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Explore the Possibility of Storm Glass to be a Weather-Thermometer

JONG, Jing-Ping*; HSIEH, Ming-Hua; CHEN, Yu-Hui; & LIN, Pei-Wen

New Taipei Municipal Jinhe High School, New Taipei City, Taiwan
E-mail: hexaphyrins@yahoo.com.tw

Abstract

Maker movement stresses using and learning practical skills and encourages novel applications. This study investigates the potential of Storm Glass to be a weather-thermometer and attempts to highlight two research questions. The first is whether the storm glass has a potential to be a weather-thermometer in our daily life. The heights of precipitation of the storm glass were recorded and then compared to the temperature on that day and the next day at the same time according to the data of Central Weather Bureau of Taiwan during August, 2013 to February, 2014. The results showed there was a high correlation between the height of crystals and the temperature on that day (r = .93) and the next day (r = .92). It reveals that the storm glass indeed has a potential to be a weather-thermometer in our daily life. Then following experiments were conducted to answer the second question, that is, which one was better for a thermometer while changing the ratio of ethanol in the storm glass solution without changing other compositions. The results revealed that there was a high correlation between the height of crystals and the temperature of thermostatic water-bath (r ranging from 0.94 to 0.99). On the basis of the results, we can select three to five different ratio of ethanol at the same time to visualize the ranges of temperature of the air to make a thermometer.
***Keywords*:** crystallization, precipitation, solubility, storm glass, weather-thermometer

Introduction

Maker is an innovative movement for integrating science, technology, engineering and mathematics. The core spirit of making is that students design, create, develop things and use them personally or for their community. Students can learn and elaborate crosscutting concepts in the process of involvement. Exploring the topic of Storm Glass involving chemistry and earth science not only develops students' inquiry competencies but also helps them understanding the history of science. A "Storm Glass" is a type of device used for the weather forecast with some evidences from its changes of the crystal shape associated with solubility. Some studies indicated that the success of prediction was no better than random probability [1-3]. Moreover, the operational variables of the above studies were crystal shapes rather than the precipitation height of the crystals. [1-3]. Other literature showed there was a

high relationship between the height of precipitation of the storm glass and the temperature of thermostatic water-bath; however, it was only short-term tests for three months [4]. So, it is emergent to record long-term data to examine the effects of Storm Glass for weather prediction. This study attempts to highlight two research questions: (1) Does Storm Glass have a potential to be a weather-thermometer in our daily life? If the answer of question 1 is yes, and then (2) how can Storm Glass be improved to be a weather-thermometer? The framework of our experiments is showed in Figure 1: the long-term data were recorded to find out the relationship between the heights of precipitation and air temperatures, pressure, and moisture. Then changing the volumes of ethanol to be a new recipe of the storm glass to demonstrate the relationship between the height of precipitation and the temperature of water-bath.

