Mathematical Model for Temperature Regulation of Self-Sustained Glycolytic Oscillations in a Closed Reactor

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Keywords: glycolytic reaction, temperature control, nonlinear oscillations

We base on the Selkov system [1] to construct the model for temperature control of glycolytic reaction in a closed spatial reactor. To establish a correspondence with the experiment [2] we add the slow catalytic term αx which describes the small value of additional substrate influx and product outflow and introduce a temperature-dependent coefficient β satisfying the Arrhenius law. We obtain the following temperature model of glycolysis:

$$\begin{aligned} \dot{x} &= \nu - \alpha x - \beta(T) x y^2, \\ \dot{y} &= -wy + \alpha x + \beta(T) x y^2, \\ \dot{\nu} &= -\varepsilon v, \end{aligned} \tag{1}$$

where the last equation corresponds to a consumption of the substrate.

The considered model explains the key experimentally observed phenomena [2]: 1) decaying of the average concentrations of reagents during the reaction, 2) Arrhenius-type temperature dependence for frequency of oscillations, 3) change of the form of oscillations with the temperature growth, 4) modulations of oscillations induced by a periodic temperature variation.

The addition of the diffusion terms to the system (1) allows to reproduce the emerging of glycolytic travelling waves observed in a closed reactor in the presence of a temperature gradient [2]. Comparison of the dynamics of travelling waves in the numerical solution with the experimental data [2] permits to propose a new method to estimate the diffusion coefficients of reagents in the case of a chemical reaction occurring in a dense media.

References

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