Demonstration tools for changes in visible colors of transmitting light beams to be caused by optical rotation in syrup as optical active material and their predictions

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Abstract: Demonstration tools were prepared for color changes in polarized visible light beams transmitting in commercially-purchased syrup as optical active material. Predictions of such color changes were successfully realized and satisfactory color matching became possible.

1. Introduction

Changes in visible colors are often good subjects for attracting attentions of children and/or students in science experiment demonstrations. One of typical examples is changes in visible colors of polarized light beams which are allowed to propagate through optical active materials [1-4]. This phenomenon is caused by optical rotation in optical active materials. Although explaining the precise mechanism of the phenomenon is difficult, most of children and students are likely to get interested in the experiment demonstration.

The authors successfully realized theoretical predictions of the visible color changes in the phenomenon with sugared water [5-6] and then commercially-available syrup [7] being used as optical active material. In this paper, some results of the predicted visible colors and actually observed results are presented. In addition, middle-sized demonstration tool prepared for enhancing visibility in demonstration is also introduced.

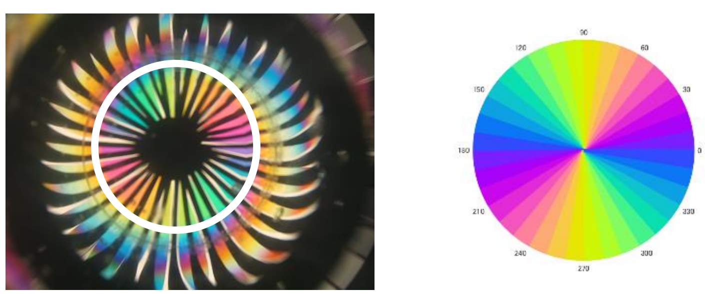
2. Predictions of visible colors of transmitting light beams and demonstration results of a tubular container

Predictions are performed by means of the authors' established theoretical mathematical expressions for calculating the angle of rotation or rotation power for a specific optical active material with respect to any wavelengths of light beams to be transmitted therein. Detailed explanations can be found in References [6-7].

Fig.1 shows the small-sized demonstration tool prepared by the authors [7]. Specifically, a tubular container was provided from an acrylic tube (with an inner diameter of 5 cm) with its one end being sealed with an acrylic plate. Commercially-purchased syrup was poured into the tubular container with the height of about 10 cm. The syrup-poured tubular container was then placed onto a white-color light box. A specially-arranged circular polarizing sheet was placed between the light box and the bottom plate of the container, in which the polarizing axis is arranged to rotate every 10 degrees. Another polarizing sheet was placed above the syrup-poured container for observation.

Fig.2(a) shows actually observed colors, while Fig.2(b) illustrates the predicted result obtained from calculation with the theoretical mathematical equation. When looking at the area surrounded with a white circle, roughly satisfactory matching in colors can be found between the actual observation result and the prediction.

Fig. 1. A tubular container for demonstration.



(a) actually observed colors (b) Color predictions

Fig.2 Actually observed colors and color prediction result.

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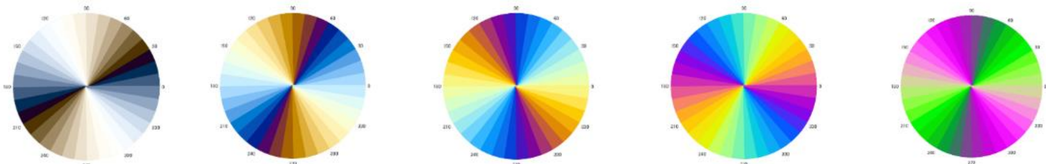
Fig.3 shows the predicted results of visible colors with different optical length values (i.e., different height of syrup in the tubular container). Colors to be observed are found to change from achromatic to chromatic with increased syrup height, and colors also become brighter.



(a) 1 cm (b) 3 cm (c) 5 cm (d) 8 cm (e) 15 cm

Fig.3 Predicted color images with different optical length values (different height of syrup in the tubular container).

3. Rectangular container as a middle-sized demonstration tool and demonstration results

For the purpose of enhancing visibility in demonstration, another demonstration tool was also prepared with acrylic plates. As can be seen in Fig.4, this tool has a shape like a rectangular container with the size of 20 cm x 20 cm x 10 cm. In the case shown in Fig.4, commercially-purchased syrup was poured into the container with the height of about 4 cm.

This rectangular container was placed over the white-color light box. A specially-arranged polarizing sheet was placed between the light box and the bottom plate of the container, in which the total of 36 pieces of the polarizing sheet were arranged in grid-pattern so that their polarizing axis rotated every 10 degrees one by one. In addition, another polarizing sheet was placed above the syrup-poured container for observation.

Fig.5(a) shows actually observed colors, while Fig.5(b) illustrates the predicted result obtained from calculation with the theoretical mathematical equation. Satisfactory matching in colors can be found between the actual observation result and the prediction.

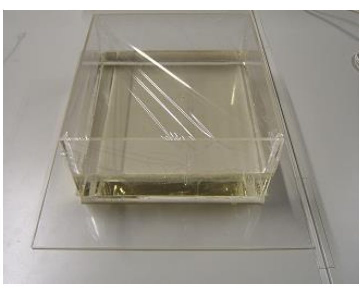


Fig. 4. A rectangular container for demonstration.

(a) actually observed colors (b) Color predictions

Fig.5 Actually observed colors and color prediction result.

4. Summary

Due to COVID-19 pandemic situation, actual demonstration activities have been suspended. After the situation is improved, these tools are being planned to be actually used for children and other audience in wider generations. Those tools are also useful for students in higher education levels to understand optical rotation phenomena.

5. References

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