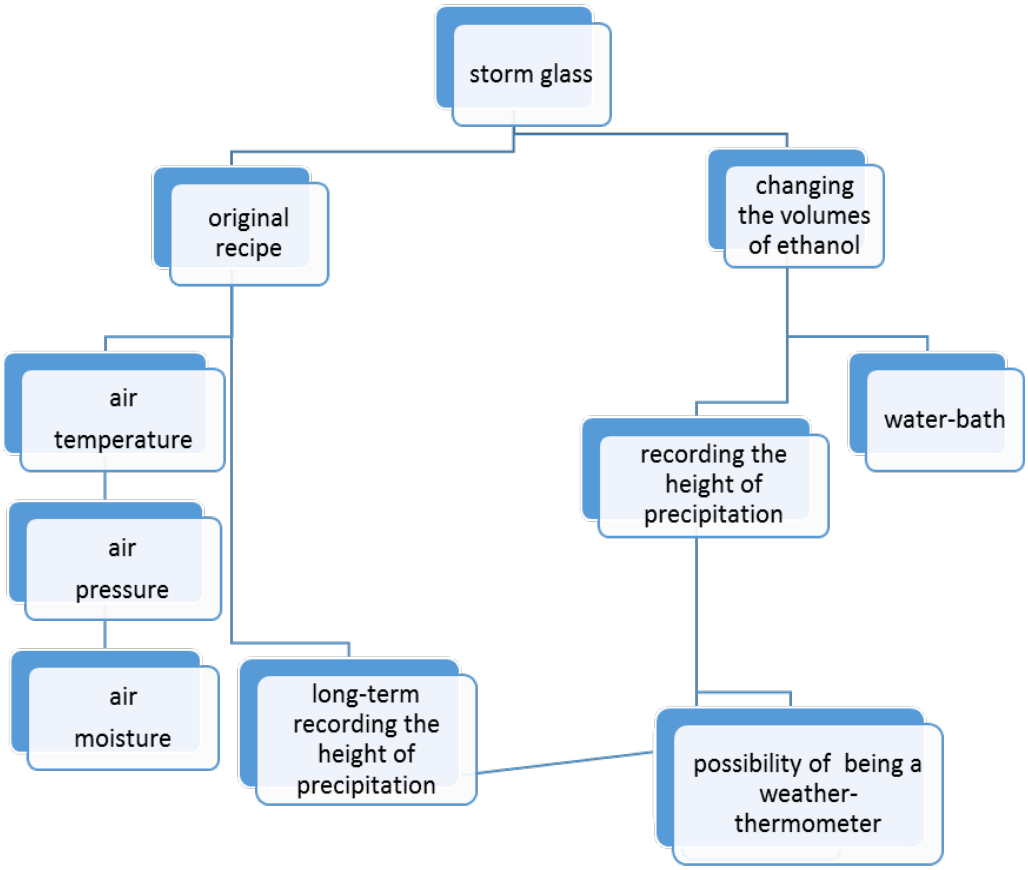

Figure 1. The framework of this study

Experimental

Materials

95% alcohol, d-camphor, ammonium chloride (NH_4Cl) and potassium nitrate (KNO_3)

were of ACS grade and were acquired from ECHO CHEMICAL. CO, LTD. in Taiwan.

Apparatus

The glass tubes [21 (diameter) X 200 (height) mm] were filled with two-thirds storm glass solution. The thermostatic water-bath (DENG YNG Water Bath D-620) was available for controlling temperature ranged from –20 to 100 °C (accuracy +/- 0.05 °C) electronically.

Solution Preparation

Experiment 1: The standard solution was prepared by mixing d-camphor ($C_{10}H_{16}O$, 10 g) with 95% ethanol (42.0 ml). Another solution was prepared by mixing ammonium chloride (NH_4Cl, 2.5 g), potassium nitrate (KNO_3, 2.5 g), and distilled water (31.0 mL). Finally, the storm glass solution was made by mixing the two solutions in a baker.

Experiment 2: Based on the standard solution, ethanol of the new prepared storm glass was changed from 37.0 to 50.0 mL without changing other compositions.

Procedures

Experiment 1: the three tubes filled with the standard solution of a storm glass were plugged with cork and placed outdoor next to windows. In order to prevent ethanol from evaporation, the storm glasses were sealed with parafilm outside the cork. The height of precipitation of the storm glass was recorded (see Figure 2) and then compared to the temperature on that day and the next day at the same time according to the data of Central Weather Bureau during August, 2013 to February, 2014.

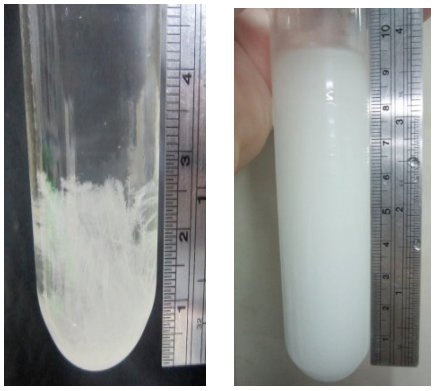

Figure 2. The measures of the height of precipitation

Experiment 2: the tubes of new prepared storm glass mentioned above were placed in a thermostatic water-bath with temperatures changing downward from 40 to 0 °C and upward from 0 to 40 °C with the rate of 2 °C per 15 minutes, and the height of crystals in the tubes was recorded (see Figure 3 and 4).

