Carbon-based catalysts for methanol production by CO_2 hydrogenation

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Terma IQ UMA

The hydrogenation of CO_2 captured represents a promising and sustainable pathway for the production of renovable methanol. The use of carbon nanofibers (CFs) as catalytic support can solve some of the drawbacks of methanol synthesis in fixed bed reactors.

Cu/ZnO/carbon nanofibers catalysts were prepared using electrospinning technique of a lignin-based solution, followed by thermal treatment (stabilization and carbonization).

Two types of organosolv lignins were used as feedstock, and the resulting CFs are labelled as CFA (lignin extracted with acetic acid) and CFF (lignin extracted with ethanol).

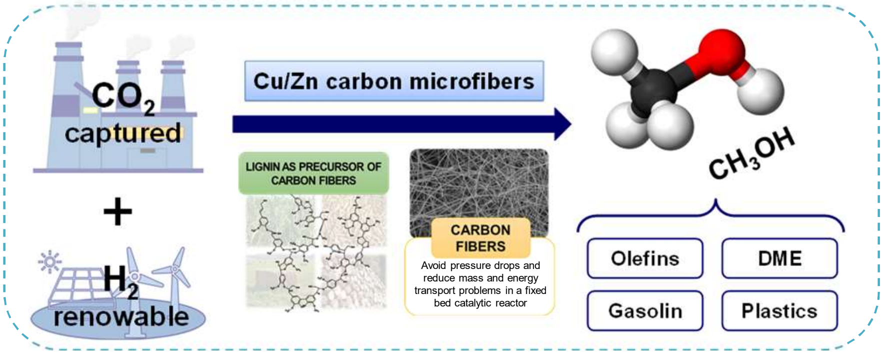
Two different methods were used to incorporate the Cu/ZnO active phases (3/2 mass ratio):

- **i) Direct addition to the lignin-based solution**
- **ii) Wet impregnation of the carbonized lignin fibers**

The catalysts prepared by direct addition with electrospinning (CFA_E and CFF_E) show lower porosity than those prepared by wet impregnation (CFA_WI/CFF_WI). XPS and XRF analyses confirm a homogeneous distribution of the active phase. However, TEM/EDAX reveals that CFA_E fibers contains significantly larger Cu particles.

The fiber CFA_WI (wet impregnation) shows the highest activity with a maximum CO_2 conversion of 22% achieved at 340 °C, while the highest methanol yield (2.3%) was observed at 220 °C. This catalyst also showed a high stability under the studied conditions.

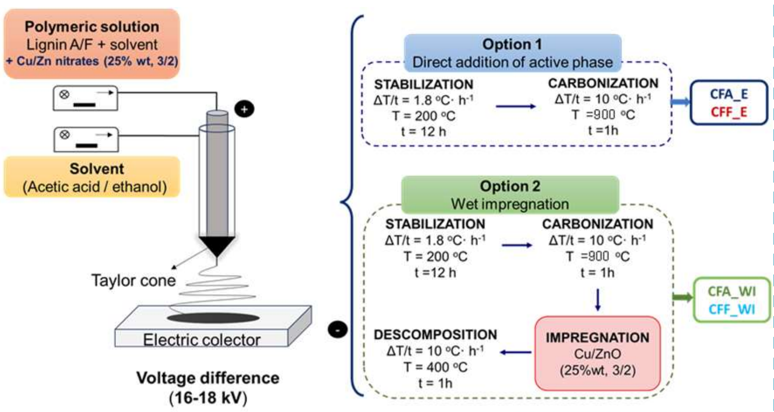
INTRODUCTION

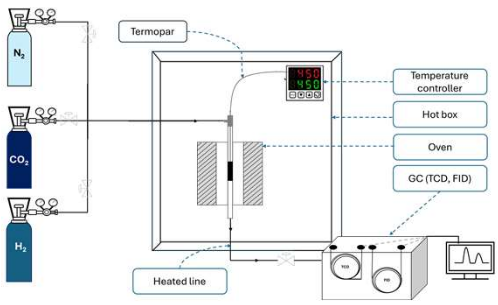


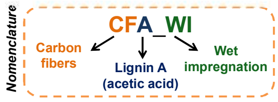
OBJECTIVES

The main objective of this work is to analyze the effect of preparation conditions of the catalysts using Cu/ZnO lignin-based carbon fibers in the hydrogenation of CO_2 to methanol.

