

## Dynamics of spiral waves in a closed photosensitive excitable chemical system

Spiral waves has been observed in a thin layer of excitable media. Especially, electrical spiral waves in cardiac tissues connect to cardiac tachycardia and life-threatening fibrillations. The Belousov-Zhabotinsky (BZ) reaction is the most widely used system to study the dynamics of spiral waves in experiments. When the light sensitive  $Ru(bpy)_3^{2+}$  is used as the catalyst, the BZ reaction becomes photosensitive, and the excitability of the reaction can be controlled by varying the illumination intensity. However, the typical photosensitive BZ reaction produces many  $CO_2$  bubbles so the spiral waves are always studied in thin layer media with opened top surfaces to release the bubbles. In this work, we develop new chemical recipes of the photosensitive BZ reaction which produces less bubbles. To observe the production of bubbles, we investigate the dynamics of spiral waves in a closed thin layer system. The results show that both the speed of spiral waves and the amount of bubbles increase with the concentration of sulfuric acid ( $H_2SO_4$ ) and sodium bromate ( $NaBrO_3$ ). For high initial concentrations of both reactants, the size of bubbles increases with time until the wave structures are destroyed. We expect that the chemical recipes reported here can be used to study the complicate dynamics of three-dimensional spiral waves in thick BZ media where the bubbles cannot escape.

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