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Booklets

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Title: Absorption and reaction of CO2 in capillaries

Engineering and Technology

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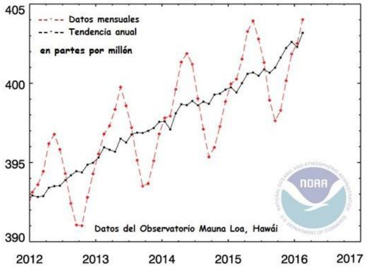
Introduction

Environmental Protection

CO_2 emissions

280 ppm
In 1750



415 ppm
may 2020

419 ppm
april 2021

***CO_2* :** a bussiness oportunity vs contaminant agent

Raw material and energy sources

CO_2 transformation

- ethanol
- methane
- hydrogen
- methanol
- Formic acid
- formaldehyde

Methodology

1

Hydrodynamic study

u_L / u_G

→ *Effect of temperature (10 and 25°C)* → *Taylor flow*

2

CO_2 absorption

- H_2O
- NaOH solutions

→ *Effect of:*

- *Temperature (10-45°C)*
- *NaOH concentration (0-0.75M)*
- *Length capillary reactor (100 and 300mm)*

→ *Mass transfer coefficients*

→ *Species involved in the process*

OH^-

HCO_3^-

CO_3^{2-}

Results

Figure 1. Experimental set-up for the absorption of CO_2

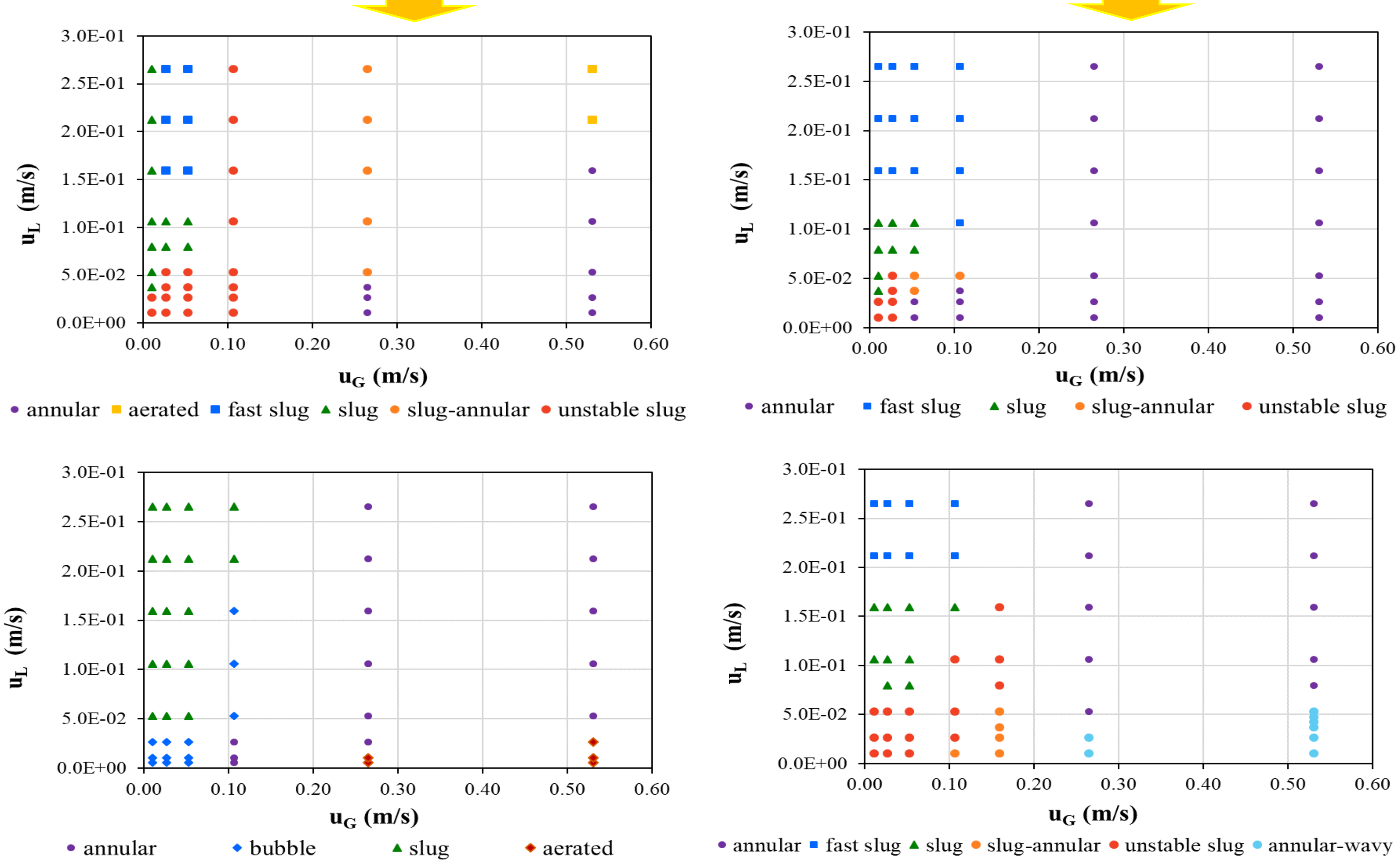
Figure 2. Flow regimes map in the 300 mm length and 3 mm internal diameter quartz capillary

