CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)
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Project Number
J1805

Project Title
Index of Refraction: Correlation with Chemistry and Density

Abstract

Objectives/Goals
Objective is to determine correlations between the index of refraction (IOR) and density and chemistry. The initial hypothesis was that denser liquids will have higher IORs because as density increases, there will be more absorption between light and liquid molecules.

Methods/Materials
Density was measured using a calibrated laboratory scale and IOR was measured using a laser pointer for ten liquids in two categories, water-based and oil-based. Each was measured at three incident angles, and IOR was calculated using Snell's Law. A total of 48 tests were done on three test dates.

Results
Data was plotted (x-axis = density, y-axis = IOR). The initial regression showed a negative correlation for all 10 liquids, but I noticed that water-based and oil-based data grouped together independent of each other. By running linear regressions separately on each subset (water-based and oil-based), I found positive correlations between IOR and density with good values for r^2 even with relatively small sample sizes (5 each).

Conclusions/Discussion
My conclusion is that the basic chemistry of the liquid is the most important factor affecting the index of refraction, and that density is second. This is because some molecules are more likely to absorb laser light than others, independent of density, meaning, that a lighter liquid such as oil will have a higher IOR than a heavier liquid like tap water. Yet, within a subset of liquids with common chemistry, the IOR vs. density correlation holds.

Thus, liquids with simple molecules (e.g., water-based liquids where the primary constituents are oxygen and hydrogen in a 1:2 ratio) are less likely to absorb light than more complicated molecules (e.g., oil-based molecules where the primary constituent are oxygen, carbon, and hydrogen in a 1:8:9 ratio).

My results contain one outlier, silicone oil, but the chemistry differences are marked enough with the other oils that I am confident declaring silicone oil as belonging to a third chemistry type.

Summary Statement
I measured the density and index of refraction of ten liquids (48 total tests) to determine that a liquid's index of refraction correlates with molecular structure (e.g., chemistry) first and density second.

Help Received
Father helped with experiments and research; mother helped with poster; science teacher let us use her scale.