

Measurement of Concentration Distribution Between Two Layers Using Laser Light

Zeze High School Group B

In this research, concentration distribution of sodium chloride solution was explored using the refraction of laser light. We found out that the concentration of the sodium chloride solution does not distribute equally.

Background

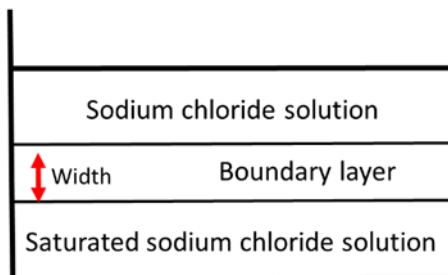
We became interested in the mechanism of mirage. It was caused by the refraction of light. The refraction happened because of the difference of air density by temperature. Sodium chloride solution is used in this research because gas was too unstable to duplicate mirage. To find out the structure of the boundary layer of two different temperature air layers of the mirage, we investigated the concentration from the refraction index in the sodium chloride solution.

Purpose

The purpose of this research is to investigate the concentration distribution of sodium chloride solution in water using the change of reflective index of the laser light.

Definitions

The black part in the photograph below between the blue solution and the light blue solution is defined as a boundary layer in this research.

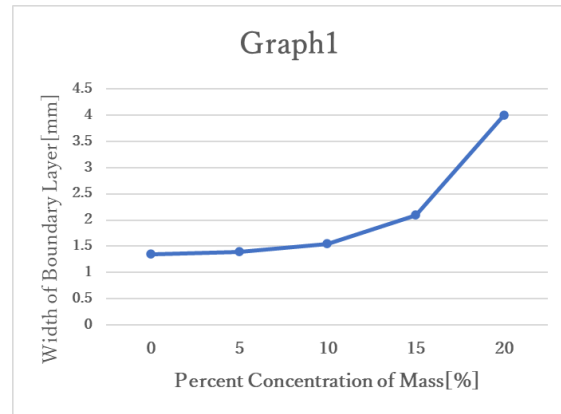


Preliminary Experiment and Results

1. Colour sodium chloride solution* blue.
2. Pour colloidal saturated sodium

chloride solution and uncoloured saturated sodium chloride solution into the water tank.

3. Stop pouring when the boundary layer becomes visible.
 4. Measure the width of the layer.
- * Experiment with each of the following percentage concentration of mass. (0%, 5%, 10%, 15% and 20%)

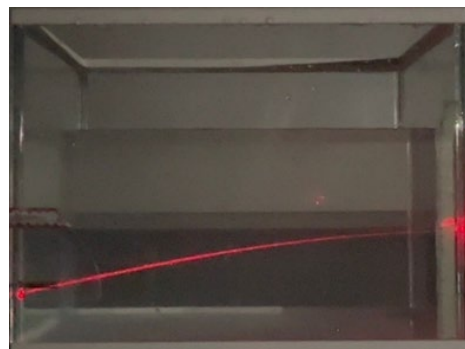


From the experiment the boundary layer becomes wider as the concentration of the sodium chloride solution becomes closer to the saturated solution.

Experiment

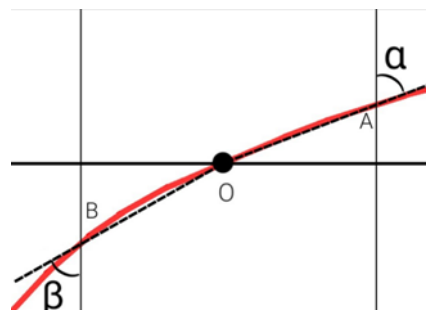
〈Measurement Methods〉

1. Pour 4kg of colloidal sodium chloride solution* into the water tank.
2. Pour colloidal saturated sodium chloride solution into the tank.
3. Radiate laser light from below the layer.
4. Take a photograph of the path of the laser light.



- Divide the boundary layer into equal parts from the top to the bottom in each photograph and draw border lines.
- Draw points where the path of the laser light and border line intersect. (This intersection is O.)
- Draw vertical lines, one on the left side and one on the right side of each intersection.
- Draw points where the path of the laser light and the vertical line intersect. (The intersection on the right side is A and the intersection on the left side is B.)
- Draw OA and OB. (The angle between the border line and OA is α and the angle between

- the border line and OB is β .)
- Measure the angle of α and β , and (calculate the average of α and β).
* Experiment with each of the following percentage concentration of mass. (0%, 5%, 10%, 15% and 20%)



Results

0%	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
α	79.750	77.875	80.750	79.500	82.000	81.500	83.250	82.500	85.500
β	79.000	80.125	79.875	81.167	82.167	79.250	82.500	85.000	86.000

5%	0.0	0.5	1.0	1.5	2.0	2.5	3.0
α	77.000	78.750	77.250	77.500	78.250	80.750	76.500
β	77.167	78.667	79.833	79.167	80.500	82.667	83.500

10%	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
α	77.875	78.125	79.125	79.000	80.750	80.750	81.167	81.250	79.500
β	75.250	79.625	80.125	80.875	79.250	81.000	82.167	81.000	82.000

15%	0.0	0.5	1.0	1.5	2.0	2.5	3.0
α	82.500	81.875	81.375	83.000	80.000	80.250	81.750
β	79.625	79.875	81.125	80.500	80.000	79.250	81.000

Discussion

From the results, we predict that there was a layer with higher concentration compared to the layer below because the saturated solution hit the side face of the water tank, raised, spread in the layer.

Conclusion

In this research we found out that a comparatively higher concentration layer was formed in the upper half of the boundary layer. We predict that this is caused by the side faces of the water tank. This is unlikely to happen in the air when mirage is formed.

Challenges

It is likely that the results of this research were affected by the water tank. The refraction index is not accurate because the angles to calculate the index were measured in a photograph. There

also is uncertainty in the values because the concentration distribution in the liquid varies with time.

Prospects

We want to do this experiment with a larger water tank so that we can get more accurate data that can correspond with the phenomenon happening in the mirage because the results of this research were affected by the side faces of the water tank.

Based on the analysis of the density distribution between the two solution layers in this study, we would like to clarify the density distribution of the air, i.e., the temperature change when a mirage occurs in the air.

References

- 「蜃気楼の原理 室内で蜃気楼発生中！ No.245」 <http://site.ngk.co.jp/lab/no245/> (Visit the site on 2023/11/06)
「てん菜のあれこれ」(農畜産業振興機構) https://sugar.aloc.go.jp/tisiki/ti_0108.htm (Visit the site on 2024/2/4)
『蜃気楼のすべて！』(日本蜃気楼研究会)

Acknowledgements

We received a lecture on mirage from Mr. Kazuyuki Matsui, Biwako Regional Environmental Education Research Association. We also received guidance and support from teachers in charge of the project in ZEZE High School and graduate members.