# 1. Introduction:

A child's development and growth are significantly influenced by their toys. Toys have always had an educational function in children's lives. An item for children to play with is what the Oxford Dictionary defines as a toy (Soanes, 2003). Toys continue to be popular even if the time has passed. I wanted to purchase my nephew a toy for his fourth birthday as a birthday present. When I was searching for one, I discovered that some of them had signs indicating they did not contain harmful ingredients. I did some research and discovered that wood is the safest material for toys, so I got an animal figurine. I was able to solve my immediate problem, but I was still concerned about a toy's potential toxicity. Even though there were other elements that were harmful for children, lead drawn much attention.

When combined with polymers, lead has a variety of uses, but it is harmful to people, especially young children. It irreversibly damages the nervous system and brain. Toys are rarely mentioned as a source of lead exposure in many publications, despite the fact that several epidemiological studies on the health consequences of lead on children have been published (Coyle et al., 2005). After that, I looked into why lead is used in polymers, and a component called pigment caught my eye. Then, since my younger brother was still playing with my childhood toys, I made the decision to check different colored legos' lead content. As a result, I decided to focus on the following question:

*What is the connection between the various colors of toys from the same brand and their UV-VIS spectroscopy-measured lead content?*

## 1.1 Background Information:

Lead (Pb), a heavy metal, has an atomic number of 82. Lead is both neurotoxic and poisonous. Pb is often used in polymers as flame retardant, UV stabilizer, pigment, and filler. Frequently, the components are provided in the form of substances that don't attach to polymers but instead create a suspension that can eventually separate from the plastic matrix. Plastics are lead-treated and colored in order to protect them from chemical degradation.

Many different mechanisms of lead toxicity have been proposed, including lead binding to proteins' sulphydryl (SH) groups. Lead displaces calcium and zinc in proteins. It has an affinity for cell membranes and interferes with mitochondrial oxidative phosphorylation. Also it inhibits DNA repair and has genotoxic effects. Furthermore lead affects sodium, potassium, and calcium levels (Centers for Disease Control and Prevention, 2020). Since there is no qualitative evidence in the literature indicating what exact concentration of lead is toxic, any lead present is considered harmful to the targeting consumers.

The methods used in this investigation are listed here. The Beilstein test is applied in this investigation to initially identify the polymer. Then, liquid samples of solid samples are produced by acid digestion. Finally, lead concentration was measured using UV-VIS spectroscopy.

## The Beilstein Test

The Beilstein Test was developed by the chemist Friedrich Konrad Beilstein. A simple qualitative approach can be used to distinguish organic halides. To begin with, a kerosene burner is used to heat a copper wire. This process causes the copper to oxidize. At 300 degrees Celsius, the following ions can form most effectively:

$$Cu + O_2 \rightarrow CuO \quad (1)$$

Following that, the melted materials were transferred to the heated wire that was dipped into the sample. The kerosene burner is then fired once again. If the observed flame is green or blue, it is possible to suggest that halogenic chemicals are present (Beilstein, 1872).

## Acid Digestion

Acid digestion, or in other words, wet ashing is a typical method for creating heavy metal solutions from solid material. The sample can be dissolved in a solution in this manner. In this process, a beaker containing the sample is added to in turn with hydrogen peroxide, hydrogen nitrate, and hydrogen chloride. To hasten the process, the beaker has to be heated (Kimbrough & Wakakuwa, 1989). The solution has become prepared for use in UV-VIS spectroscopy after filtering.

