Control of Oscillation Pattern in the Malonic acid-Bromate-Ruthenium-Hydroquinone Reaction by the Illumination of Visible Light

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Oscillatory chemical reactions have been in the focus of interest since the early seventies partly due to their uncommon temporal behaviour and partly their connection – at least phenomenologically – to periodic processes occurring at many levels of material organizations. Especially the Belousov-Zhabotinsky type (BZ) reactions which are understood as the catalytic oxidation and bromination of organic reductant compounds by bromate ion in acidic condition have been studied rather thoroughly. The study of photo-controlled chemical reactions is a subject of considerable interest in modern reaction kinetics. In addition to the practical applications in such areas as product selections by irradiation, investigations of photosensitive reactions have also provided a unique approach to understand interactions between intrinsic dynamics and external forcing.

In this study, we have examined the control of temporal oscillation patterns by the illumination of visible light in the malonic acid/BrO₃⁻/Ru²⁺/H⁺ system. The ruthenium catalyzed BZ reaction has been known to be sensitive to the visible light, however, we got more various patterns of temporal oscillation by adding a small amount of hydroquinone to the reaction system. Hydroquinone is a good reagent inducing a characteristic oscillating pattern in the BZ type reaction using 1,4-cyclohexanedione/BrO₃⁻/Fe²⁺/H⁺. Such an oscillation system is well-known for being suitable for CO₂ gas-free BZ reactions. Recently, many kinds of characteristic temporal and spatio-temporal phenomena have been observed in the reaction system. In a very recent investigation, Huh et al. have found that hydroquinone could play an important role in characteristic pattern formations in that kind of reaction system.

Figure 1 shows a typical experimental result on the influence of visible light to the oscillation pattern in the malonic acid/BrO₃⁻/Ru²⁺/H⁺ system. The reaction system is well-known for being suitable for CO₂ gas-free BZ reactions. Recently, many kinds of characteristic temporal and spatio-temporal phenomena have been observed in the reaction system. In a very recent investigation, Huh et al. have found that hydroquinone could play an important role in characteristic pattern formations in that kind of reaction system.

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induce complex bursting behaviors. However, it is difficult to interpret exactly for the obtained pattern variations only by this experimental result since the pattern in this BZ system is dependent on the concentration of the other reactants by the FKN mechanism. The effect of the illumination of the visible light on the malonic acid/BrO₃⁻/Ru²⁺/H⁺/hydroquinone system will be studied continuously in our future research.

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References

9. Typical experimental condition is as follows: Stock solutions of 0.6 M NaBrO₃, 0.2 M of malonic acid, 0.2 M hydroquinone, 1.0 × 10⁻⁵ M Ru(bpy)₃²⁺, and 2.0 M nitric acid are prepared with double distilled water. Reactions are carried out in a thermostated 50 mL vessel, where the temperature is controlled at room temperature at 25 ± 0.1 °C. The oscillating reactions were monitored by a platinum redox electrode. The potential was recorded with a multi-channel recorder (Cole-Parmer, G08373-20) through a pH/ISE meter (Orion, 940). A 100 W halogen lamp (Microtech, Model No. DLS-100HD) with continuous variable light level is used as a light source. The illumination has been done by optical fiber on both side of the reaction beaker.