Figure 3. Thermostatic water-bath

Figure 4. New prepared storm glasses were placed in a thermostatic water-bath

Hazards

Be careful of the flammable solvent (ethanol) used in the procedure.

Results

Finding 1: the storm glass has a potential to be a weather-thermometer in our daily life

The heights of precipitation of the storm glass were recorded and then compared to the temperature on that day and the next day at the same time according to the data of Central Weather Bureau of Taiwan during August, 2013 to February, 2014 [5]. The results showed there was a high correlation between the height of crystals and the temperature on that day (r = .93) (See details in Figure 5) and the next day (r = .92) (See details in Figure 6). However, there was a low correlation between height of crystals and the pressure (See Figure 7 and 8) and moisture (See Figure 9 and 10). It reveals that the storm glass indeed has a potential to be a weather-thermometer rather than a pressure or moisture detector in our daily life.

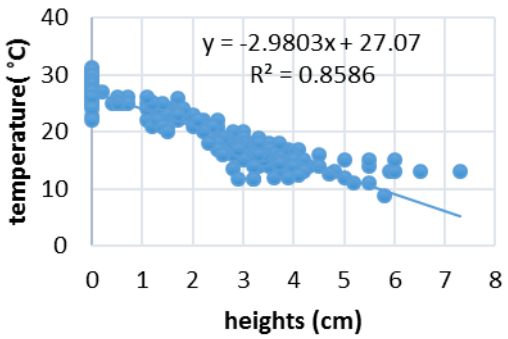

Figure 5. Relationship between the heights of crystals and temperature on

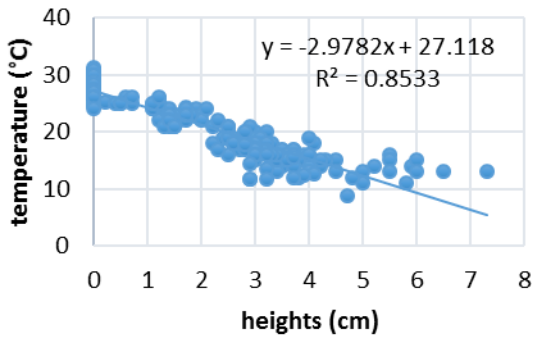

Figure 6. Relationship between the heights of crystals and temperature on the next day

that day

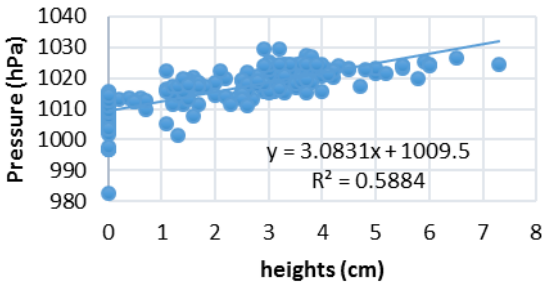

Figure 7. Relationship between the heights of crystals and pressure on that day

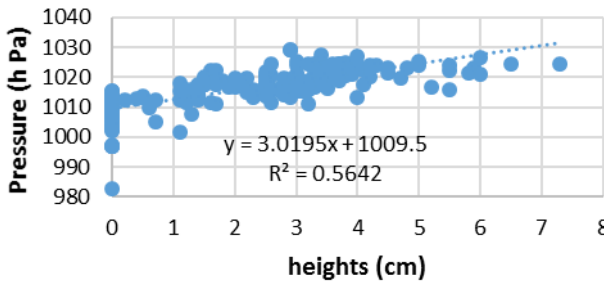

Figure 8. Relationship between the heights of crystals and pressure on the next day