## UV-VIS Spectroscopy

Its full name is ultraviolet-visible spectroscopy (UV-VIS). This absorption spectroscopy examines a portion of the electromagnetic spectrum's ultraviolet and visible regions. Given that it is fairly priced and easy to use, this approach is commonly used in a number of practical and fundamental applications. The energy difference between two separate chemical orbitals of the chromophore, a component of the molecule responsible for its color, is within the range of the visible spectrum. As a result, the chromophore may efficiently transition an electron from the ground state to the excited state so that it can absorb visible light. The Beer-Lambert equation states that a solution's absorbance is directly proportional to the path length and the concentration of the absorbing species present in the solution. The approach is often used quantitatively, utilizing the equation, to evaluate concentrations of an absorbing species in solution. The Beer-Lambert equation is as follows (Karge et al., 2004):

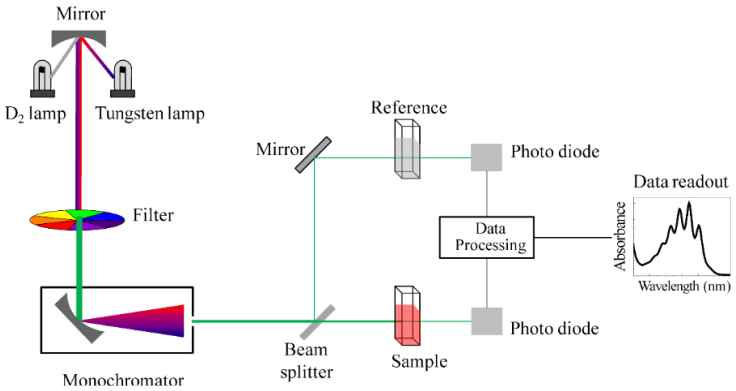



*Figure 1 A visual illustration of the spectroscopic procedure (Sobarwiki, 2013)*

$$A = \log\left(\frac{I_O}{I}\right) = \varepsilon CL \quad (2)$$

Where,

$A$ = Measured absorbance

$I_o$ = The monochromotic light's intensity in wavelength form before the sample (nanometer)

$I$ = The monochromotic light's intensity in wavelength form after the sample (nanometer)

$\varepsilon$ = The material's molar attenuation (reducing in the strength of the signal) coefficient
$C$ = The absorbing sample's molar concentration
$L$ = Path length (width of the cuvette) through the sample

In order to obtain the reference points, a sample of one material in a range of concentrations is first placed inside the spectrometer. The calibration curve is sketched using reference points. The experiment is then performed using the same wavelength interval as it used for the first sample, but with samples of unknown concentration levels. The concentration values of the samples are read when the experiment is finished while taking the calibration curve into account. This conclusion is quantitative, and analytical chemistry often uses this technique.

# 2. Hypothesis

In most cases, lead may be discovered in PVC-made toys. Lead is used to colorize polymers and make them more flexible. Varied colors of the same brand toy will have distinct lead concentrations when measured by UV-VIS spectroscopy if each color contains a different pigment and different ingredients.

# 3. Methodology

The same toy, but in five different colors, is utilized as samples in this experiment. After the samples have gone through the acid digestion and Beilstein test processes, the concentration is determined using UV-VIS spectroscopy.

## 3.1 Variables

Independent Variable: Color of the same brand toy.

- As a sample, legos that have been painted in the colors blue, yellow, green, white, and red are selected as a sample.

Dependent Variable: Concentration of Lead.

- The concentration value is directly proportional to the absorbance value as it seem in Equation (2), which is calculated after the experiment. This technique makes it possible to calculate the lead concentration in each sample.
- The absorbance value is presented in $\pm$ 0.001 λ form using UV-VIS Spectroscopy.

Controlled Variables are listed in the Table 1 below:

*Table 1 The list of controlled variables with their effect on data and the method for controlling the variable.*

| Controlled Variable | Effect on the Data | The Method for Controlling the Variable |
|---|---|---|
| Weight of the samples | For the experiment to produce accurate lead concentration data, each sample's weight must be the same. | Using an electronic scale (± 0.0001 g) on a stable surface without the presence of external factors like wind. |
| Surface area of the sample | Sample surface area must be constant since it influences response rates. | Using a ruler (± 0.1 cm) to cut identical piece of sample |
| Time taken to experiment happen | The amount of uncontrolled evaporation depends on how long it takes to heat or cool the solution. | Stopwatch (± 0.01 s) |
| The concentration of solutions | The rate of reaction is influenced by the solution's concentration. | The same concentrations solutions are used. |
| The volume of the solutions | The volume of solution effects the rate of reaction. | Graduated pipette (± 0.05 $cm^3$) |

