Information Processing with Belousov-Zhabotinsky Reaction

By

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Abstract

It is well known that the time evolution of concentrations of reagents of Belousov-Zhabotinsky reaction can be interpreted as a sequence of information processing operations. In the case of ferroin catalyzed reaction two states of the medium, corresponding to high concentrations of the catalyst in the reduced or the oxidized forms can be easily distinguished by the medium color. We can assign the logical "TRUE" state to a high concentration of the oxidized catalyst and the other state to the logical "FALSE". Information can be coded in propagating pulses of excitation and it is processed in regions of medium where pulses interact. In reaction-diffusion computing the geometrical structure of chemical medium is equally important as chemical dynamics because it has a significant influence on interactions between excitations. I will demonstrate that computing based on Belousov-Zhabotinsky reaction is universal and all logic gates can be constructed with the proper geometry of excitable and non-excitable regions. Alternatively one can use frequency of chemical oscillations for information coding. It can be also shown that all logic gates for such information coding can be constructed using a chemical medium.

It seems especially interesting to self-generate chemical information processing structures at carefully selected nonequilibrium conditions. We hope that such self-generation will be possible in a medium composed of lipid-covered droplets containing reagents of Belousov-Zhabotinsky reaction. The lipid-covered BZ droplets can interact via exchange of reagents through the separating lipid layer and the surrounding hydrocarbons. The structure of multiple droplets can be regarded as a prototype of a neural network, where individual droplets play the role of nonlinear elements (neurons) that are linked together and communicate.

Short Biography

Jerzy Gorecki is a professor at the Institute of Physical Chemistry of the Polish Academy of Sciences. At the Institute he heads the Department of Complex Systems and Chemical Processing of Information. He also works as a teaching professor at the Department of Mathematics and Natural Sciences of Cardinal Stefan Wyszyński University in Warsaw. He received his doctorate in physics from the Institute of Physical Chemistry of the Polish Academy of Sciences in 1984 for quantum theory of resistivity of liquid metals. After postdoctoral position at Manchester University, U.K. and visiting professor position at Institute of Molecular Science in Okazaki, Japan he received habilitation in theoretical physics from the Department of Mathematics and Physics of the Jagiellonian University in Cracow. His main research interests are unconventional computing, especially with a chemical medium, fluctuations in nonequilibrium chemical systems and computer algorithms for large scale simulations of nonequilibrium effects associated with chemical reactions. He has published over 100 papers, 89 of them listed by Web Science database. He has over 700 citations and the h-index 16.