Experimental study of the combustion of pyrolysis gas with oxygen carriers

XII JORNADA DE JÓVENES INVESTIGADORES DEL I3A

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RATIONALE

Pyrolysis enables obtaining valuable products (biochar and bio-oil) from residual biomass. Usually, pyrolysis gases are combusted with air to provide energy for the process.

Low temperature oxidation of pyrolysis gases using Cu-based oxygen carriers would allow [1]:

- Obtaining a CO_2 stream, available for further use.
- Providing heat for the pyrolysis process.

OBJECTIVES & ADVANTAGES

Objective: To evaluate the performance of several oxygen carrier materials (OCs) for pyrolysis gas oxidation, to obtain a pure CO_2 stream (CO_2 capture) [2].

Advantages: CLC techology allows to capture & use CO_2 from the gas fraction. The process could be a NET (Negative Emission Technology) [3].

MATERIALS

Three Cu-based OCs were used:

- CuO
- *Carulite* (mixed Cu-Mn oxide)
- CuO (13 %wt.) supported on Al_2O_3

CuO is exothermal when reduced with CO and CH_4 (other OCs have endothermal processes). OCs were tested at low temperatures, close to those of pyrolysis.

EXPERIMENTAL RESULTS

The three OCs used in this work exhibited high pyrolysis gas oxidation efficiencies (= high CO_2 concentrations at the outlet)

Figure 1 shows the behaviour of CuO as OC. A very high purity of CO_2 (for 625, 650 and 700 ºC) in the outlet stream is achieved. For 700 ºC the efficiency is almost 100 % during the whole experiment time.

Temperatures under 600 ºC produce low oxidation efficiencies.

WHSV for these experiments is around 0,014 h^{-1}.

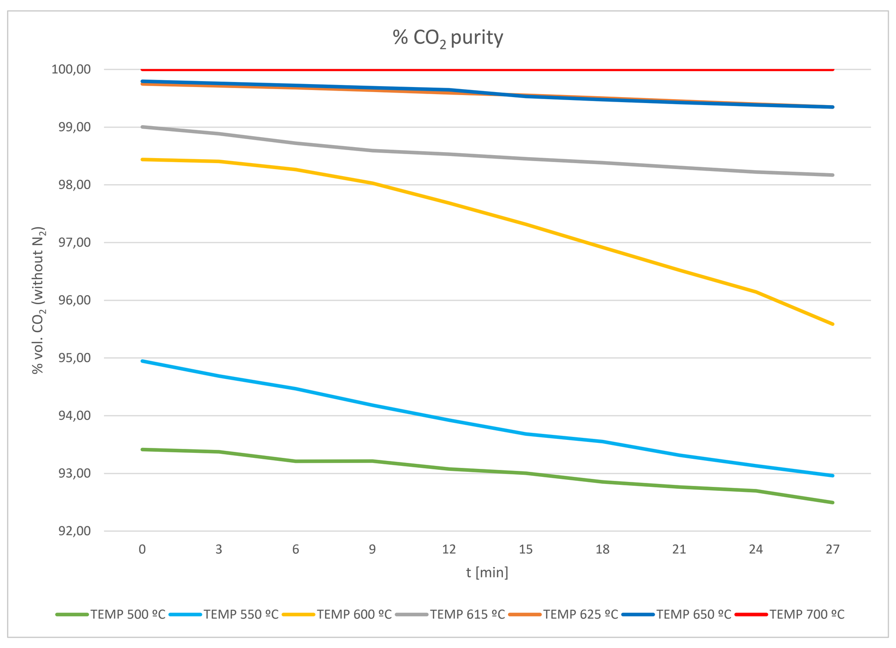


Figure 2: Shows the behaviour of *Carulite* as OC. As temperature increases, CO_2 purity also increases. At 625 ºC, the CO_2 purity is close to 100 % for a long reduction time (>15 minutes).

At 700 ºC, CO_2 purity is almost 100 % for the whole experiment (30 minutes).

WHSV for these experiments is around 0,041 h^{-1}.

