Belousov–Zhabotinsky reaction

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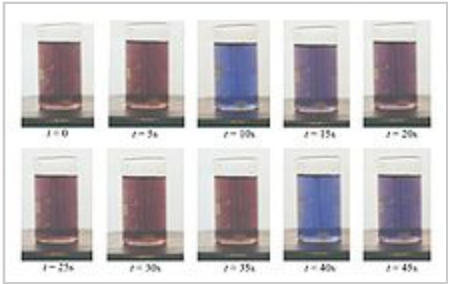
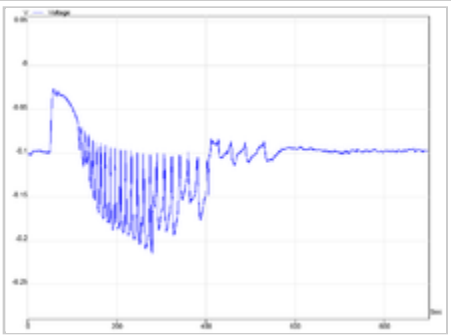
A **Belousov–Zhabotinsky reaction**, or **BZ reaction**, is one of a class of reactions that serve as a classical example of non-equilibrium thermodynamics, resulting in the establishment of a nonlinear chemical oscillator. The only common element in these oscillating systems is the inclusion of bromine and an acid. The reactions are theoretically important in that they show that chemical reactions do not have to be dominated by equilibrium thermodynamic behavior. These reactions are far from equilibrium and remain so for a significant length of time. In this sense, they provide an interesting chemical model of nonequilibrium biological phenomena, and the mathematical models of the BZ reactions themselves are of theoretical interest.

An essential aspect of the BZ reaction is its so called "excitability" — under the influence of stimuli, patterns develop in what would otherwise be a perfectly quiescent medium. Some clock reactions such as Briggs–Rauscher and BZ using the tris(bipyridine)ruthenium(II) chloride as catalyst can be excited into self-organising activity through the influence of light.



A stirred BZ reaction mixture showing changes in color over time



Plot of the electrode potential of a BZ reaction, using silver electrodes against a $Ag/AgNO_3$ half-cell

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History

The discovery of the phenomenon is credited to Boris Belousov. He noted, sometime in the 1950s (various sources' date ranges from 1951 to 1958), that in a mix of potassium bromate, cerium(IV) sulfate, propanedioic acid and citric acid in dilute sulfuric acid, the ratio of concentration of the cerium(IV) and cerium(III) ions oscillated, causing the colour of the solution to oscillate between a yellow solution and a colorless solution. This is due to the cerium(IV) ions being reduced by propanedioic acid to cerium(III) ions, which are then oxidized back to cerium(IV) ions by bromate(V) ions.

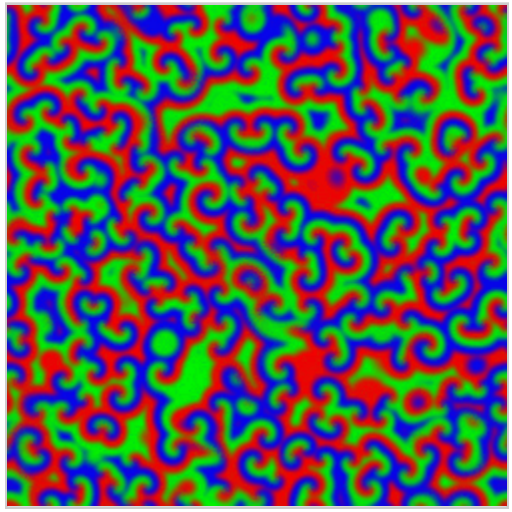
Belousov made two attempts to publish his finding, but was rejected on the grounds that he could not explain his results to the satisfaction of the editors of the journals to which he submitted his results. His work was finally published in a less respectable, non-reviewed journal.[1]

Later, in 1961, a graduate student named Anatol Zhabotinsky rediscovered this reaction sequence;[2] however, the results of these men's work were still not widely disseminated, and were not known in the West until a conference in Prague in 1968.

There are a number of BZ cocktails available in the chemical literature and on the web. Ferroin, a complex of phenanthroline and iron is a common indicator. These reactions, if carried out in petri dishes, result in the formation first of colored spots. These spots grow into a series of expanding concentric rings or perhaps expanding spirals similar to the patterns generated by a cyclic cellular automaton. The colors disappear if the dishes are shaken, and then reappear. The waves continue until the reagents are consumed. The reaction can also be performed in a beaker using a magnetic stirrer.

Andrew Adamatzky, a computer scientist in the University of the West of England reported on liquid logic gates using the BZ reaction.[3]

Investigators are also exploring the creation of a "wet computer", using self-creating "cells" and other techniques to mimic certain properties of neurons.[4]



Computer simulation of the Belousov–Zhabotinsky reaction occurring in a Petri dish.

See also

- Excitable medium
- Briggs–Rauscher reaction

Notes

1. **^** B. P. Belousov. Периодически действующая реакция и ее механизм. [A periodic reaction and its mechanism]. Сборник рефератов по радиационной медицине (Compilation of Abstracts on Radiation Medicine), 147:145, 1959.
2. **^** A. M. Zhabotinsky. Периодический процесс окисления малоновой кислоты растворе (исследование кинетики реакции Белоусова). [Periodic processes of malonic acid oxidation in a liquid phase.] Биофизика [Biofizika], 9:306–311, 1964.
3. **^** Motoike I., Adamatzky A. Three-valued logic gates in reaction-diffusion excitable media. Chaos, Solitons & Fractals 24 (2005) 107–114. [1] (http://uncomp.uwe.ac.uk/adamatzky)
4. **^** BBC (Science News) (http://news.bbc.co.uk/2/hi/science/nature/8452196.stm) Chemical computer that mimics neurons to be created (11 January 2010)

References

- Pabian and Zarins, "Banded Agates; Origins and inclusions", University of Nebraska–Lincoln, Educational circular #12.

External links

- Interactive Science Experiment Showcasing the BZ Reaction (A-Level) (http://www.syngenta.com/country/uk/en/learning-zone/science-lab/experiments/Pages/BZClock.aspx)
- A Survey Article on the Mathematics of the BZ Reaction (http://www.rose-hulman.edu/mathjournal/v3n1.php)
- The Scholarpedia article on the Belousov-Zhabotinsky reaction (http://www.scholarpedia.org/article/Belousov-Zhabotinsky_reaction)
- The Belousov–Zhabotinski Reaction (http://staff.science.nus.edu.sg/~parwani/c1/node65.html)
- The Belousov–Zhabotinsky Reaction (http://online.redwoods.cc.ca.us/instruct/darnold/deproj/Sp98/Gabe/)
- The Phenomenology of the Belousov–Zhabotinsky Reaction, with pictures (http://www.ux.uis.no/~ruoff/BZ_Phenomenology.html)
- Video of BZ reaction (http://youtube.com/watch?v=g3JbDybzYqk&feature=related)
- The Belousov–Zhabotinski Reaction (http://ed.augie.edu/~awaspaas/inorg/bz.pdf) PDF file
- Paper cargo surfs chemical waves (http://technology.newscientist.com/channel/tech/dn13341-paper-cargo-surfs-chemical-waves.html?feedId=online-news_rss20) — Oscillating chemical waves induced by BZ reactions can propel small objects, *New Scientist*, 18 February 2008
- The home page of Anatol M. Zhabotinsky (http://hopf.chem.brandeis.edu/anatol/anatol.htm)

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