Ionic Liquids for CO_2 Capture: a Technological Review Focused on Bubble Columns

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Climate change has put the focus on the decarbonization pathways of both industrial and energy production processes, thus increasing the need for efficient, flexible and "*industrial-scale*" CO_2 capture technologies. In this broader framework, Ionic Liquids (*ILs*) have gained growing interest as alternative solvents, owing to their many advantages (e.g., negligible vapor pressure, high thermal stability, tunable properties). In particular, the above-mentioned tunability has allowed high CO_2 solubility and lower energy requirements for regeneration, posing them as promising alternatives to conventional amine-based solvents (e.g., *MEA* or *DEA*).

For what concerns chemical reactors available for CO_2 capture, the most widely used are gas-liquid contactors. Among these, bubble column reactors are interesting owing to their many advantages (e.g., simple design, low maintenance and efficient heat and mass transfer), making them attractive for this type of processes. Despite these advantages, the precise understanding of the multi-scale fluid dynamics and mass transfer is elusive to date. Moreover, when unconventional solvents, as *ILs*, are employed, such knowledge is even more scarce. In this respect, it is worth mentioning that recent developments, such as functionalized *ILs*, hybrid *IL*–amine or water mixtures, have improved CO_2 absorption capacity and regeneration efficiency. However, there is still a lack of comprehensive experimental datasets and validated predictive models for *IL* systems.

Given this broader context, this review covers *IL*-based CO_2 capture systems, encompassing *ILs* classification and properties, towards the "*reactor-scale*" performances. The main goal of this paper is to gather what is known about *ILs* as CO_2 absorbers and how they behave in real processes, particularly in bubble column reactors. This is achieved by describing the main classes of *ILs* and investigating the main physicochemical properties influencing their performance in absorption processes (e.g., viscosity, surface tension, and CO_2 solubility). Moreover, the experimental studies available in literature with liquid-gas contactors are reviewed to provide insight into the fluid dynamics and mass transfer behavior of *ILs* systems. Finally, existing industrial applications employing *ILs* are discussed. In the conclusions of this review, based on the present state-of-the-art, a novel system for CO_2 absorption using bubble columns is proposed as part of the *AURIGA* project.