10°C

25°C

H_2O

NaOH



Results

Figure 3. Comparison of the CO_2 absorption profile in a) water and b) in 0.5M NaOH

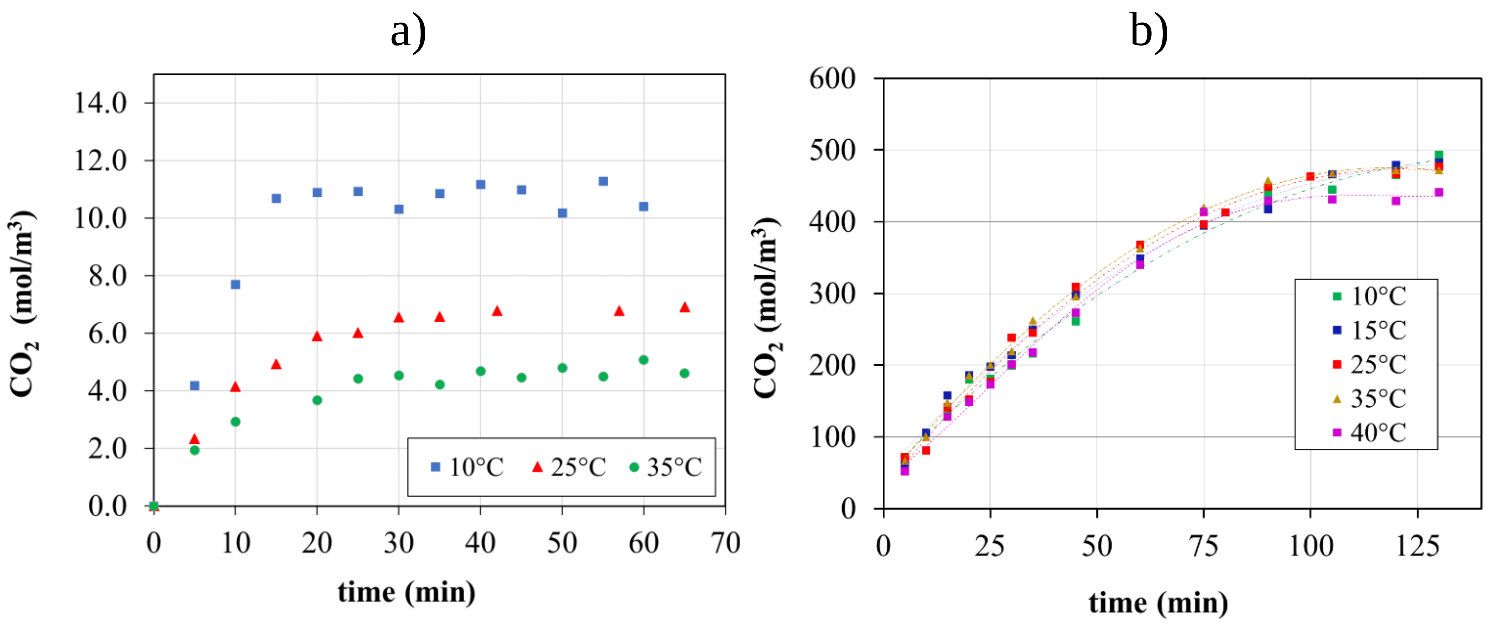
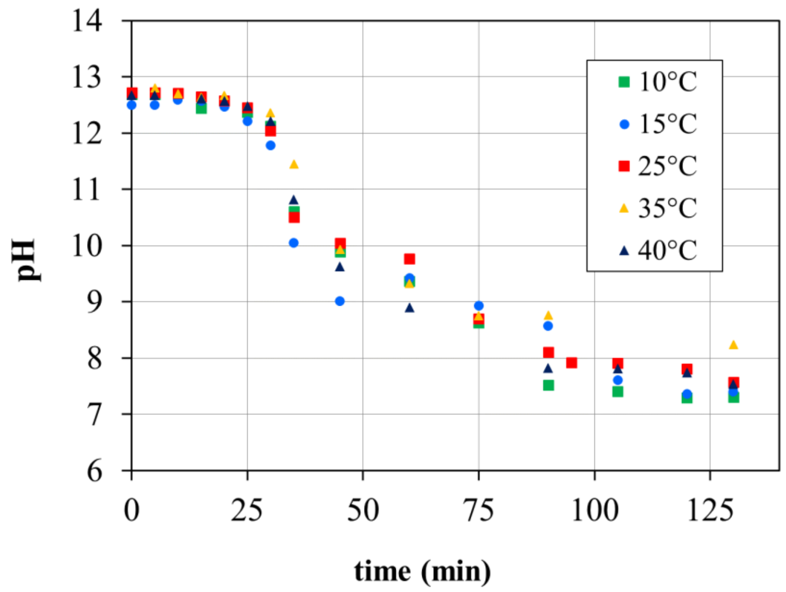


