Impact of an Electric Field on the Buoyancy Instability of an Autocatalytic Reaction Front in a Narrow Cell

Ales Zadrazil, Tomas Godula, Hana Sevcikova

Center for Nonlinear Dynamics of Chemical and Biological Systems, Institute of Chemical Technology, Prague, Technicka 5, 166 28 Prague 6, Czech Republic. telephone : 00 420 2 2435 3292, fax : 00 2 420 2 3333 7335, e-mails : Ales.Zadrazil@vscht.cz, Hana.Sevcikova@vscht.cz

Convective instabilities may arise in the batch, non-stirred reactors, where the reaction proceeds in the form of a front converting reactants ahead of the front into products behind the front. Due to chemical change not only the gradients of species concentration are set across the front but also the gradient of the density may arise. Buoyant forces then evoke convective flows that can destroy the shape of the front and cause the mixing of products and reactants. The onset of buoyancy instability has been studied in the arsenous acid-iodate reaction system in the narrow, vertical reactor (Hele-Shaw cell, cf. Fig. 1.) Two reaction fronts, initiated at the negative electrode (a conductive stripe of indium-thin-oxide on the glass wall), convert the denser unreacted solution into the less dense reacted solution. The buoyancy forces then destabilise the ascending front that forms fingers. This paper investigates the possibility of influencing the stability of arsenous acid-iodate fronts by external d.c. electric fields (U = 10 or 20 V) applied on the cell. It is shown that the buoyancy instability, observed on ascending fronts, can be suppressed by EF if the ascending front propagates towards the positive electrode and can be facilitated if the ascending front propagates towards the negative electrode. The descending fronts, stable under no EF conditions, stay stable if the positive electrode faces the approaching front but become unstable when the polarity of d.c. EF applied is reversed. The stabilising (destabilising) effects increase with the increasing strength of EFs and include slower (faster) development of fingers and the decrease (increase) of their number.

Figure 1. The experimental apparatus (Hele-Shaw cell) for investigation of buoyancy instability.