EXPERIMENTAL METHODOLOGY





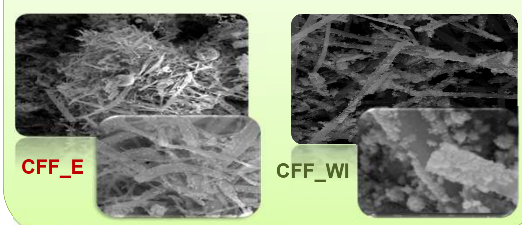


REACTION CONDITIONS

Fixed bed reactor **In situ reduction**: H_2, 400°C, 3 h
Pressure: 30 bar τ : 7.2 $g_{cat}\cdot s\cdot mmol^{-1}$ **H_2:CO_2:N_2** : 3/1/1

CHARACTERIZATION

SEM

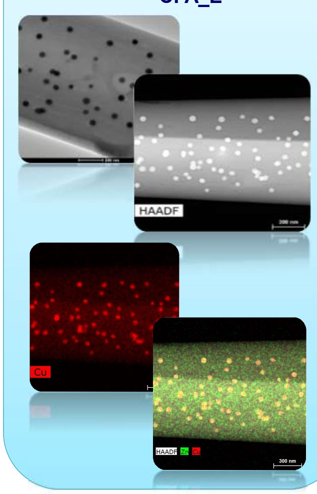


Physicochemical properties of the prepared catalysts

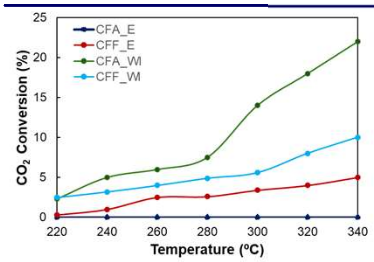
Catalysts	Ads.-Des. N_2 (-196ºC) and Ads. CO_2 (0ºC)				XRF		XPS	
	S_{BET}^{N2} $m^2\cdot g^{-1}$	V_{DR}^{N2} $cm^3\cdot g^{-1}$	S_{DR}^{CO2} $m^2\cdot g^{-1}$	V_{DR}^{CO2} $cm^3\cdot g^{-1}$	Cu % wt	Zn % wt	Cu % wt	Zn % wt
CFA_E	5	<0.01	253	0.09	4.4	3.2	4.1	2.0
CFF_E	9	0.01	108	0.05	27.7	14.8	22.0	12.0
CFA_WI	108	0.17	290	0.20	6.5	4.4	6.4	4.2
CFF_WI	279	0.14	335	0.16	4.7	3.2	4.7	2.9

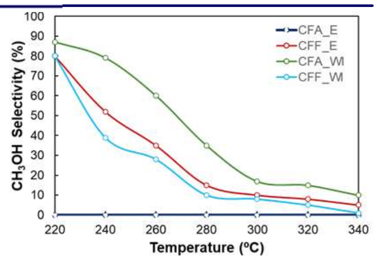
TEM/EDAX

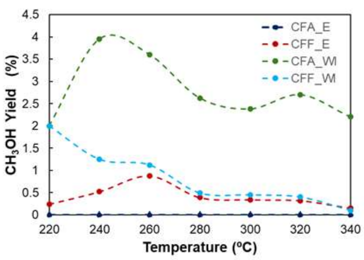
CFA_E

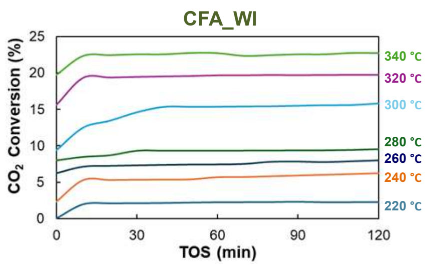


REACTIONS









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