Reaction system to obtain MeOH and DME by hydrogenation of CO_2

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INTRODUCTION

New technologies based on the capture and storage of CO_2 have recently received much attention, since the reduction of greenhouse gas emissions represents one of the main challenge in climate change [1]. Among can be found the hydrogenation of CO_2 to methanol, a product that can be easily transported and used as a fuel or as an intermediate to produce other chemical products such as DME [2]. The present work focuses on the design of a reaction system to obtain MeOH and DME by hydrogenation of CO_2 at low pressure, which has been tested using polymetallic catalysts and bifunctional catalysts. The CO_2 used in the process could be obtain from digestion of waste

Methanol synthesis reaction: $CO_2 + 3H_2 \rightleftharpoons CH_3OH + H_2O$ (1)

Methanol dehydratation reaction: $2CH_3OH \rightleftharpoons CH_3OCH_3 + H_2O$ (2)

Reverse-water-gas-shift reaction: $CO_2 + H_2 \rightleftharpoons CO + H_2O$ (3)

$2CO_2 + 6H_2 \rightleftharpoons CH_3OCH_3 + 3H_2O$ (1) + (2) = (4)

EXPERIMENTAL SYSTEM

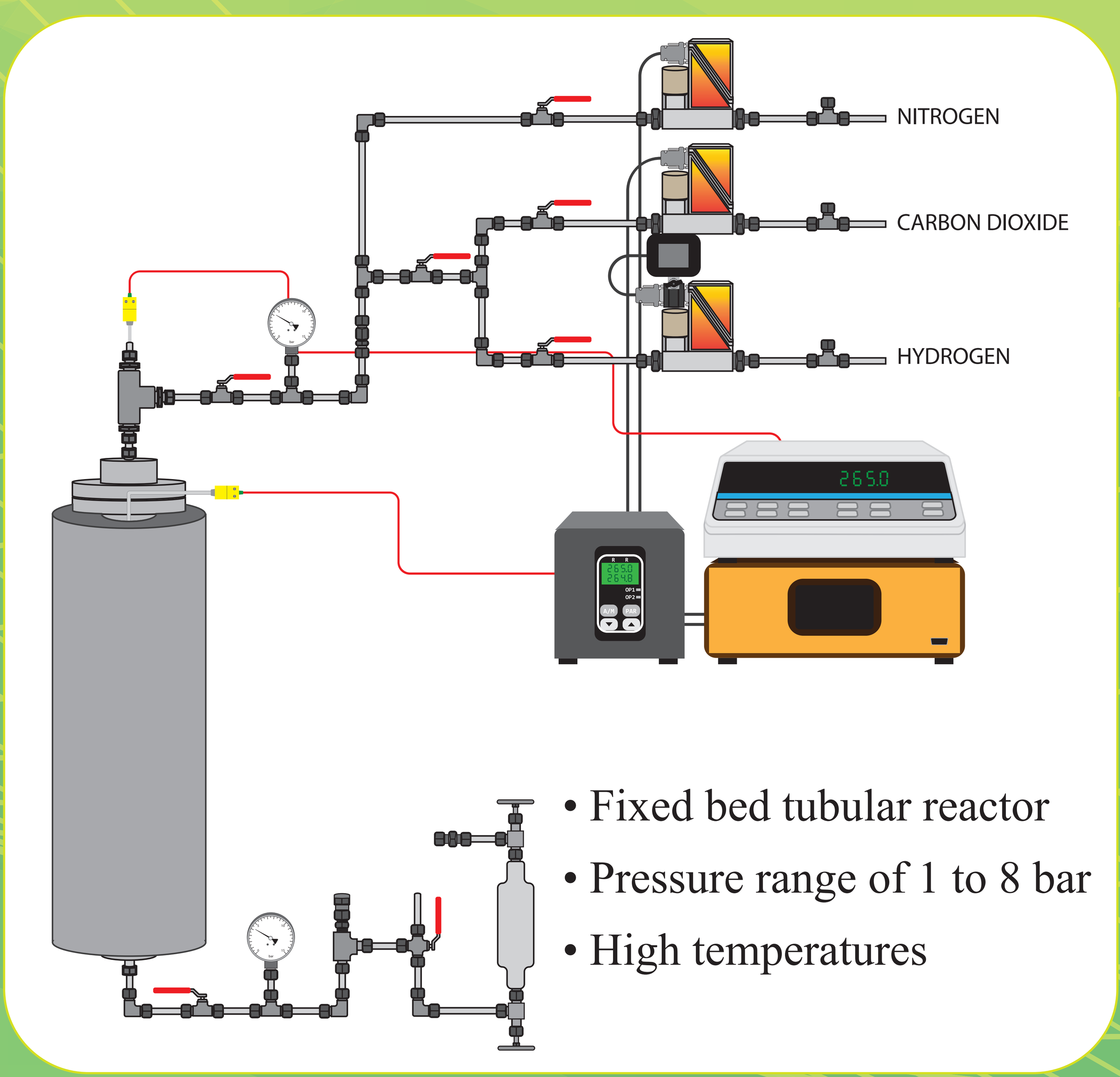
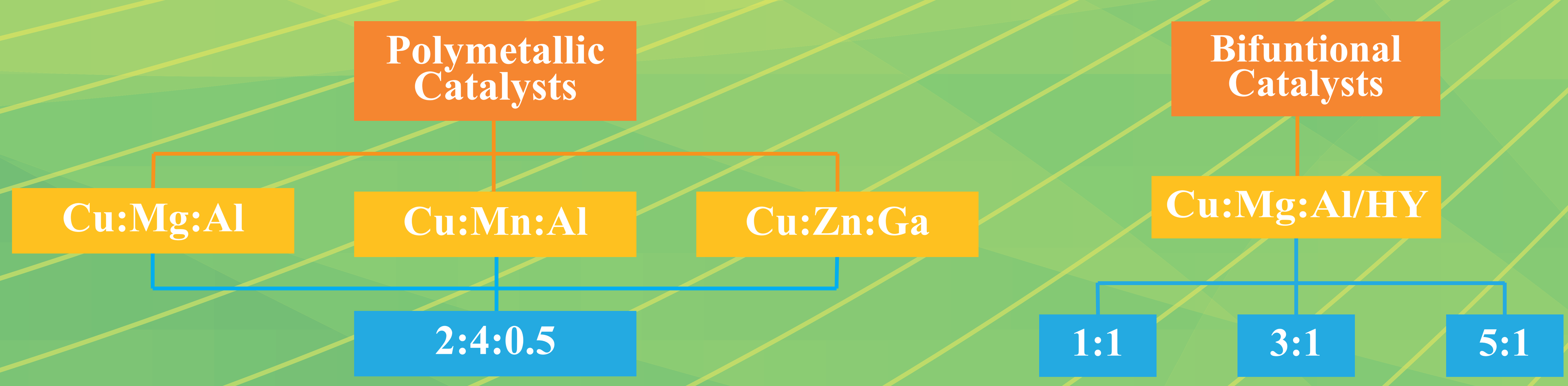


Figure 1. A schematic of fixed-bed reactor set-up used in this study

CATALYTIC SYSTEM



Reduction conditions

H_2 flow	51 mL/min
Temperature	300,0 °C
Pressure	6,0 bar
Catalyst Mass	2,00 gr

Reaction Conditions

H_2/CO_2 flow relation	5
Temperature	265,0 °C
Pressure	6,0 bar
Space velocity	1860 mL/h.gr
Catalyst Mass	2,00 gr

RESULTS

Table 3. Average values of conversion and selectivity to products of the different catalysts used

Catalysts	Conversion (%)	Selectivity (%) DME	Selectivity (%) MeOH	Selectivity (%) CO
Cu:Mn:Al	21,00	0,14	20,15	79,71
Cu:Mg:Al	11,78	0,06	31,10	68,83
Cu:Zn:Ga	1,76	14,63	37,64	47,73
HY (756)	2,06	2,50	31,12	66,38
Cu-Mg-Al/HY (1:1)	12,37	0,05	11,39	88,56
Cu-Mg-Al/HY (3:1)	13,54	1,94	12,68	85,37
CU-Mg-Al/HY (5:1)	22,54	0,00	20,28	79,72

