L. Schreiberová:

Poster title:

Dynamics of mass-coupled flow reactors with a nonlinear pH-oscillatory reaction

Oldřich Pešek, Lenka Schreiberová and Igor Schreiber

Department of Chemical Engineering and Center for Nonlinear Dynamics of Chemical and Biological Systems, Institute of Chemical Technology, Prague, Technická 5, 166 28 Prague 6, Czech Republic, e-mail: Lenka.Schreiberova@vscht.cz

Abstract:

Oscillating reactions with an autocatalytic effect involving protons called pH-oscillators form a distinct class of both inorganic-chemical and enzyme-biochemical systems with possible applications in the field of functioning of biological systems. By taking a reltively simple inorganic pH-oscillator, we focus on experimentally studying cooperation between two interacting subsystems represented by two mass-coupled stirred flow-through reactors. The chosen reaction involves hydrogen peroxide and thiosulfate in a diluted solution of H_2SO_4 and is catalyzed by Cu^{2+} (HPTCu reaction). In a single continuous-flow stirred tank reactor (CSTR), this reaction displays nonlinear dynamical behavior including different types of steady states, spontaneous oscillations, bistability between steady states or between a steady state and oscillations, and hysteresis. In addition, there exist conditions under which the system is excitable. When two reaction cells are coupled via a membrane allowing for diffusion-like mass transfer, dynamical behavior becomes highly complex. We studied effects of the flow rate and the coupling strength on the system that is intrinsically oscillatory or in a bistable mode in each subunit when decoupled. Dynamical behavior includes nonhomogeneous steady states, synchronized periodic as well as desynchronized nonperiodic behavior. In addition, effects of external pulse perturbations causing propagation of chemical signals through the coupled system, which is set in an excitable mode, are studied. We observe either partial or complete propagation of the excitatory signals to the second reactor, depending on the coupling strength and the kind of perturbant used. All the described dynamics were also simulated by using a 9-species mechanism assumed for the HPTCu reaction. We find that on a qualitative level, the model reproduces some dynamical phenomena associated with mass-coupling. Relevance to coupled biological systems is stressed.