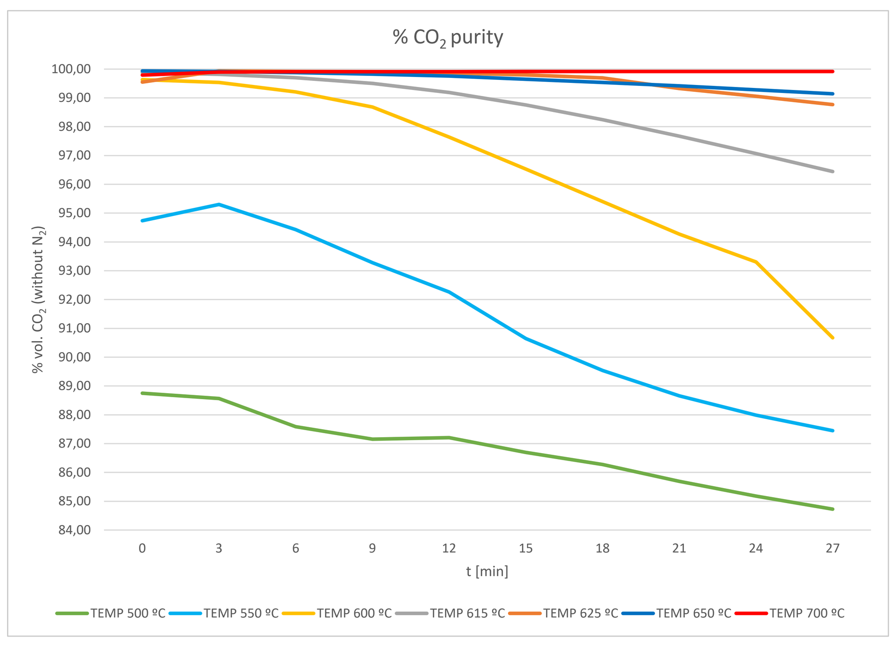
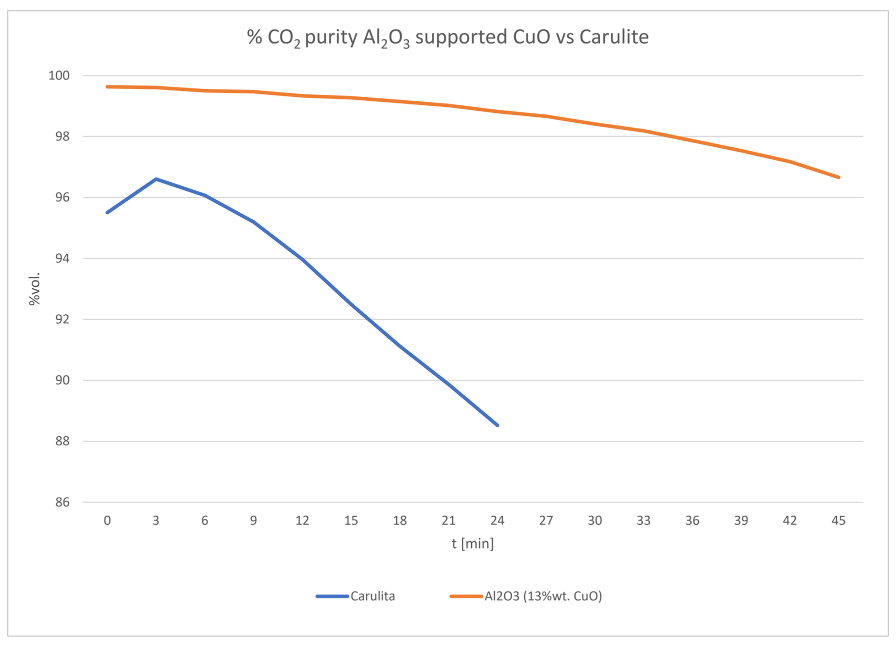


