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Enhanced methanation assisted by CO_2 adsorption on a bimetallic catalytic fixed bed reactor

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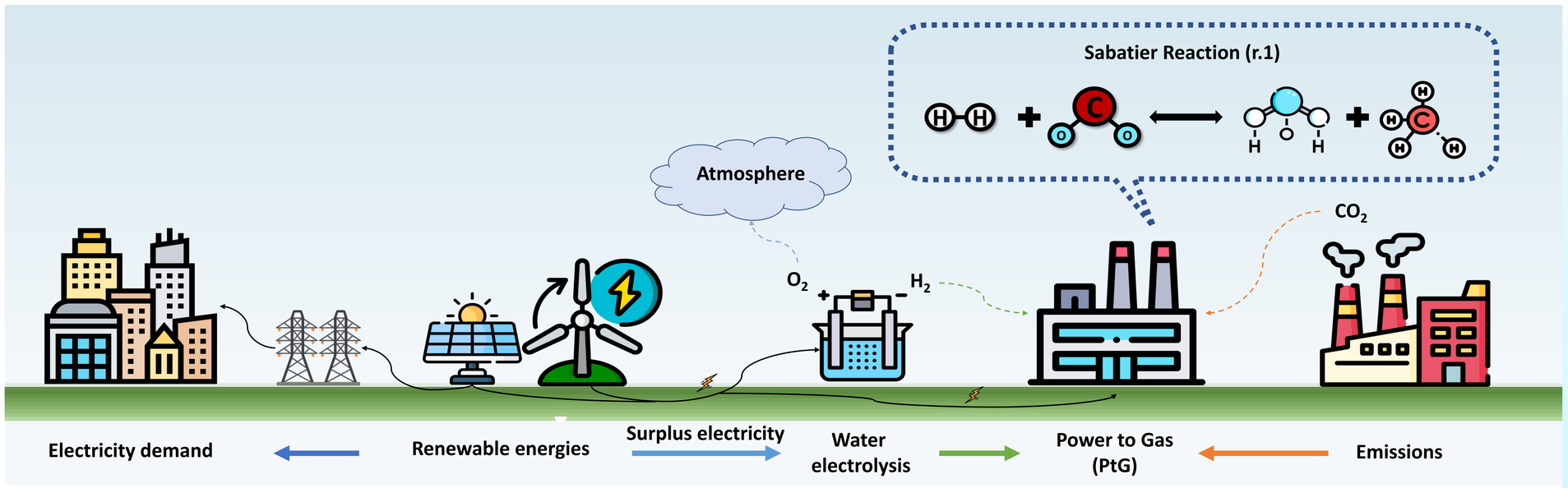
Power to Gas: key role in the energy transition



1

Surplus electricity from renewables is used to produce **green hydrogen** from water electrolysis

2

H_2 produced is combined with CO_2 (captured or biogas) and converted to CH_4 by the ***Sabatier reaction***:

$4H_2 + CO_2 \leftrightarrow CH_4 + 2H_2O$ (r.1)

$\Delta H_r^0 = -165.1\ kJ/mol$

3

CH_4 is injected directly into the existing gas network (controlling its composition) and mixed with natural gas as a form of **indirect energy storage**

EXPERIMENTAL

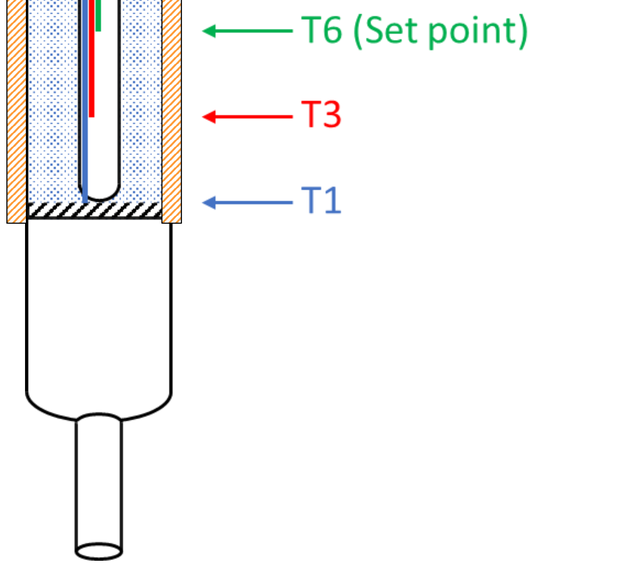


Figure 1. Schematic representation of the fixed-bed reactor. The thermocouple label indicates the height (cm) of the measurement point in the fixed bed.