| | | |
|---|---|---|
| The temperature of the heating solution | The temperature effects the rate of reaction. | Infrared thermometer (± 0.1 °C) |
| Equipment used | The use of different pieces of equipment could make random error higher. | The same equipment is used. The equipment is first cleaned with distilled water and ethanol if it has to be reused. |
| Room pressure | They have an effect on how much of the solution evaporates and how quickly a solution heats up. | The laboratory where the experiment is being conducted had no open windows. |
| Room temperatue | | A thermometer made sure there wasn't a big temperature fluctuation. |
| Filtration | Using filters with varied hole sizes affects how much liquid solution is formed in the end. | The same filter paper is used. |

## 3.2 Apparatus

Table 2 below includes a list of the apparatus used in the experiment.

*Table 2 List of used reagents and equipment. Equipment used for quantitative reasons is given along with its level of uncertainty.*

| Reagents | Equipment / Equipment with it's Uncertainty | |
|---|---|---|
| 5 x 20 ± 0.01 cm of Copper Wire | Kerosene Burner | 5 x Watch Glasses |
| 250 ± 0.0001 g mg of Lead Nitrate | Fire Resistant Gloves | Stopwatch (± 0.01 s) |
| 5 x 15 ± 0.2 $cm^3$ mL of Nitric Acid | 5 x Erlenmeyer Flask | UV-VIS Spectroscopy |
| Distilled Water | 10 x Volumetric Flask (50.00 ± 0.01 $cm^3$) | Safety Goggle |
| 5 x 6 mL ± 0.2 $cm^3$ of Hydrogen Peroxide | Ruler (10.0 ± 0.1 cm) | Latex Gloves |
| 5 x 10 mL ± 0.2 $cm^3$ of Hydrochloric Acid | Electronic Scale (± 0.0001 g) | Fume Hood |
| | Infrared Thermometer (± 0.1 °C) | Laboratory Coat |
| | 5 x Beaker (50 cm) | Spatula |
| | Graduated Pipette (5.00 ± 0.05 $cm^3$) | Scissor |
| | Graduated Cylinder (10.0 ± 0.2 $cm^3$) | Funnel |
| | Laboratory Electric Hot Plate | Filter paper |

## 3.3 Procedure

This study aims to evaluate the relationship between a toy's color and its lead concentration. First, the Beilstein test is used to determine whether the toy is made of plastic. Afterthat five solutions with varying concentrations of lead are prepared. Then the absorbance value is determined using UV-VIS spectroscopy, which is done to be used as reference points. Then, in the same lego set, painted pieces in the colors of blue, yellow, green, white, and red are chosen as samples. Each sample is put through the Beilstein Test first, and then it is prepared to be a solution for UV-VIS spectroscopy. Acid digestion of materials is done to produce a solution. Quantitative findings are obtained for the lead levels of each sample using UV-VIS spectroscopy.

The solutions are prepared using the unit "ppm" which the term to represent "parts per million". It is equal to the mass ratio of solute and solution in gram and this value is multiplied by $10^6$. Uncertainty for mass of solute is $\pm 0.0001\ g$ and volume of solution is $\pm 0.05\ cm^3$.

$$ppm = \frac{mass\ of\ solute\ (g)}{mass\ of\ solution\ (g)} \times 10^6 \quad (3)$$

Example Calculation 1: Finding the ppm value of the prepared solution

$$\frac{0.25}{50\ cm^3 \times 1\ g/cm^3} \times 10^6 = 5000\ ppm \quad (4)$$

Example Calculation 2: Associated Uncertainty Calculation

$$\left(\frac{\pm 0.0001}{0.25} \times 100\right) + \left(\frac{\pm 0.05}{50} \times 100\right) = 0.14\% \quad (5)$$

### 3.3.1 Preparation of Various Lead Nitrate Concentrations for Reference

1. In a 50 ± 0.01 $cm^3$ volumetric flask, 250.0000 ± 0.0001 mg of lead nitrate $Pb(NO_3)_2$ are first added.
2. The volumetric flask is then filled to a height of 50.00 ± 0.05 $cm^3$ with distilled water.
3. A solution volume of 25.0 ± 0.1 $cm^3$ is transferred to another volumetric flask using a graduated pipette.
4. Steps 2 and 3 are repeated up until the sixth volumetric flask.
5. As a consequence, lead-contained solutions with concentrations (0.14%) of 5000.0 ppm, 2500.0 ppm, 1250.0 ppm, 725.0 ppm, and 362.5 ppm are prepared.

