Micromixing in two-phase (g-l and s-l) systems in a stirred vessel

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Abstract

In recent years, the iodide/iodate reaction scheme based on parallel competitive reactions has been used for various single-phase micromixing studies (see, for example [1]). A small amount of work has also been done on solid-liquid stirred systems [2, 3] at relatively low particle concentrations. However, there are conflicting reports in the literature regarding turbulence damping or enhancement due to the presence of low concentrations of particles [4], so more work would still be of interest to aid clarification. In addition, work at higher concentration, as often encountered in industrial practice, is required. Furthermore, though micromixing in gassed stirred vessels as a function of impeller speed has occasionally been studied before, its use at constant power input but different gas flow rates has not been reported. Therefore, here, micromixing in single- and two-phase (s-l and g-l) stirred systems using the iodide/iodate reaction scheme is reported.

Experiments were conducted in a fully baffled vessel, diameter, T = 0.288 m, liquid height H = 1.3T, equipped with a standard Rushton turbine (D = T/3). The impeller speeds used gave realistic mean specific energy dissipation rates, $\bar{\varepsilon}_T$, from 0.2 to 1.2 W/kg. Two feed positions were chosen: one near the impeller and one near the free surface. Air and nominally 500 µm glass Ballotini were used for the gaseous and solid phases, respectively. The reactant concentrations and experimental procedure followed those in related previous single phase work [1] to allow easy comparison with 0.5 and 1 M H_2SO_4; and also, based on it [1], the feed rates ensured that the reactions were being conducted in the micromixing regime.

Two sets of preliminary tests were carried out. Firstly, single-phase micromixing experiments were conducted which gave reasonable agreement with earlier work at the same reactant concentrations [1]. Secondly, at these reactant concentrations, neither the presence of glass particles up to relatively high concentrations or of air had any detrimental effect on the method, i.e. during the time for which experiments are undertaken, iodine was neither adsorbed on the particles or stripped by the air. The main work to date has concentrated on feeding close to the impeller where the local specific energy dissipation rate, ε_T, is high, i.e., $\varepsilon_T / \bar{\varepsilon}_T >> 1$, so that micromixing effectiveness is high [1]. In this region, at different gassing rates up to ~1.5 vvm, the impact on micromixing is negligible when $\bar{\varepsilon}_T$ is kept constant. Similarly, in the presence of the Ballotini at low concentrations up to about 1% by vol., the impact was again negligible. The latter result is particularly interesting since many studies using laser-based flow

measuring techniques (PIV or LDA) to measure ε_T have often indicated a surprisingly large drop, even at such low concentrations [4].

Now that the technique has been fully established, many additional experiments can be conducted, initially, feeding to the upper region of the vessel where $\varepsilon_T / \bar{\varepsilon}_T < 1$ but where it is much easier to do, will also be investigated. A similar range of gassing rates and low solids concentration with sizes from ~250 to 1000 µm, since there is some evidence the local specific energy dissipation rate is a function of particle size [3, 4], will be used. For the s-l case, concentrations up to ~20 % by weight, at which 'cloud formation' appears, will also be used, with addition both in and above the cloud [5]. Such studies have not been conducted previously. The work presented at the NAMF meeting will also cover other new topics.