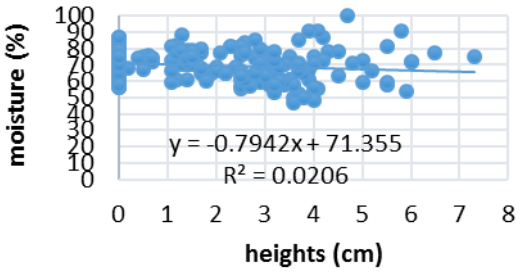

Figure 9. Relationship between the heights of crystals and moisture on that day

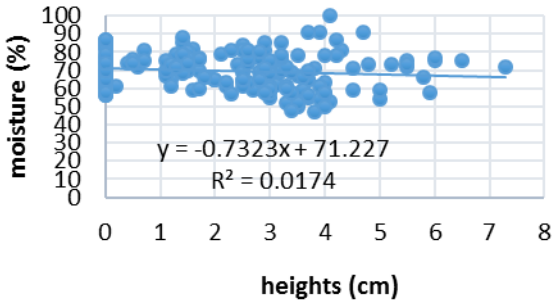

Figure 10. Relationship between the heights of crystals and moisture on the next day

Finding 2: Select different ratio of ethanol to visualize the ranges of temperature

The experiment 2 was conducted to answer the second question, that is, which recipe was better for a thermometer while changing the ratio of ethanol in the storm glass solution with the total volumes keeping constant. The results (see Figures 11 to 13) revealed that the more ethanol was, the less precipitation of the storm glass was. In the meantime, there were high correlations between the height of crystals and the temperature of thermostatic water-bath (r ranging from 0.94 at 37mL to 0.99 at 43mL and to 0.96 at 50mL volumes of ethanol).

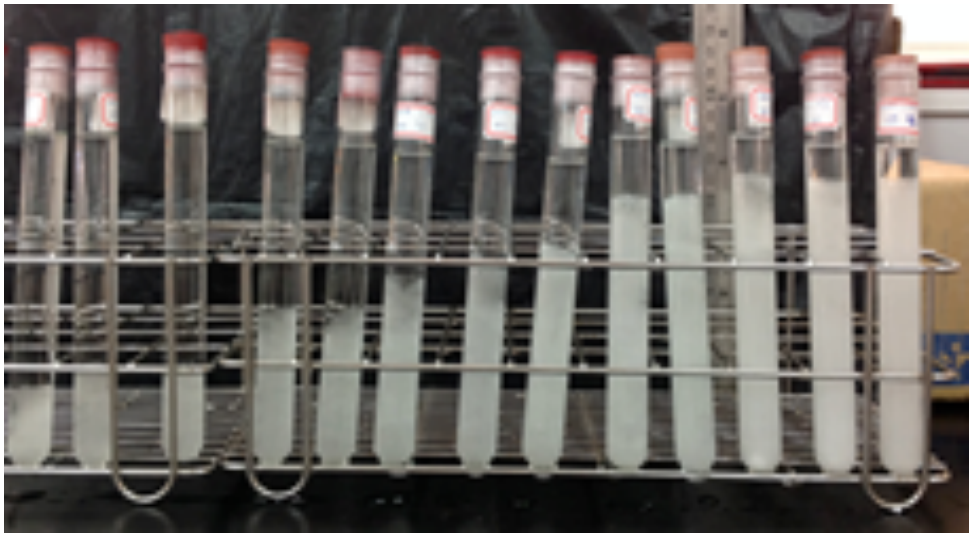

Figure 11. The height of precipitation with different ratio of ethanol in the storm glass at 16 °C.