### 3.3.2 Getting Absorbance Value Based on Prepared References for UV-VIS Spectroscopy

1. A reference cuvette is filled with diluted water, and a sample cuvette is filled with lead nitrate solutions of varying concentrations.
2. The absorbance value graph (calibration curve) is produced.

### 3.3.3 The Beilstein Test

1. Copper wire heated to 300.0 ± 0.1 °C is dipped into the sample.
2. Following that, a copper wire is placed on a kerosene burner.
3. The change in the flame is observed.

### 3.3.4 Acid Digestion

1. 1.0000 ± 0.0001 g of each toy with a distinct color is sampled, and it is then cut into smaller pieces with scissors.
2. 10.00 ± 0.05 $cm^3$ of hydrogen nitrate ($HNO_3$) is added using a graduated cylinder to samples in a 50 ± 0.01 $cm^3$ $cm^3$ beaker. Watch glass has been placed over the beaker.
3. The sample is heated on an electric hot plate when the temperature of the hot plate is 75.0 ± 0.1 °C. Sample is cooked for 15 minutes, then let to cool for 10 minutes.
4. A graduated cylinder is used to pour 5.00 ± 0.05 $cm^3$ of hydrogen nitrate ($HNO_3$) into the same beaker. Watch glass has been placed over the beaker.
5. When the hot plate is heated to 75.0 ± 0.1 °C, the sample is heated there for 30 minutes. The sample is given 10 minutes to cool down before being used.
6. A solution of 3.00 ± 0.05 $cm^3$ hydrogen peroxide ($H_2O_2$) and 2 ± 0.05 $cm^3$ distilled water is prepared on a graduated cylinder. After that, this is added to the beaker.
7. When the hot plate is heated to 75.0 ± 0.1 °C, the sample is heated continuously. 1.00 ± 0.05 $cm^3$ of $H_2O_2$ is added to the beaker after 10 minutes. This step is repeated until there are no more changes on solution.

8. Sample is heated continuously on an electric hot plate at 75.0 ± 0.1 °C until the solution does not exceed 10 $cm^3$ in volume. Then, the beaker is allowed to cool.
9. Hydrogen chloride ($HCl$), measured using a graduated cylinder, is poured into the beaker in an amount of 10.00 ± 0.05 $cm^3$.
10. The sample is heated for 15 minutes on an electric hot plate at a temperature of 75.0 ± 0.1 °C.
11. Using filter paper and a funnel, the digested mixture is collected in an Erlenmeyer flask.
12. For each set of five samples, all procedures are repeated.

### 3.3.5 Calculating Lead Concentration in Samples Using UV-VIS Spectroscopy

1. The sample cuvette is filled with the sample solutions, and the reference cuvette is filled with diluted water.
2. The absorbance value graph is produced.
3. The obtained values are compared with the calibration curve, and the final concentration values are found.

## 3.4 Modification of the Process

The majority of the existing analytical methods for lead (Pb) use graphite furnace atomic absorption spectroscopy, inductively coupled plasma-mass spectrometry, inductively coupled plasma-optical emission spectroscopy, and atomic absorption spectroscopy. However, those procedures require expensive machinery and highly skilled operators. In addition, those approaches need substantially more preparation for the sample and calibration (Hee & Boyle, 1988).

