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Experimental and Theoretical Mass Transfer Studies of Pure Carbondioxide Absorption in Sodium Hydroxide in Millichannels

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Abstract : For the past several decades, CO2 levels have been dramatically increasing in the atmosphere due to the man-made emissions such as fossil fuel-fired power plants. With the increase in CO2 emissions, CO2 concentration in the atmosphere has increased resulting in global warming. This shows the need to study different ways to capture the emitted CO2 directly from the exhausts of power plants or atmosphere. There are several ways to remove CO2, such as absorption into a liquid solvent, adsorption into a solid, cryogenic separation, permeation through membranes and photochemical conversion. In most industries, the absorption of CO2 in chemical solvents (in absorption towers) is used for CO2 capture. In these towers, the mass transfer along with chemical reactions take place between the gas and liquid phase. This helps in the separation of CO2 from other gases. It is important to understand these processes in detail. These flow patterns are difficult to maintain in large scale industrial absorbers. So to get accurate information controlled gas-liquid absorption experiments are carried out in milli-channels in this work under controlled atmosphere. The absorption experiments of CO2 in varying concentrations of sodium hydroxide solution are carried out in T-junction glass milli-channels with a circular cross section (inner diameter of 2mm). The gas and liquid flow rates are controlled by a mass flow controller (MFC) and a Harvard syringe pump respectively. The slug flow in the channel is recorded using a camera and the videos are analysed. The gas slug of pure CO2 is found to decrease in size along the length of the channel due to absorption of gas in the liquid. This is also captured with the model developed and the mass transfer characteristics are studied. The pressure drop across the channel is determined by sum of the pressure drops from the gas slugs and the liquid plugs. A dimensionless correlation for the mass transfer coefficient is developed in terms of Sherwood number and compared with the existing correlations in the literature. They are found to be in close agreement with each other. In this case, due to the presence of chemical reaction, the enhancement of mass transfer is obtained. This is quantified with the help of an enhancement factor.

Keywords : absorption, enhancement factor, mass transfer coefficient, Sherwood number
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