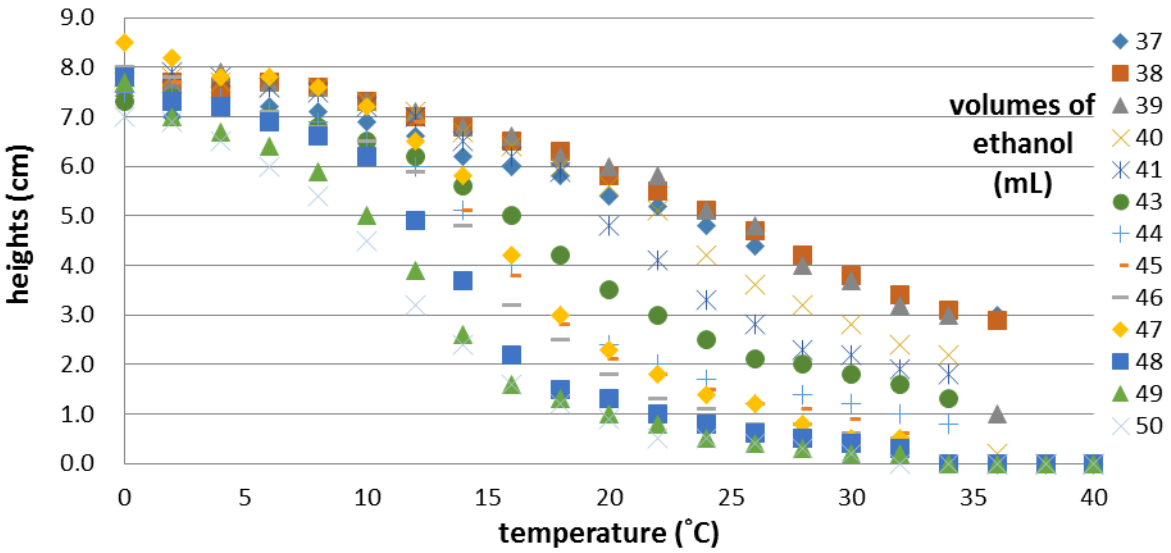

Figure 12. Relationship between the heights of crystals and different volumes of alcohol

As the Figure 12 showed that different volumes of ethanol in the storm glass solutions had different amount of rooms to dissolve solute of camphor at the same temperature. However, it was too complicated to figure out which one was better for a thermometer. In order to be recognized easily, we selected three to five different ratio of ethanol at the same time to visualize the ranges of temperature to make a thermometer. We tried to divide it into six blocks from 0 to 40°C in term of 0-6, 7-12, 13-18, 19-24, 25-30, above 30°C to form a visual scale for a thermometer. As showed in Figure 14, if the temperature is 13°C, we could easily recognize what we should wear from the visualization of temperature. On the basis of

the results, although it was not a linear relationship between temperature and the height of precipitation of the storm glass, we still can make a judgment according to the visualization of the temperature ranges.

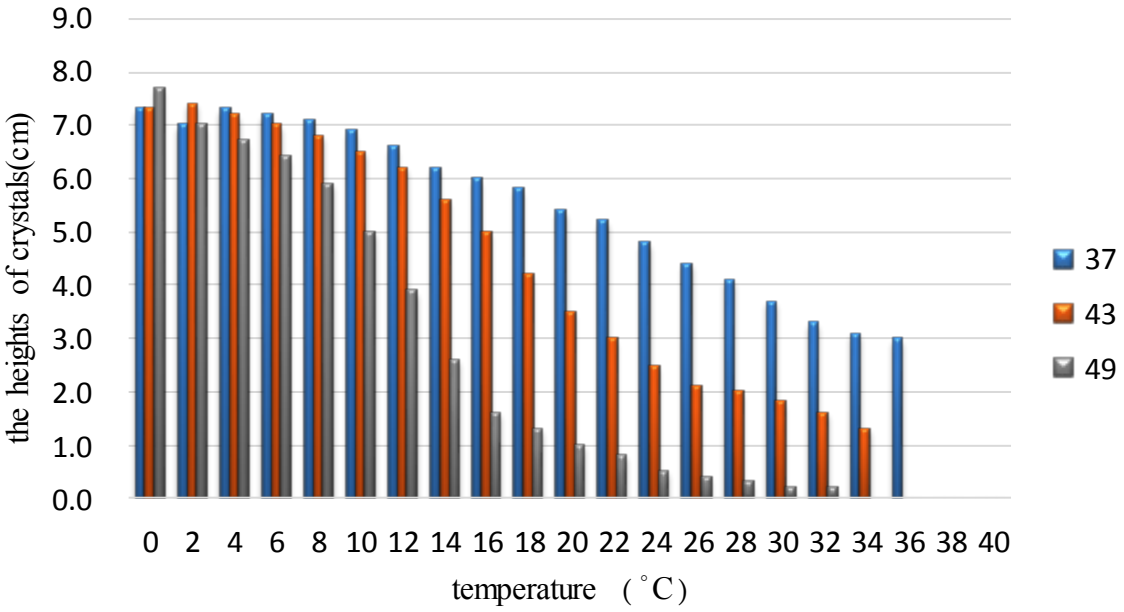

Figure 13. Relationship between the heights of crystals and selected volumes of alcohol

