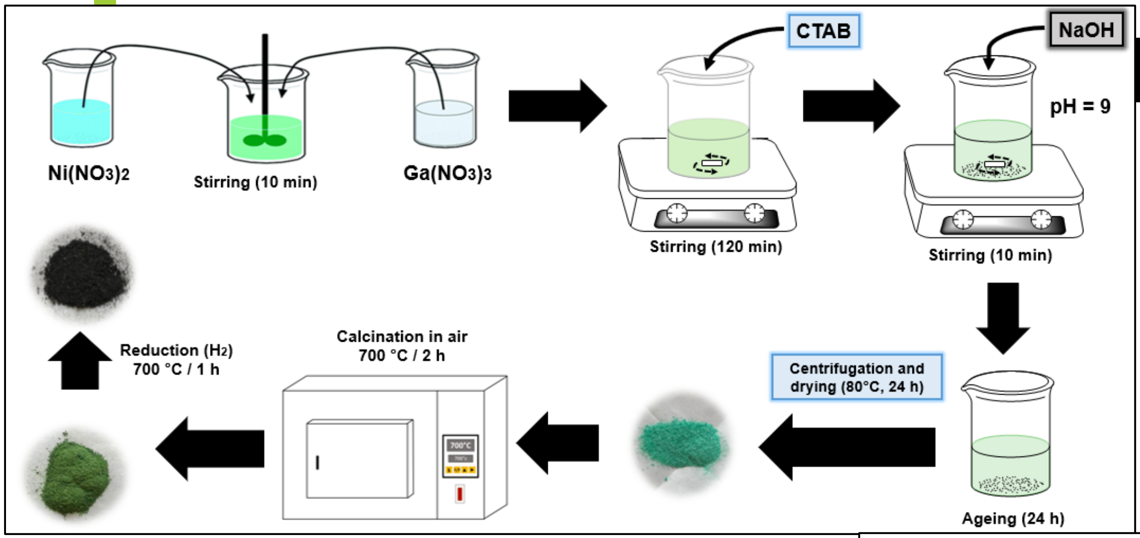
- ✓Make the process cheaper; < P and T
- ✓ Increase CO_2 conversion rate;
- ✓Increase **methanol** selectivity and decrease **CO** selectivity;
- ✓Minimize the deactivation of catalyst

Objectives

- Synthesize a Ni_5Ga_3 alloy by a surfactant assisted co-precipitation method with different quantities of the surfactant;

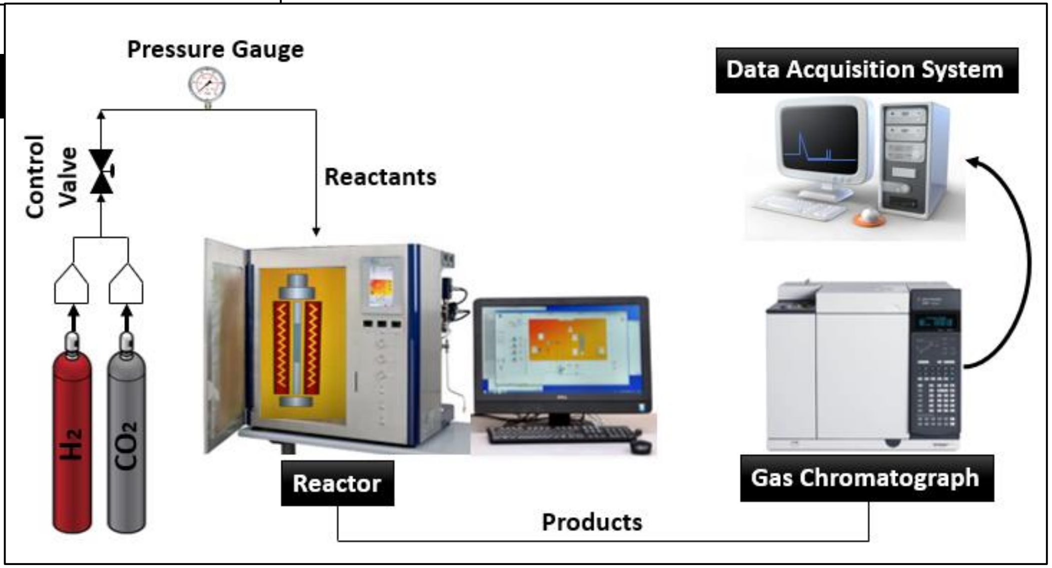
- Characterize and evaluate the catalysts for CO_2 hydrogenation into methanol.

Catalysts preparation and catalytic tests



Catalysts synthesis

All the precursors were added at stoichiometric ratio of 5Ni:3Ga.

