FLOW REGIME TRANSITION IN BUBBLE COLUMN WITH IONIC LIQUIDS

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Summary

Experiments were performed in a laboratory scale bubble column (2.5m height, 0.2m internal diameter) and detected by using electrical resistance tomography and high speed camera. The effects of column pressure, temperature and sparger type on gas holdup and flow regime transition are investigated at different superficial velocities. Different flow regimes have been identified based on void fraction and pictures recorded by electrical resistance tomography and high speed camera. The general trend is that the transition velocities increase with the pressure and temperature increasing.

Keywords

Flow regime; Ionic liquids; Electrical resistance tomography; Bubble column

Introduction

Ionic liquids are melts of salts usually at room temperature. They have advantageous physical and chemical properties related to non-measurable vapor pressure, high thermal stability, high ionic conductivity and a large range of electrochemical window and are able to dissolve a variety of organic and inorganic solutes. Over the past years, ionic liquids have gained in importance, and more and more scientists and engineers investigated their possible application in many fields, especially in chemical industry[1]. Zhao et al[2] reviewed many potential applications of these unique liquid materials in industrial catalysis. Recently, ionic liquids have been proposed as absorbent for many gas separations without concurrent loss of themselves into the gas stream[3, 4]. With the global warming, many funding and manpower are put into development of new technologies to control emissions of CO_2. The absorption of CO_2 with ionic liquids was studied and the results indicated that the ionic liquids can absorb CO_2 from gases effectively[5]. The ION Engineering Company[6] has become the first to successfully integrate ionic liquid solutions into carbon capture and emissions control technology by replacing the water based solution with ionic liquids. Except that, Sun et al.[7] have used ionic liquids as a homogeneous catalyst to the new process for chemical fixation of CO_2 with epoxy compounds to cyclic carbonate which has been in pilot scale.

As described above, ionic liquids are starting to find their way into a wide variety of industrial applications. That will need more engineering data which will be very important for the suitable design and operation of industrial unit used for ionic liquids. Bubble column has emerged as attractive multiphase contacting device and is widely being used in industrial processes for it high mass and heat transfer rates. It will be a suitable choice device for some gas-ionic liquids system. The demarcation of hydrodynamic flow regime is an important task in the design and scale-up of bubble column. Many different results in the organic solvent[8], water[9], a solution of inorganic[10, 11] or organic solute[12, 13] have been investigated on the behavior of the gas-liquid systems occur in the open engineering literature. These significant conclusions obtained by these authors are based on a limited number of gas-liquid low viscosity systems. Therefore it may be unsuitable to extrapolate these results to other systems, especially to high viscosity ionic liquids systems. For this reason, further work could reveal something that is substantially new and different from these prior efforts.

In this study, electrical resistance tomography was used to measure void fraction wave characteristics, and high speed camera was used to record the gas and ionic liquids interaction process to indentify flow regime transition. We first present experimental results on the effects of the temperature, pressure and sparger on the flow regime transition of gas-ionic liquids system in bubble column.

Experimental

Fig. 1 shows a schematic diagram of the experimental setup used in this study. The heart of the experimental set-up is a 2.5m height, 0.2m internal diameter column filled by [bmim]BF_4. The hydro-pressure of the experimental setup is 6 MPa at room temperature and its maximum allowable working pressure is 3.5MPa at a maximum temperature of 523 K. A jacket covers the column. The

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space between the jacket and the column was filled with heat transfer oils to keep constant temperature which varied less than 1℃. The heat transfer oils flow was controlled by pump, and it was heated and cooled off through heater and condenser during an experimental sequence. The bottom flanges of column can be equipped with three spargers: a single-orifice nozzle (7 mm in diameter), a multiple-orifice plate (150 holes of 1 mm uniformly spaced) and a metal sintered plate (mean pore diameter: 70μm). The air was then injected into the column through the air sparger at a desired flow rate.

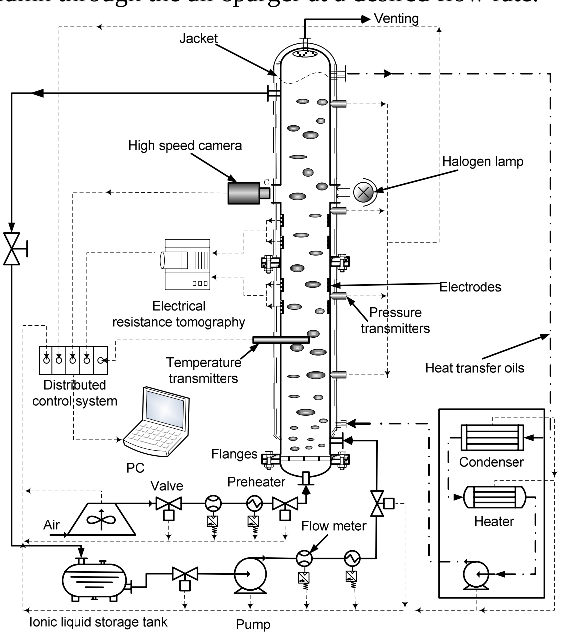

Fig. 1 Schematics of the experimental setup

Two gas mass flow meters (0～30L/min and 0～250L/min) for the air were used alternately to control and record the flow rates accurately at different ranges. The column is provided with two pair sight windows located near the middle position in order to enable recording the bubbles size/behavior with high speed video camera (MC1310) under a given operating condition. An electrical resistance tomography (ITS2000) is used to obtain information of the gas holdup distribution within cross-sections of the column. The air/[bmim]BF_4 system is used at different pressure and conducted in the temperature range 308.15～398.15K. The superficial gas velocity is varied from 1mm/s up to 12 cm/s. A check valve is placed at the gas inlet of the column to prevent the [bmim]BF_4 backflow.

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