Beer-Lambert Laws state that light will encounter scattering, reflection, or absorption as it passes through a material in the UV-VIS spectroscopy technique. Depending on the sample concentration and the distance that the light must travel through, the output light's intensity will decrease. With this in mind, it would be possible to use UV-VIS spectroscopy to measure the concentration of substances without a challenging experimental process. Additionally, in our experiment, the samples are solid; but, in order to employ UV-VIS spectroscopy, they must be in solution form, which is produced via an acid digestion procedure (Tan et al., 2014).

## 3.5 Health and Safety Risk Assessment

Table 3 lists several chemicals along with any potential health risks they cause. Precautions are taken as mentioned in the table below to avoid any health issues in laboratory when working with chemicals and equipment.

*Table 3 Health and Safety Risk Assessment Table.*

| Chemical/Equipment | Potential Harm to One's Health and Safety | Taken Precautions |
|---|---|---|
| Lead (Pb) | Particularly in young children and pregnant women, lead causes damage to the brain and nervous system. It is a large, highly toxic metal. | In order to prevent injury from chemical vapour and to be secure when a chemical is thrown,<br>- latex gloves,<br>- a surgical mask,<br>- a safety goggle,<br>- a lab coat are worn. |
| Nitric Acid ($HNO_3$) | They are strong acids with low pH values. Acids can injure skin by resulting in severe burns and tissue damage, and their fumes can | |

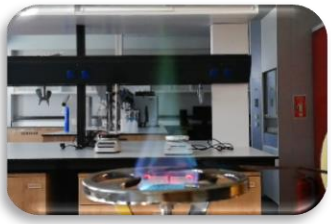
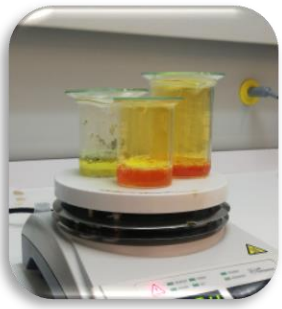
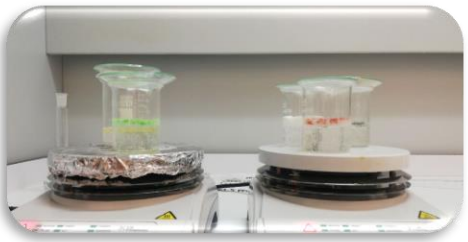
| | | |
|---|---|---|
| Hydrochloric Acid ($HCl$) | impair the respiratory system and the eyes. Additionally, they could strongly react with other substances. | The interaction of chemicals with my skin is avoided in this way. I was not permitted to enter the lab without my supervisor's approval. I frequently take a pause to prevent being exposed for too long. In order to prevent any unwanted chemical reactions, used equipment is cleaned using distilled water and ethanol. The purpose of an infrared thermometer is to measure temperature, not to get closer to the reaction. |
| Hydrogen Peroxide ($H_2O_2$) | The respiratory system is permanently harmed by high exposure levels. It may cause a serious allergic reaction. | |
| Kerosene Burner | Risk of fire and explosion, as well as its effects. | |

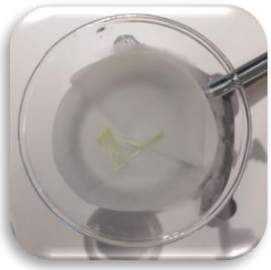
# 4. Analysis

## 4.1. Qualitative Data

In this section for each sample the aquaired qualitative datas are Table 4 below:

*Table 4 Experimental qualitative data.*

| | |
|---|---|
| The Beilstein Test's color change: When the procedure was used, all samples (blue, yellow, green, white, and red) produced a greenish hue on flame. Nothing differentiated any of the samples; the reactions were all identical. |  |
| The solution's hue changed to brown after adding nitric acid to the beaker containing the sample, and after some time, a brown gas was seen. The observed brown gas density was in the following order, from highest to lowest: green, red, yellow, white, and blue. |  |
| After adding hydrogen peroxide to the beaker containing the sample, the color of all solutions changed to colorless. |  |
| After adding hydrochloric acid to the beaker containing the sample, the color of the solution changed to a yellowish orange, and an orange gas was observed. Orange concentration was greater in the following order: green, red, yellow, white, and blue. |  |

| | |
|---|---|
| Because of the color of the solution, the color of the solid samples could not be seen. After the solutions were filtered, the remaining pieces were white. |  |
| The filtered solution for each sample was colorless. |  |

Studying Table 4 reveals that each sample has a halogen group, which in this case is most likely PVC as the Beilstein test identified this for each sample. The white solid pieces that remained after the final solution was filtered showed that the acid digestion process completely transferred the paint on the toy to the solution.