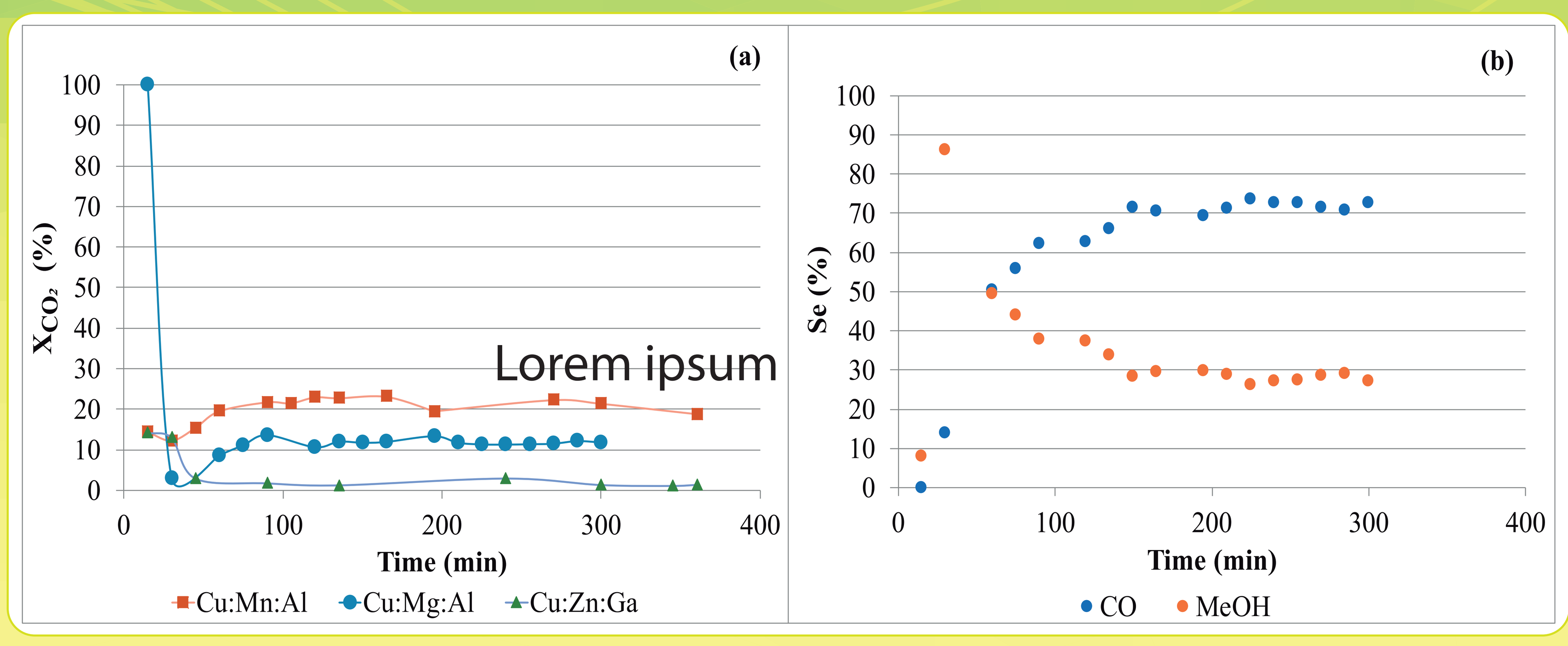


Figure 2. Polymetallic catalysts, a) CO_2 conversion; b) Cu:Mg:Al selectivity

For the polymetallic catalysts, Cu: Mn: Al phase shows the highest conversion of CO_2 (20%), (Figure 2a), but Cu: Mg:Al phase shows the highest selectivity to MeOH with a value of 30%, while its selectivity to CO is 70%, (Figure 2b).