Figure 4. Evolution of pH during CO_2 absorption in 0.5 M NaOH



Results

Figure 5. CO_2 absorption profile in NaOH 0.25M, 0.5M and 0.75M

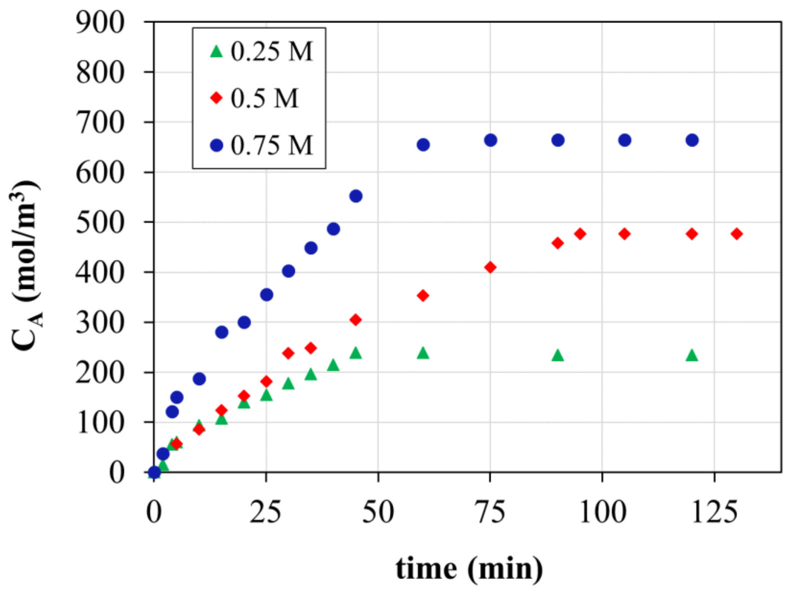
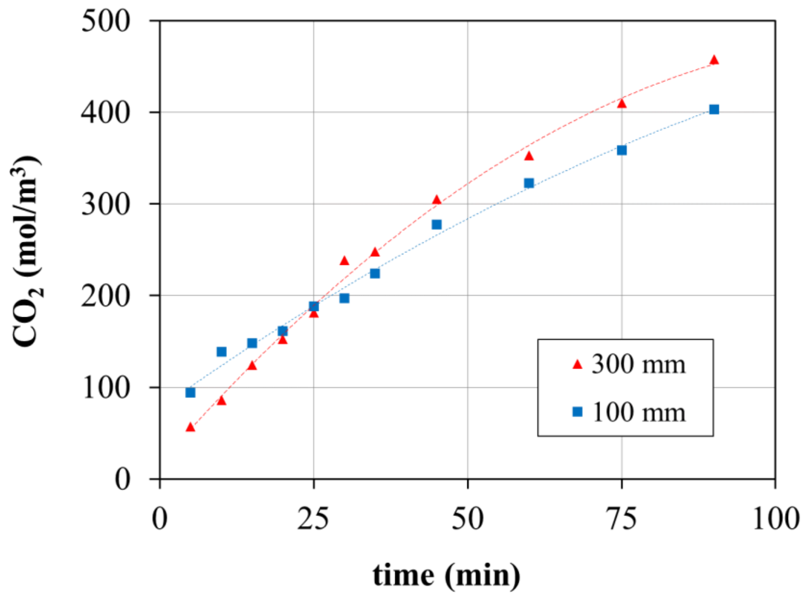


