# Optical Activity

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7 November 2021

## 1 Introduction

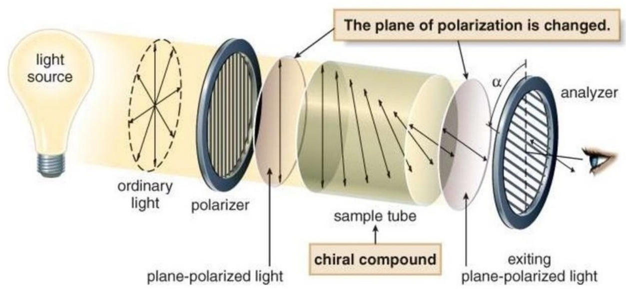
Examining the interaction of light with substances can reveal to us the intrinsic properties of the molecules and thus it has great applications in biology and chemistry. In this experiment, we examined the optical activity in maple syrup. Specifically, we observed an increase in the rotation angle as the density of the syrup increased.

## 2 Theory

Chiral molecules are the type of molecules that can not be superimposed to their own mirror image by rotation and translation mappings[1]. The concept of chirality is a concern of knot theory (hence topology) whereby a knot is defined as the embodiment of a circle into the three-dimensional euclidean space. Chiral molecules have the same chemical formula but the optical properties of these are different. On the macroscopic scale, human hands or screws are a great analogy to understand chiral molecules. Thus we can conclude that the enantiomer molecules can be separated into two namely right-handed and left-handed. It should be pointed out that the circularly polarized light also shows chirality.

Optical activity can be described as the change of linear polarization of the light when it interacts with an optically active medium. Optically active mediums are composed of chiral molecules. Depending on the dominance of one of the types of chirality, we observe a change of linear polarization of the light (see figure below). Any linear polarization can be represented as the superposition of two circularly polarized lights. The result of being the media chiral manifests itself in different refractive indexes for right and left circularly polarized light causing phase shift between these. The output thus will be the change of linear polarization. The change of linear polarization thus depends on the optical path length and in our experiment the concentration of the solution. Hence the linear relation of the degree and concentration is given by the following equation.

$$[\alpha] = \frac{\alpha(deg)}{L(dm) * C(\frac{g}{ml})} \tag{1}$$

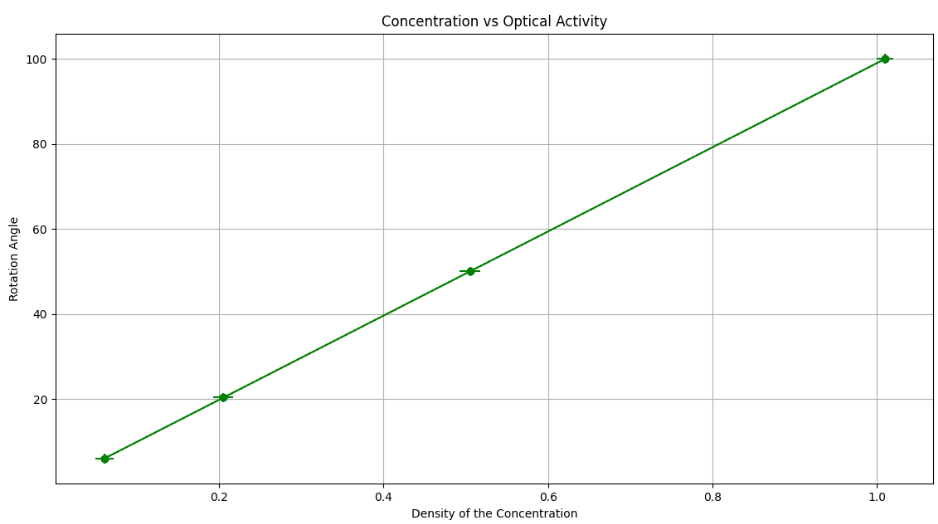



# 3 Results

The length of the tubes $L = 1dm$ is the same for all measurements. For the calculation of the error bars and the concentration of the solution, it is assumed measurement devices have normal distribution error, thus making the same measurement reduced the error proportional to $\sqrt{n}$.

The slope of the best line gives us the rotation power since $L$=1dm. Thus the rotation power is $[\alpha] = 100$

| Solution Number | $\theta_1$ | $\theta_2 - 180°$ | $\theta_3$ | Averages |
|---|---|---|---|---|
| 1 | 100° | 100° | 100° | 100° |
| 2 | 50° | 50° | 50° | 50° |
| 3 | 20° | 21° | 20° | 20.33° |
| 4 | 6° | 6° | 6° | 6° |



# 4 Discussion

The rotation direction of the light and thus the solution's chirality character is deduced from the fact that the iterative relation between rotations and the density of the solutions. We observed, looking from the table, rotation of the light to be clockwise from towards thus the solution is dextrorotatory. During the calculation of the density of the tubes other than tube number one, we just considered the linear relationship between the angle and concentration hence ignoring the higher-order terms assuming the irradiance of the laser low enough.

According to the table for some chemical substances[2] this does not correspond to a specific molecule. Possible errors can cause such a situation. Maple syrup contained some particles which are not sugar. The dextrorotatory effect therefore could be reduced or increased due to imperfection. And since our polarizers were imperfect full absorption of the light was not possible. While measuring the rotation angle we looked at the minimum brightness with the naked eye thus human error is involved.

Although the specific substance is unknown from the data that has been gathered, it can be said that the linear theory of the optical activity for this sample and this energy regime is valid.

# 5 References

1- https://en.wikipedia.org/wiki/Optical-rotation
2- R. C. Weast (1974). Handbook of Chemistry and Physics (55th ed.). CRC Press.