In the case of bifunctional catalysts, (Figure 3a), the catalyst Cu:Mg:Al/HY (5.1) shows the highest conversion of CO_2 (22%), with the highest selectivity to MeOH, with a value of 20%, while its selectivity to CO is 80%, but DME is not produced with this catalyst (Figure 3b). The highest selectivity to DME is obteined for relation 3:1.

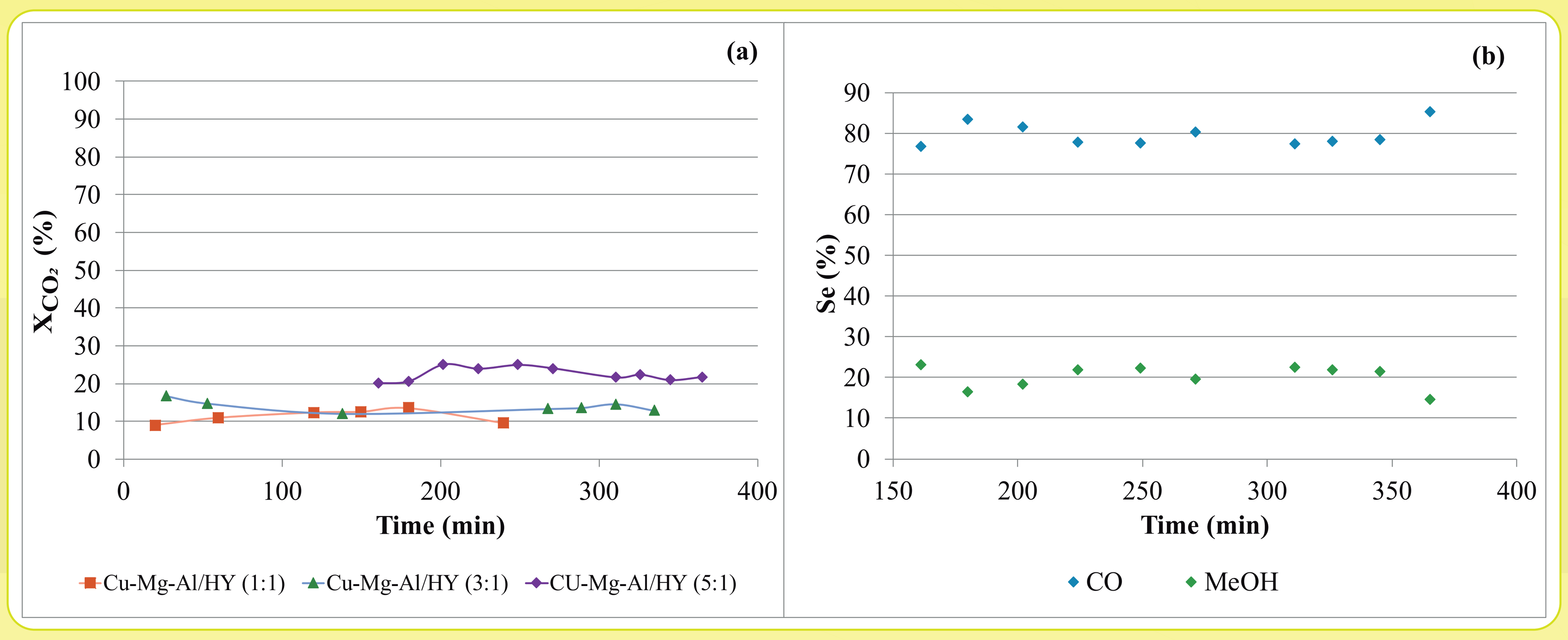


Figure 3. Bifuntional catalysts, a) CO_2 conversion; b) Cu:Mg:Al/HY (5:1) selectivity

CONCLUSIONS

The partial results obtained indicate that the polymetallic solids that offer the best results are those that present the metal phases Cu, Al in their composition.

Among the polymetallic solids studied, the one that obtains the best result of selectivity to MeOH is Cu:Mg:Al.

Cu as a single metal phase should be tested to obtain MeOH, as well as, the bimetallic solid Cu:Al.

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