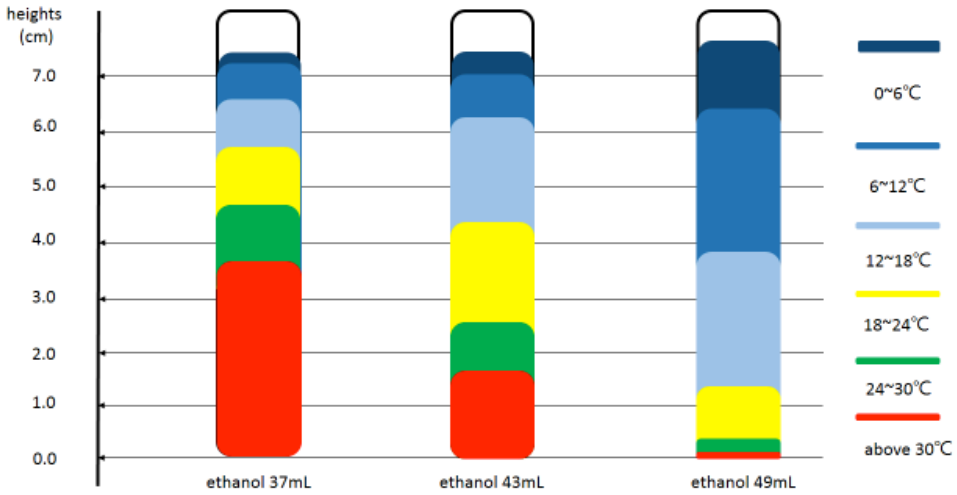

Figure 14. Visualize the relationship between the heights of crystals and selected volumes of alcohol

Discussion

Instead of short-term records, the first experiment of this study was to examine whether

the storm glass could predict the weather or not. Owing to the closed system of the storm glass, our results were similar to Nakamoto and Hiroi [6]. It is obviously that a storm glass solution are not affected by pressure and moisture [6-7]. Different from Nakamoto and Hiroi, this study recorded long-term data to examine the relationship between the heights of precipitation of the storm glass and temperature of the air. It is still worth noting that the high correlation didn't mean the success of prediction of temperature on the next day.

Based on the first finding, we argued that the solutions were in a dynamic equilibrium with temperature outside the system. That is, the storm glass solutions were in an equilibrium smoothly with outside temperature on these days. According to the findings of Jong et al. [4] and this study, the less ethanol of the solution was, the more precipitation of the storm glass was at the same temperature.

Nagashima and his colleagues [8] had changed the components to examine the appearance of camphor crystals under cyclic temperature change, but they did not further explore the application of the change of the crystals. Similar to Nagashima and his colleagues, the second experiment of this study changed the solvent of the storm glass solution. Instead of exploring the effect of crystallization and recrystallization of components, our results tried to elucidate the effects of ethanol in the storm glass solutions. Based on the results of the relationship between precipitation of the storm glass and the temperature, we also adapted the storm glass by selecting three to five different ratio of ethanol at the same time to visualize the ranges of temperature of water-bath.

Although there are already more sophisticated instruments as weather-thermometer tools, our efforts can provide another possible novel application of the storm glass based on the intuitive thinking of human being such as recommendations for wearing from the perspective of innovation. We argue that our results provide a new insight for a storm glass and it is critical for high school students that making is a means to develop a mindset rather than to create an instrument that can change the world.

Conclusions

Maker as a kind of learning emphasizes learning-through-doing in a social environment. Students could learn not only content knowledge of subjects (e.g., solution, solubility, crystal, precipitation) but also inquiry competencies (e.g., controlling variables, formulating hypotheses, experimenting, interpreting data, formulating models) from their involvements. In this study, we conducted long-term observations and changed the volumes of ethanol in the storm glass solutions to interpret the effects of the storm glass as a weather forecasting tool. It reveals that the storm glass indeed has a potential to be a weather-thermometer in our daily life. In the future, we will try to be a maker to modify the weather-thermometer.

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