Briggs–Rauscher Oscillating Reaction for Color Display

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Keywords: Briggs–Rauscher Oscillating Reaction

ABSTRACT

Briggs–Rauscher reaction exhibit three optical states: yellow, blue and the transparency, which are happen to be the color mixing for white balance. This report demonstrates the color mixing evaluation procedures for the possible application of this reaction for the display application.

1. INTRODUCTION

The first known homogeneous oscillating chemical reaction was reported by W.C. Bray in 1921[1)]. The survey was a chemical clock between *Hydrogen Peroxide* (H_2O_2) and *Iodate* (IO_3^-) in an acidic solution. After that in 1958 Belousov discovered the Belousov-Zhabotinsky reaction[2)], which is quite suitable for demonstration. However, the chemical oscillation behavior is not well understood at that time, it was keep suspected until Zhabotinsky's validation it in 1964. Major breakthrough is reached in 1973, that the Briggs-Rauscher reaction is complete by replacing the *Bromate* ($BrO3^-$) in the Belousov-Zhabotinsky reaction with iodate and adding hydrogen peroxide[3)].

Beautiful visual effect with yellow and blue color was created by the addition of starch indicator. After that, researchers have joined the study of this unusual chemical clock response. Based on the two color system (yellow and blue) that performed by Briggs-Rauscher reaction (B-R reaction for short), this report will discuss the effects and procedures to analysis the effects of B-R reaction to the display application.

2. MATERIAL AND METHODS

2.1 preparations

Aqueous solution contains *Hydrogen Peroxide*, *Iodate*, and *Divalent Manganese* (Mn^{2+}) as a catalyst. *Sulfuric Acid* (H_2SO_4) and active organic compounds like $CH_2(COOH)_2$ can reduce the free *Iodine* (I_2) to I*odide* (I^-). Starch was added as an indicator to indicate a sudden increase in the absorption of *Iodide*, which suddenly changed between *Iodine-Starch Complex* (blue) and *Iodine* (yellow).

2.2 reactions

Frequency and modulation of the light source depend on the initial conditions, and the mixture to the last residue contains *Hydrogen Peroxide*, *Iodized Malonic Acid*, *Manganese* catalyst, mineral acid and un-reacted *Iodate*. After the oscillation is stopped, the *Iodomalonic* Acid decomposes and produces iodine. Note that the *Hydrogen Peroxide*, *Iodate* and *Iodine* are strong oxidants; acids might corrosive, such that the ingredients present in the residual mixture are issues to be aware of. A simple method has been developed using inexpensive salts, *Thiosulfate* and *Carbonate*, to remove all oxidants, neutralize acidity and recover *Manganese* ions (in *Manganese Dioxide*)[4)].

2.3 colors mixing

White color can be produced through the mixing between the yellow and blue component, black color can be produced by removing the backlight (dimming). Changing the proportions of chemical components can lead to different yellow and blue color coordinate, such that the color temperature can be modulated by the chemical composition directly. The following is the procedure to complete the color mixing for the B-R reaction through a simple image process.

1. Acquisition the images from the experiment;
2. Prepare the yellow and blue sample images according to different ingredients;
3. Placed the yellow sample image as the bottom layer, while setting the blue sample image in the upper layer with 50% transparency;
4. Overlap the two pictures. The middle area is the result of the simulated light mixing for the B-R Reaction. Adjust the brightness of the upper layer images (blue one) to restore the original experiment images for the blue sample.

3. DISCUSSION

Figure 1 is the experimental examples for the Briggs–Rauscher reacton[5]. Yellow, blue and transparent states under this chemical composition is obtained. Note that the RGB coordinate indicates below. Figure 2 demonstrates the accurate procedures that discussed in section 2.3 of the color mixing. Images with mixing values in RGB coordinate is denote for each region. Figure 3 is the results of the BR-reaction that demonstrate in figure 1. Notice that the yellow color of this BR-reaction is not saturate enough, such that leads to the unsatisfied mixing results for the information display application.

However, by changing the mole ratio for the components, one can control the performance of the color coordinates. Figure 4 is the results of the BR-reaction, which the color variations and frequency can be controlled by the pH and temperatures of the chemicals. Figure 5 is the temperature distribution during the mixing of the two chemicals with different initial temperature, and figure 6 give the plot of the variations of the color coordinates for the BR reactions, as function of pH and temperature.

4. CONCLUSION

This report demonstrates the possibilities that using the color mixed by the Briggs-Rauscher reaction for the display application. Modulation and the frequency are governed by the mole ratio between the chemicals. Procedure is developed for verification, and note that the modulation and the frequency are determined by the ratio of the B-R chemicals, such that the important features for display (color and frequency) can be controlled. However, the effective time to preserve the mixed color is one of the problem need to be solve for specific application.

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Acknowledgements

The authors would like to express their appreciation for the financial support of this research from the Ministry of Science and Technology of Taiwan under grant nos. MOST 105-2221-E-164-004, MOST 106-2221-E-164 -006 and MOST 107-2221-E-164-002.

