Microreactors for Aqueous-Organic Multiphase Systems – Kinetics & Dynamics Studies

Introduction
Over the past years, significant advances have been made towards developing novel equipments and/or methods for the conduction of chemical reactions with special interest given to multiphase reactions. An intriguing prototype for process intensification in these systems is the combination between the microreactor technology, phase transfer catalysis (PTC) and ultrasound irradiation.

In this research, the reaction between 0.4M benzyl chloride dissolved in toluene with 1M aqueous solution of sodium sulfide using 0.04M tetrahexylammonium bromide as a PTC in a capillary microreactor assisted by ultrasound irradiation has been studied.

Experimental
Fig. 1 shows the experimental setup. The working fluids were fed via two separate lines and brought together in a T-shape connector. The capillary tubing (φ 260 µm X 1 m) is attached directly downstream of the T-shape connector. An ultrasound device with 28 kHz, 60 W was used. External heat was supplied to the ultrasound bath via coil-heat exchanger immersed in the ultrasound bath. Two HPLC pumps were used to feed the aqueous and organic feeds. The reaction products are analyzed by GC.

Results
Fig. 2 shows the profiles of reaction at different operational conditions in a batch reactor system. Increasing the speed of agitation from 0 rpm to 500 rpm has speeded up the reaction. This indicates that the reaction is mass transfer-limited. The reaction has been also initiated and proceeded in a good speed under sonication conditions only. This shows the effectiveness of ultrasound irradiation in reducing the mass transfer limitations. However, the reaction conversion has been intensified up to a complete conversion in ~ 5 minutes when mechanical agitation (500 rpm) is performed along with ultrasound irradiation. Such combination will produce very fine dispersions, thereby increasing the interfacial area available for reaction. Fig. 3 shows the profiles of reaction in the capillary microreactor. It is clear that the conversion when using the capillary microreactor is higher than the conversion obtained in the batch reactor system within the time scale of 0.5 min. This demonstrates the superiority of the capillary microreactor in intensifying the interfacial area. The reaction conversion in the capillary microreactor under sonication conditions is higher than that under silent conditions. Under sonication conditions, the organic slugs undergo continuous break-up and coalescence, thereby enhancing the mass transfer performance. Accordingly, enhanced reaction performance was obtained.

Fig. 1 The capillary microreactor experimental setup.

Fig. 2 Reaction profile in a batch reactor

Fig. 3 Reaction profile in a capillary microreactor.

E-mail: S.H.M.ALBBOUR@GMAIL.COM