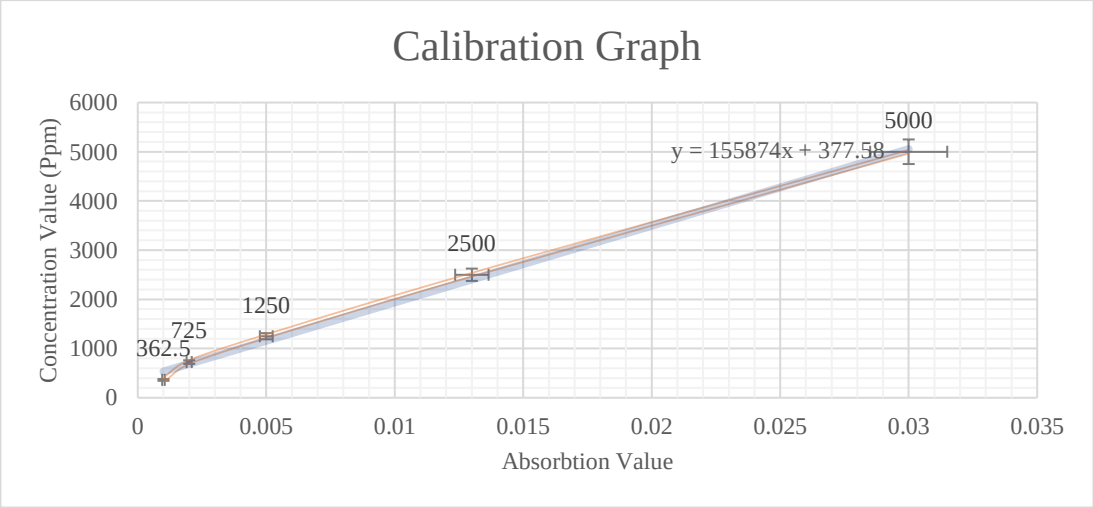
## 4.2. Quantitative Data

Table 5 below lists the measured quantitative data for each sample in this section.

*Table 5 Absorption value for prepared lead nitrate solutions as well as sample solutions.*

| **Preapared Lead Nitrate Solutions** (0.14%) | 5000.000 ppm Lead Nitrate | 2500.000 ppm Lead Nitrate | 1250.000 ppm Lead Nitrate | 725.000 ppm Lead Nitrate | 362.500 ppm Lead Nitrate |
|---|---|---|---|---|---|
| **Absorption Value** | 0.030 | 0.013 | 0.005 | 0.002 | 0.001 |
| **Sample Solutions** | Blue Sample | Yellow Sample | Green Sample | White Sample | Red Sample |
| **Absorption Value** | 0.010 | 0.042 | 0.110 | 0.023 | 0.062 |

Using the values on Table 5, Graph 1 which is calibration graph generated.




*Graph 1 Graph of calibration produced using Table 5. The trendline is shown by a black linear line.*

## 4.3. Processing Data

The data from the generated lead nitrate solutions are first used to create Graph 1, which shows the trendline. Instead of relying solely on the absorbance value, it would be possible to calculate sample concentrations this way.

$$y = \left(1.559 \times 10^5\right)x + 377.6 \quad (6)$$

Where,

$y$ = Concentration value (ppm)

$x$ = Absorbtion value

This equation is linear, hence it will be used to calculate the value of x or y. When absorbtion values from sample experiment results are factored into the equation, the Table 6 is generated.