Figure 6. Effect of the capillary length on CO_2 absorption in NaOH 0.5 M at 25°C



Results

Figure 7. Graph for the calculation of the volumetric mass transfer coefficient in the CO_2-H_2O system

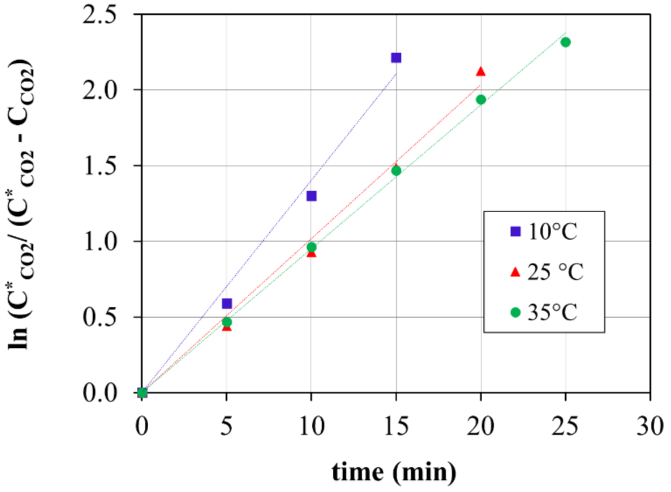


Table 1. Determination coefficient and slope of the linear equations plotted in Figure 7

Temperature, °C	Time to reach equilibrium, minutes	Slope = k_L^0a, s^{-1}	Determination coefficient, R^2
10	15	0.00234	0.987
25	20	0.00169	0.992
35	25	0.00158	0.998

Table 2. Kinetic and mass transfer coefficients obtained in the chemical absorption process of CO_2 in 0.5M NaOH

Temperature	10°C	25°C	35°C
Ha	47.0	72.7	127.1
k_B (m^3/mol s)	0.0372	0.0551	0.0716
k_L x 10^5 (m/s)	3.381	2.831	2.296
k^0_L x 10^6 (m/s)	1.657	1.272	9.939
k_L/k^0_L	20	22	23

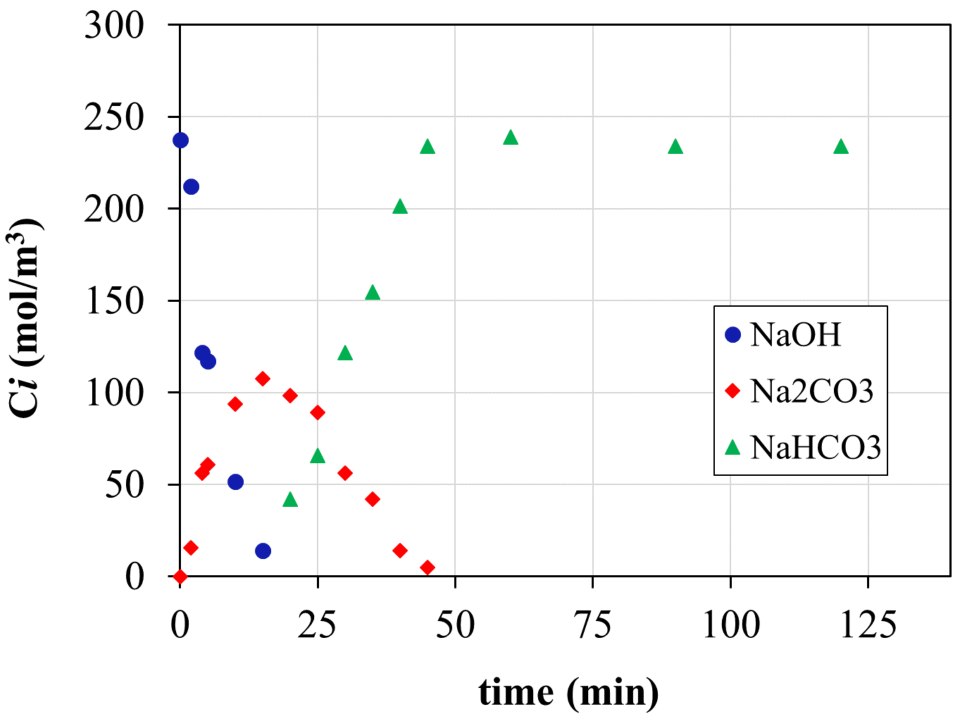
Table 3. Kinetic and mass transfer coefficients obtained at 25 ° C in the process of chemical absorption of CO_2 in NaOH solutions with concentrations of 0.25, 0.5 and 0.75M

