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Coupling of a bio-catalytic reaction using enzymatic-coated foam with a breakthrough technology: The Elastic Foam Reactor ? Application to CO2 hydration

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PURPOSE OF THE ABSTRACT

Due to CO2 contribution in the global warming, novel efficient solutions for carbon dioxide capture and storage are necessary to reduce greenhouse effect. One of the environmentally friendly way consists of using a biocatalyst for CO2 transformation [1].

The carbonic anhydrase (CA) has a high activity toward CO2 hydration thank to the enzymes action, which transform the dissolved CO2 into carbonates species (e.g. carbonate salt). For this promising alternative solution, research efforts are focused on immobilization strategies that would ensure good catalytic and lifetime performances [2].

However, a high CO2 dissolution in water is pivotal for good enzymatic transformation performances. Indeed, as the enzyme has a very high turnover frequency (i.e about 10^6 s-1) for CO2 hydration, the limiting step is generally the gas-liquid (G-L) mass transfer [2]. Attempts with CA immobilized on Raching Rings placed within a Robinson?Mahoney basket scrubber had fallen short due to rather bad mass transfer efficiency of the given technology [3]. This study underlines the absolute necessity of having reactor engineering studies in which mass transfer issues with immobilized CA are thorough analyzed. However, this critical topic is hardly addressed in the literature. Indeed, most studies do not surpass flask-scale exploratory tests because specific emphasis is based on immobilization, which is already an important challenge to consider.

In this context, the present work meet both relevant requirements by proposing a suitable method to overcome this issue of reliable CA immobilization and by using a new technology of reactor in order to improve G-L mass transfer. The reactor concept is the Elastic Foam Reactor (EFR) relies upon compressed/relaxed cycles of an elastomeric open cell foam packed within a column.

Lab-scale tests on the CO2 dissolution into a commercial water show that the EFR technology can effectively enhance the G-L mass transfer, with low energy consumption (i.e maximum energy input for the motor of 50W). The kLa (global mass transfer coefficient) estimate with the total mass balance given by stemmet et al. [4] are at 10^(-2) s-1 magnitude with the EFR mode whereas with a fixed-foam bed (conventional configuration), i.e. FFR mode, they average at 10^(-3) s-1. This G-L mass transfer efficiency with the EFR configuration is greatly dependent of the gas flowrate and the frequency of the cycles (Fig 1). Given this analysis, a satisfactory correlation is proposed to characterize this specific working mode (Fig 2).

As it relates to the use of CA, experiment in semi-batch conditions reveal that free-enzyme can reasonably enhance CO2 capture with better result with EFR configuration. Two methods of CA immobilization have been

selected: adsorption with electrostatic interactions (i.e E form) and entrapment within a hydrogel (i.e H form) [5]. The catalytic foams have been tested in the middle part of the reactor, in between two elastic polyurethane foam blocks because of apparent better shear stress conditions. First tests show that the effect of the immobilized CA was suppress after the first run in continuous operating conditions. However, the catalyst foam used were still active in flask-scale tests leading to the hypothesis that the remaining quantities of immobilized CA are too low to be observable in the reactor. Additionally, an in-depth overview of the operating parameters impact is compulsory to optimize the use of immobilized CA since their interest is very limited by a short operating window [3].

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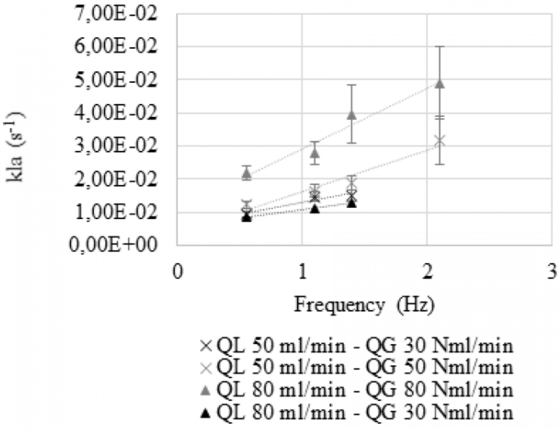
FIGURES



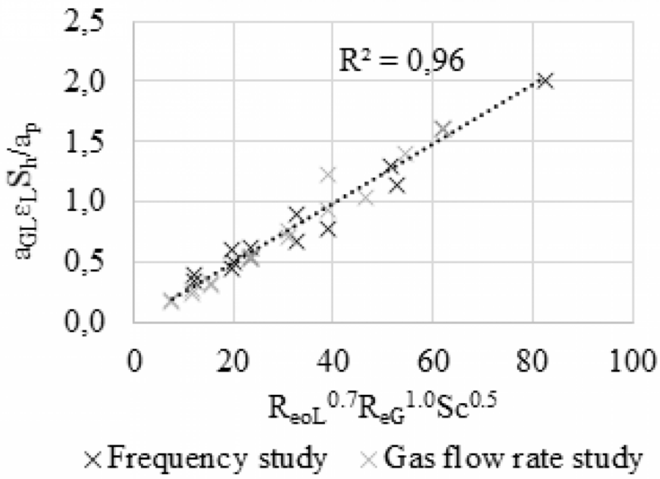


FIGURE 1

Figure 1

Frequency, liquid flowrate (QL) and gas flowrate (QG) effects on total kla values

FIGURE 2

Figure 2

correlation for kla for EFR mode

KEYWORDS

intensification | CO2 capture | gas-liquid mass transfert | carbonic anhydrase

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BIBLIOGRAPHY

[1] M. Verma et al. Ind. Eng. Chem. Res. 2021, 60, 4777-4793

[2] C. Molina-Fernández; P. Luis. J. CO2 Util. 2021, 47, 101475

[3] F. Larachi et al. Chem. Eng. Sci. 2012, 73, 99-1

[4] C.P. Stemmet et al. Chem. Eng. Sci. 2007, 62, 13, 5444 - 5450

[5] J. Rodon Fores et al. Polym. 2021, 13(11), 1793