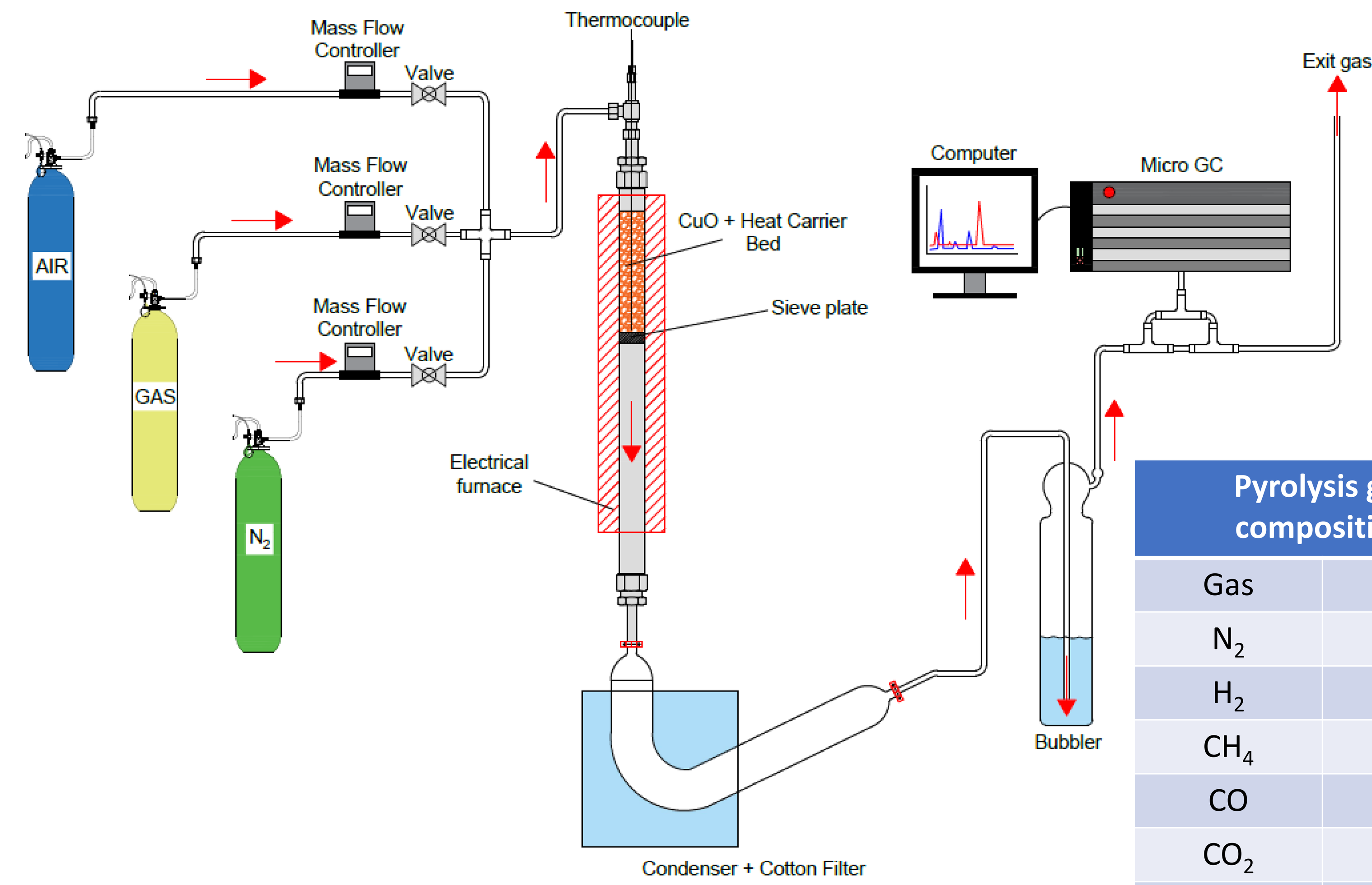
Figure 3: Al_2O_3-supported CuO showed the most promising CLC performance, taking into account that the total amount of CuO was much lower. In Figure 3, a comparison with *Carulite* is shown.

Unfortunately, only a little amount of this comercial material was available for the experiments. Thus further research is needed in order to evaluate its adequacy.

WHSV for these experiments is around 1,466 h^{-1}.



EXPERIMENTAL SYSTEM



Pyrolysis gas composition	
Gas	% vol.
N_2	7,52
H_2	13,03
CH_4	12,98
CO	25,00
CO_2	39,96
C_2H_2	0,50
C_2H_4	0,50
C_2H_6	0,51

Experiments were done in a laboratory-scale fixed bed reactor, using a commercial gas bottle with composition resembling that from pyrolysis gases.

Experimental conditions were the following:

- T = 500 -700 ºC
- P = Patm = 1,01 bar
- Q = 30 mL/min of pyrolysis gas
- Outlet gas composition was determined using a gas microchromatograph

CONCLUSIONS

- Complete oxidation of pyrolysis gases to CO_2 (and H_2O) at relatively low temperatures using CuO-based OCs has been proven.
- Both the OC type and temperature affect the pyrolysis gases oxidation process. Temperatures around 650 ºC have been determined as adequate for the process.
- OC reoxidations (not shown in this work) are relatively fast at these temperatures.
- CH_4 is the less reactive gas of the pyrolysis gases. Its content increases in the outlet gas as the CO_2 purity decreases due to progressive OC reduction.
- CuO appears to work better as OC when is supported in other material such as Al_2O_3; however, further experiments are required.
- Future works should focus on testing taylor-made, supported copper oxide OCs.
- The reoxidation stage and the cycle repeatability should also be investigated.
- Equivalent WHSV should be also investigated.

References

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Acknowledgements: The authors acknowledge the funding from Project PDC2022-133374-I00. Next Generation EU: Plan de Recuperación, Transformación y Resiliencia.