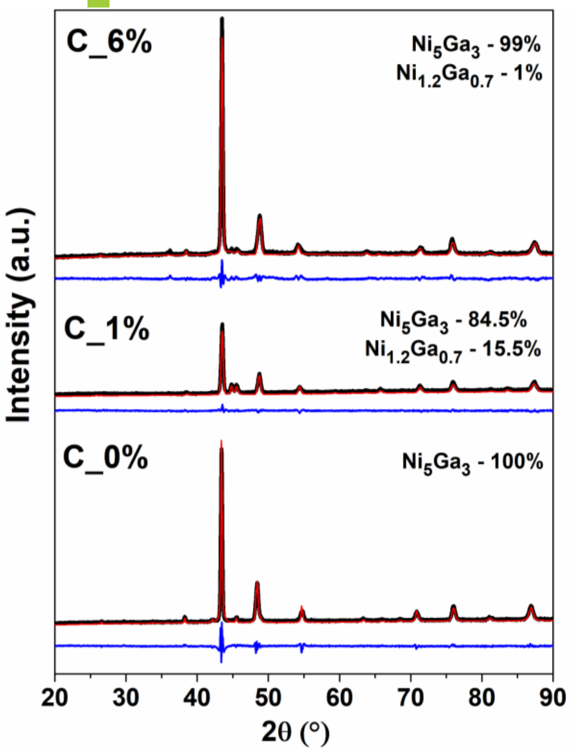


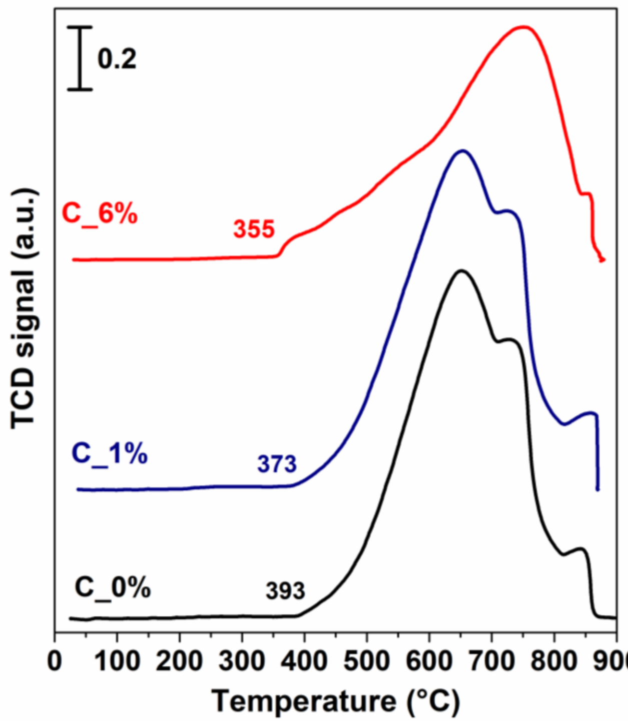
Catalytic reaction

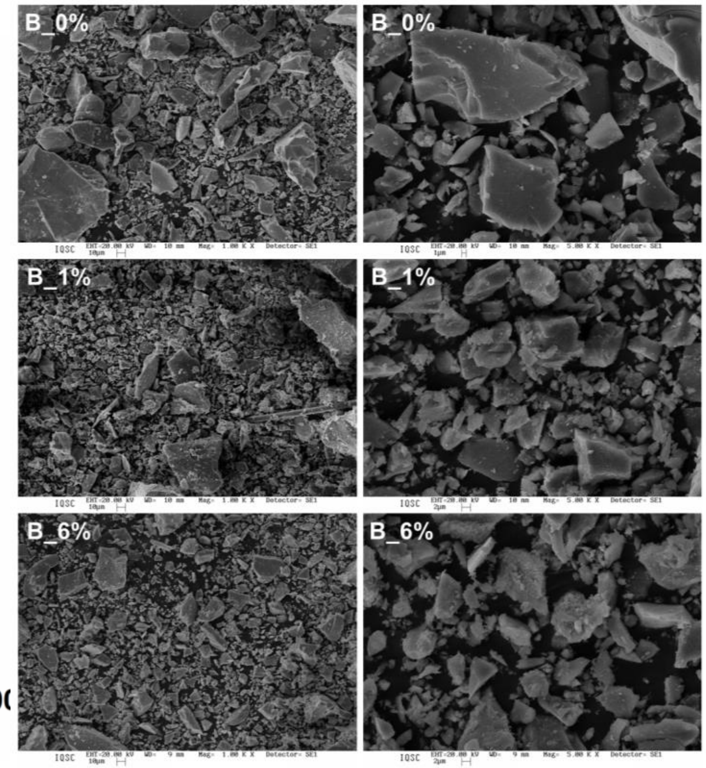
Reaction conditions:

- ~0.200g of catalyst + 0.100g of silicon carbide
- 10 bar, 225° C
- H_2/CO_2 ratio of 3:1 (GHSV=3000 h-1).

Results







Catalyst	Crystallite size (nm)		Rwp
	Ni_5Ga_3	$Ni_{1,2}Ga_{0,7}$	
C_0%	24,0	-	6,3
C_1%	23,6	24,3	5,1
C_6%	20,1	12,4	5,2

Catalyst	Basicity (µmol/g)*	SBET (m2/g)**
C_0%	62,2	90,9
C_1%	39,0	94,9
C_6%	165,0	98,2

** Referentes ao intervalo de temperatura de 30-300 ° C*

*** Área B.E.T. dos catalisadores B*

Catalyst	CO_2 conversion(%)	Activity (µmol CH_3OH/g_{cat}.min)
C_0%	5,7	29,2
C_1%	3,0	15,3
C_6%	4,6	36,9

Next Steps

- Characterization and evaluation of other Ni/Ga ratios with the best percentage of CTAB in the CO_2 hydrogenation to methanol;

- Evaluate all the catalysts in the CO_2 hydrogenation to methanol in different temperatures, GHSV and pressures (until 10 bar).

- Founded the best alloy, support it in different types of silica (micro, meso and micro/mesoporous);

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