Table 1. Experimental conditions

Parameter	*Units*
Catalyst load	2g
Adsorbent load	2g
Total volumetric flow	150 mL (STP) / min
CO_2 concentration (inlet flow)	40 ^{v}%
H_2 concentration (inlet flow)	5 ^{v}%
N_2 concentration (inlet flow)	5 ^{v}%
Inert gas (dilutant)	Ar
Pressure	1 bar
Adsorption steps duration	30 min (each one)
Methanation steps	1h and 30 min

RESULTS

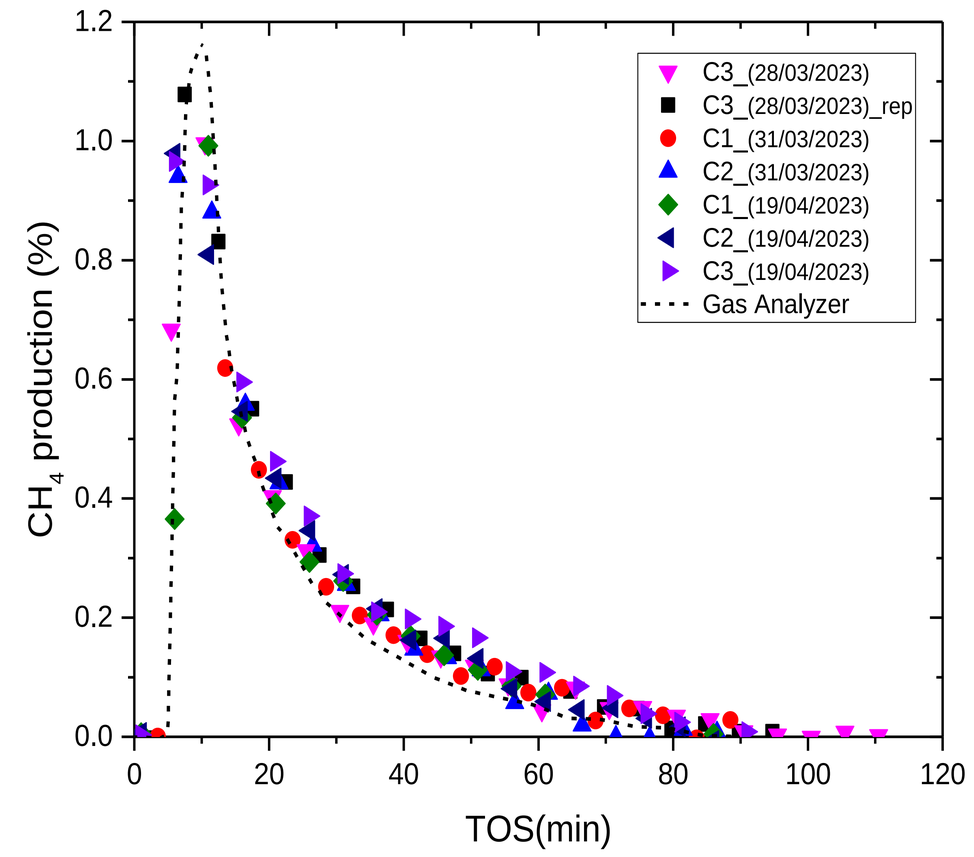


Figure 1. CH_4 production reproducibility of FeNi +CaO catalyst experiments carried out in the fixed bed reactor.