NaOH concentration	0.25M	0.5M	0.75M
Ha	40.5	72.7	103.1
k_B (m^3/mol s)	0.0537	0.0551	0.0573
k_L x 10^5 (m/s)	2.466	2.83	2.924
k^0_L x 10^6 (m/s)	1.272	1.272	1.272
k_L/k^0_L	19	22	23

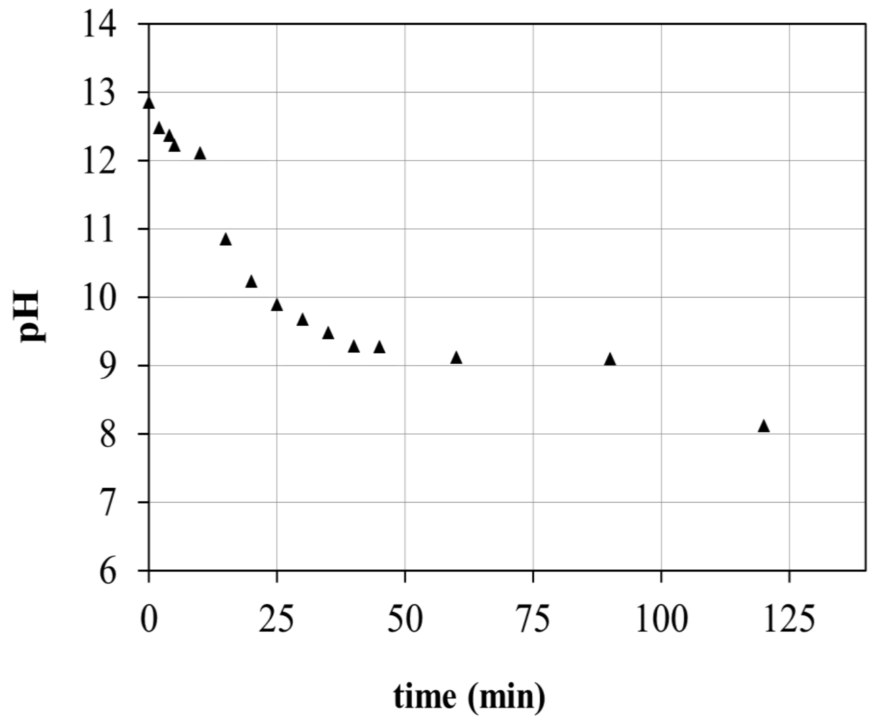
Results

Figure 8. Chemical Species Concentration and pH temporary profiles in the CO_2 absorption process at 25 °C

a) C_i in NaOH 0.25M



b) pH in NaOH 0.25M



Conclusions

- The operating window of the gas and liquid surface velocity to obtain the Taylor-type regime, at 10 ° C in a capillary with 3mm internal diameter is $1x10^{-2} < v_G < 5x10^{-2}$ and $7.9x10^{-2} < v_L < 1.1x10^{-1}$ m/s, using water and 0.5M NaOH, respectively.
- The operating window of the gas and liquid surface velocity to obtain the Taylor-type regime, at 25 ° C in a capillary with 3mm internal diameter is $1x10^{-2} < v_G < 5x10^{-2}$ and $8x10^{-2} < v_L < 1.6x10^{-1}$ m / s, using water and 0.5M NaOH, respectively.
- There is a greater absorption of CO_2 using alkaline solutions than using only water.
- The value of the volumetric mass transfer coefficient in the absorption of CO_2 with water, increases with decreasing temperature
- The mass transfer coefficient in the absorption of CO_2 with NaOH in solution increases directly with temperature.
- The combined method of titration and pH measurement allows monitoring the behavior of the different ionic species that can be generated during the absorption of CO_2 in alkaline solutions.

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