Fig. 1 Colors for B-R reaction[5]

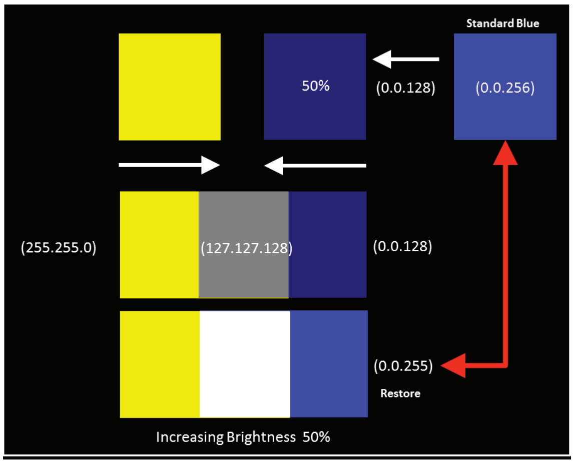

Fig. 2 Color mixing for the standard color display

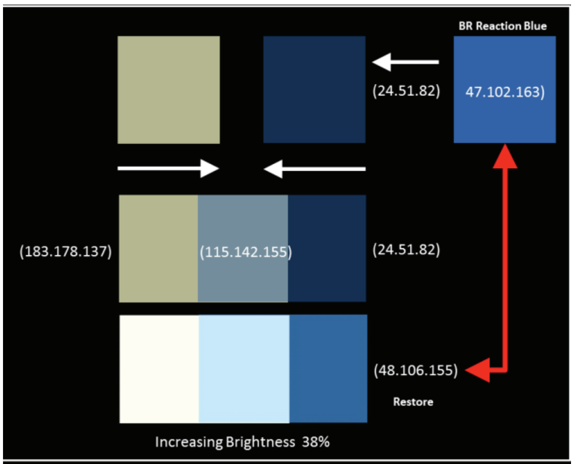

Fig. 3 Color mixing for B-R reaction reference[5)]

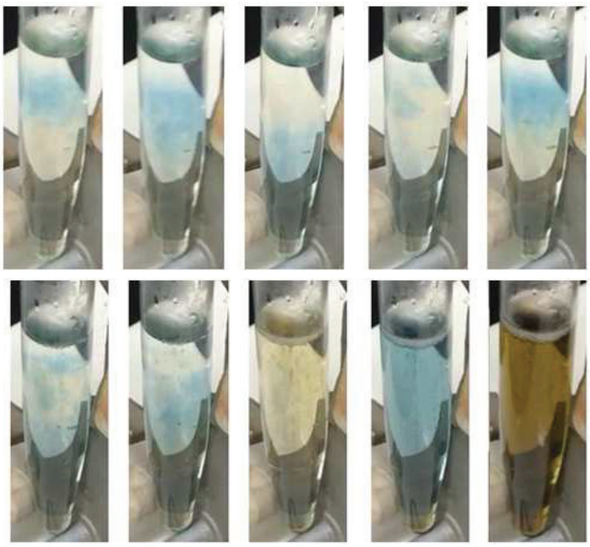

Fig. 4 Color variations and frequency can be controlled by pH and temperature of the compositions

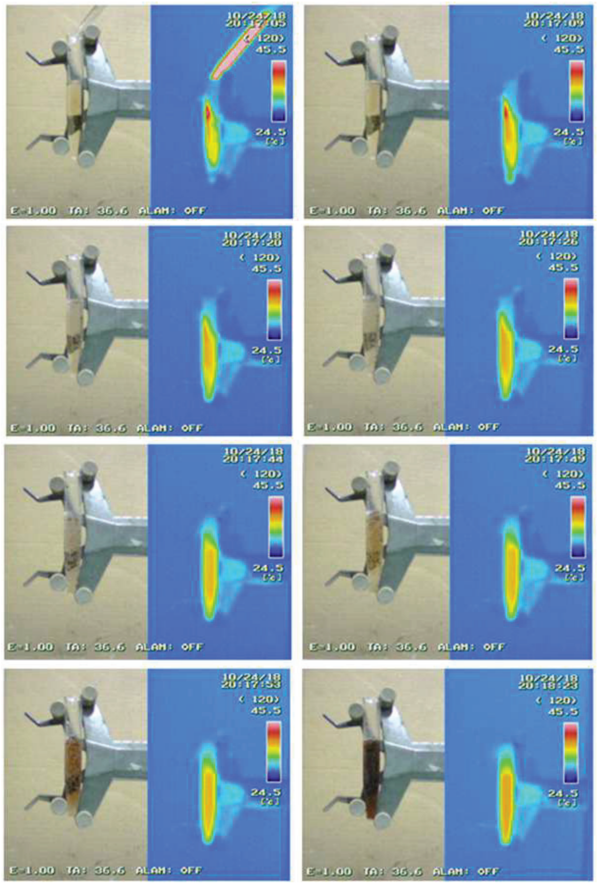

Fig.5 Temperature distribution of mixing chemicals

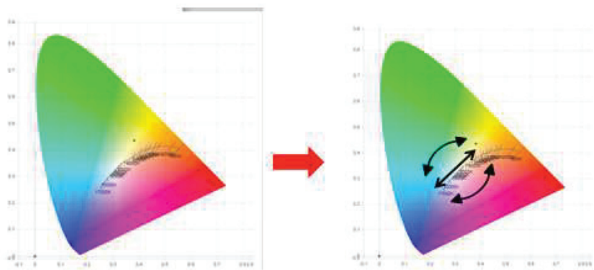

Fig. 6 Dynamic variations on the display color coordinate as function of pH and temperature