

Study of post-combustion CO₂ capture process using biphasic solvents applied to cement flue gases

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Since the preindustrial period, global anthropogenic greenhouse gases emissions (carbon dioxide, methane, nitrous oxide and fluorinated gases) have increased sharply. In order to mitigate the climate change, industrial solutions such as improvement of energy efficiency, development of renewable energies, and applicability of carbon capture and reuse (CCU) or storage (CCS) technologies have been proposed. Post-combustion CO₂ capture with absorption-regeneration using solvents is by far the most advanced technology. However, the use of conventional monoethanolamine (MEA)-based absorption process involves high energy consumption. An innovative alternative to improve the process performances is the use of biphasic solvents-based CO₂ absorption processes.

Biphasic solvents exhibit a liquid-liquid phase separation, CO₂ rich and lean phases, for given temperature and/or CO₂ loading conditions. This phenomenon allows an important energy saving by regenerating only the heavy rich phase, after a separation in a decanter, and thus reduces the energy required for the regeneration step in the stripper (see Fig.1). The principle of the phase separation can be categorized mainly into two types: the low critical temperature type (type I), and the mutual solubility type (type II).

For type I, the loaded amine solution changes into two liquid phases at certain temperature like in DMX process. The process is claimed to reach specific reboiler duty as low as 2.1GJ/tCO₂ compared to 3.7 GJ/tCO₂ for the conventional process with 30%wt MEA [1]. For type II, the absorbent consists of at least two amines, in which there is a solubility limitation of one amine reaction products with CO₂ in the other. Type II mixture components are for example composed of diethylaminoethanol (DEEA) and N-Methyl-1,3-Propanediamine (MAPA) blend [2] , or 1,4-Butanediamine + DEEA blend [3].

The present study is achieved under the framework of the ECRA Chair scientific project, established between the university of Mons and the European Cement Research Academy. This work is focusing on the simulation with Aspen software of a post-combustion CO₂ capture process, using biphasic solvents and applied to cement flue gases. A comprehensive bibliographic review was carried out to highlight the most promising biphasic system. Solvents presenting required properties for CO₂ capture are necessarily composed of mixed amines. Usually, the mixture may contain amines with good absorption properties and amines as a regeneration promoter. Specific equilibrium and kinetic tests will be achieved to determine necessary parameters for thermodynamic modeling and Aspen simulations. In parallel to our simulations tasks, original absorption-regeneration tests will be performed with the existing micro-pilot after its adaptation to biphasic solvents. Finally, technico-economic investigations are scheduled to optimize biphasic CO₂ capture process specifically for the cement industry application. A schematic presentation of the interconnected thesis tasks is given in Fig.2.

References

- [1] L. Raynal. et al., *Energy Procedia*, vol. 4, pp. 779–786, 2011.
- [2] D. D. D. Pinto. et al., *Int. J. Greenh. Gas Control*, vol. 28, pp. 318–327, 2014.
- [3] Z. Xu. et al., *Int. J. Greenh. Gas Control*, vol. 16, pp. 107–115, 2013.

Figures

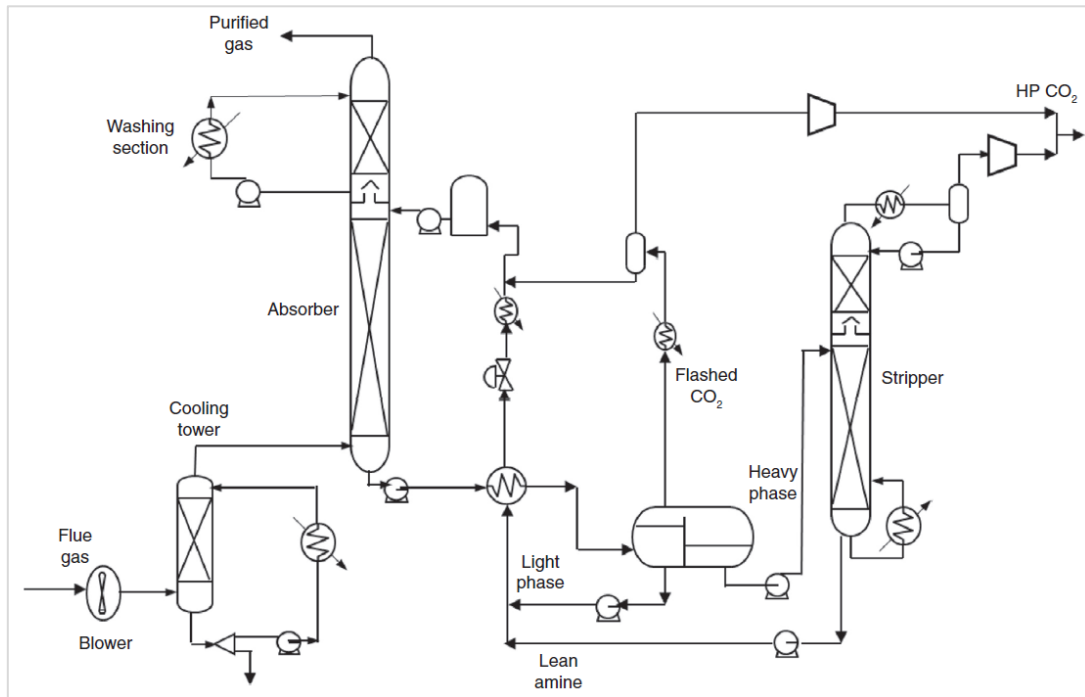


Fig.1. Simplified process flow diagram of the IFP Energies nouvelles DMX process

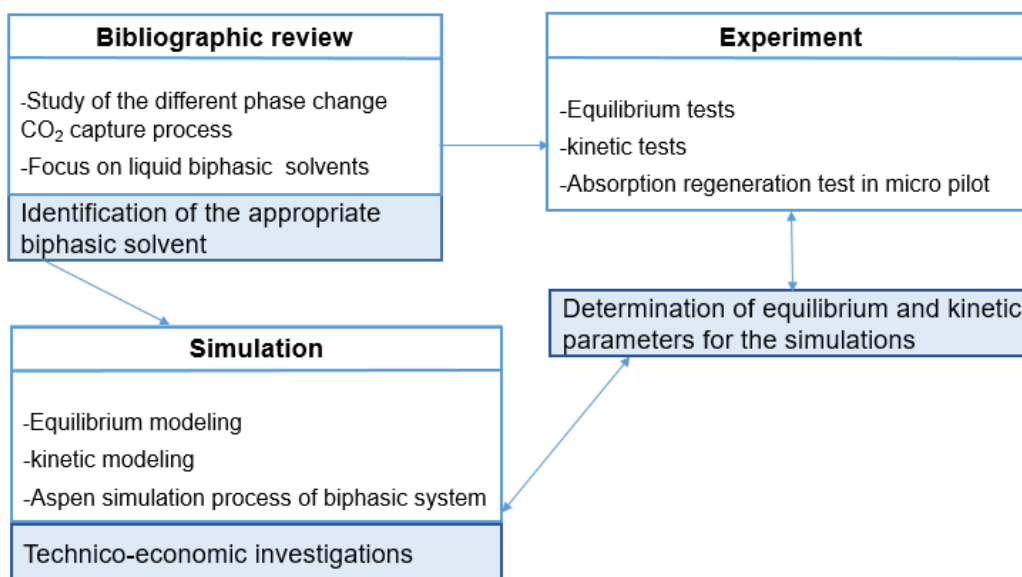


Fig.2. Schematic presentation of the planned thesis tasks