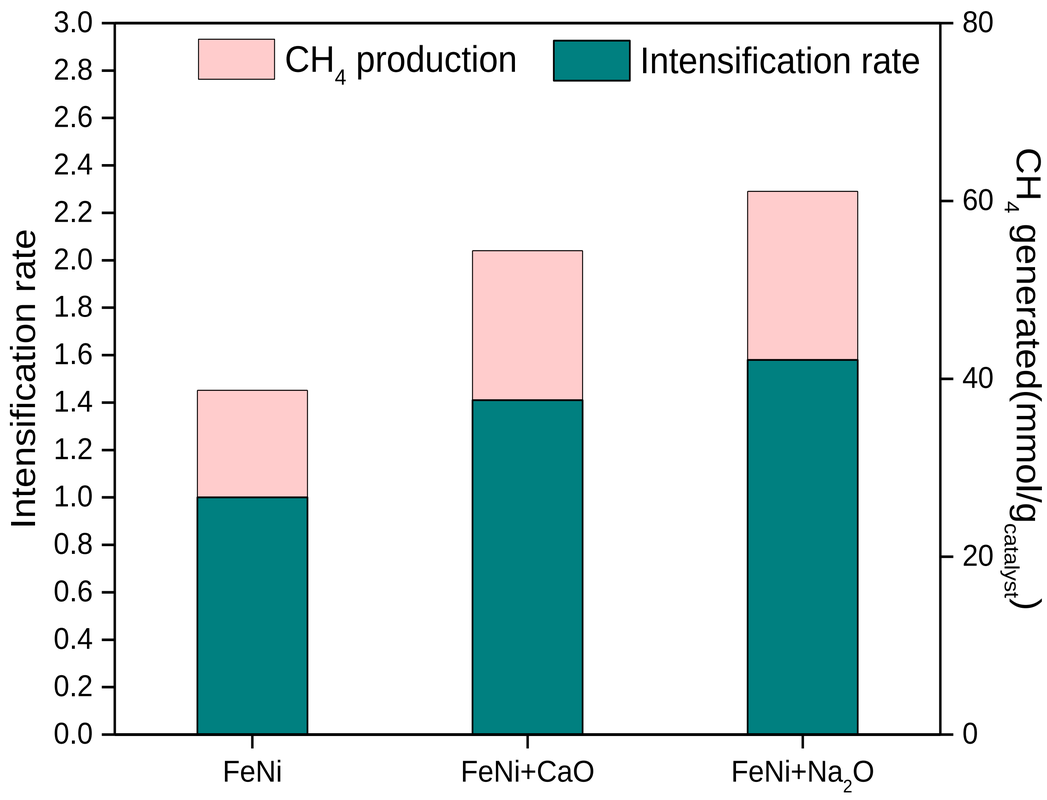


Figure 2. CH_4 and intensification rate referred to FeNi (mmol CH_4 generated with FeNi+adsorbent/ mmol CH_4 generated with only FeNi) .

INTRODUCTION

Power-to-Gas (PtG or P2G) has the potential to **reduce CO_2 emissions**, obtaining as product H_2O and CH_4 (*Synthetic Natural Gas, SNG*) [1]. **SNG** would be able to fulfill the requirements to be injected into the preexisting **natural gas network.** Thus, PtG technologies might produce an **alternative energy vector** easy to **store** and **transport.**

The CO_2 hydrogenation is carried out in a catalytic bed by the ***Sabatier reaction*** *(r.1)*. Catalyst cost is a determinant variable for the scale-up in the methanation process. In this work, the influence of adding a **CO_2 adsorbent** on the Fe-Ni catalytic bed in order to improve the **reactants interaction** [2] is studied.

Experiments are performed in a **fixed bed reactor** with the characteristics showed in *Table 1*. **Results** presented on the graphs were measured by gas **chromatography** and a **FTIR** gas analyzer [3].

CONCLUSIONS

Results show a high **reproducibility** during the different repetitions of the experiment.

The inclusion of the **CaO** in the reactor bed **improved** the **methane production** by 40%. Meanwhile, the intensification for the **Na_2O elevated** the **methane production** by 60%.

As general conclusion, **both adsorbents** showed their potential to **enhance** the **methanation** reaction performed by adsorption followed by hydrogenation.

[1] Thema, M., Bauer, F., Sterner, M. Power-to-Gas: Electrolysis and methanation status review. *Renewable and Sustainable Energy Reviews*. 112 (2019) 775–787. doi: 10.1016/j.rser.2019.06.030.

[2] Bermejo-López, A., Pereda-Ayo, B., González-Marcos, J.A., González-Velasco, Juan R.. Alternate cycles of CO_2 storage and in situ hydrogenation to CH_4 on Ni-Na_2CO_3/Al_2O_3: influence of promoter addition and calcination temperature. *Sustainable Energy and Fuels* 5(4) (2021) 1194–1210. doi: 10.1039/d0se01677b.

[3] Sanz-Martínez, A., Durán, P., Mercader, V.D., Francés, E., Peña, J.Á., Herguido, J. Biogas Upgrading by CO_2 Methanation with Ni-, Ni-Fe-, and Ru-Based Catalysts. *Catalysis* 12(12) (2022) 1609. doi: 10.3390/CATAL12121609.

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