## 4.4. Processed Data

*Table 6 Acquired absorbtion values are entered into the Equation (3) to determine concentration.*

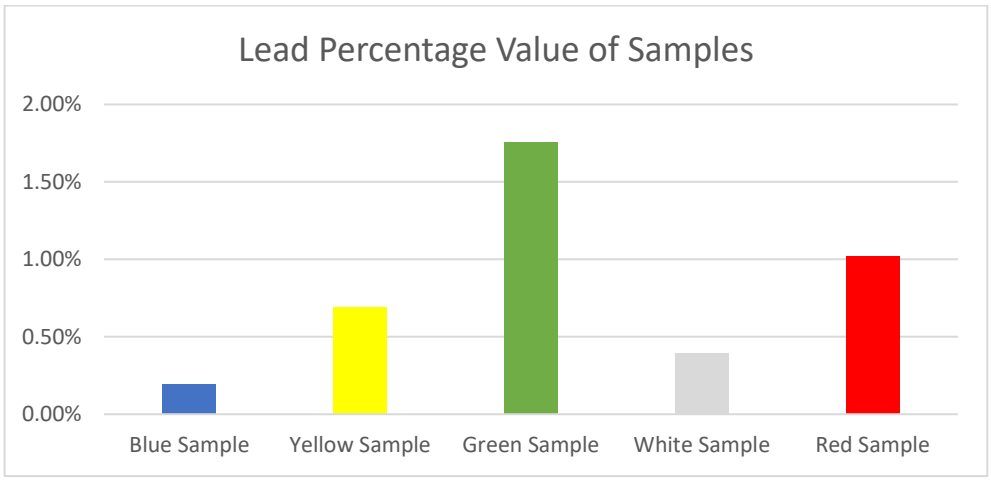
| **Samples** | **Result $\pm 0.001$** |
|---|---|
| Blue Sample | 1936.600 ppm |
| Yellow Sample | 6925.400 ppm |
| Green Sample | 17526.600 ppm |
| White Sample | 3963.300 ppm |
| Red Sample | 10199.300 ppm |

When expressed as a percentage, one ppm equals 0.0001%. This equivalency is found when the values of ppm and % are equalized. When the values are acquired and then printed again in percentage form, the Table 7 is created.

*Table 7 The proportion of lead content in five samples.*

| **Samples** | **Percentage Value** |
|---|---|
| Blue Sample | 0.19366% |
| Yellow Sample | 0.69254% |
| Green Sample | 1.75266% |
| White Sample | 0.39633% |
| Red Sample | 1.01993% |

Finally the percentage value listed in Table 7 used to generate the bar chart in Graph 2.




*Graph 2 Lead percentage value of samples*

# 5. Evaluation

The errors that occurred throughout the experiment will now be evaluated; they fall into two categories: random errors and systematic errors. The topic of potential improvements is included under this title as well.

## Random Errors

The uncertainties brought on by the measurement tool's limits are known as random errors. Random errors reduce the accuracy of the findings and lead to unpredictable fluctuations in the resulting data, either upward or downward, which cannot be entirely eliminated.

The experiment's random error, which resulted from ppm calculation, was 0.14%. I utilized the same amount of chemicals, a graduated pipette, and a cylinder for each sample in order to maintain a consistent evaporation surface area. An infrared thermometer with a ± 0.1 °C uncertainty is used to measure the temperature of the solutions. Since infrared thermometers detect the temperature of a particular spot, in my solution, this particular point wasn't always liquid; it may also occasionally be a denser layer that is solid or a less dense layer that is a bubble (opaque). The measured temperature would vary because solid forms would have lower temperatures and gases would have higher temperatures. With a right-angled infrared thermometer, temperature is taken in the middle of the beaker to remove this random uncertainty.

A calibration graph is created once the data has been processed; this graph shows the best fit line. The best fit line was obtained with some uncertainty due to the five reference data points, but a more accurate trendline might be produced if the number of reference points were increased.

In addition, because of the way the experiment was set up, I had to manually run the stopwatch which has an uncertainty ± 0.01 s to calculate how long the heating or cooling took. So, at this moment, a random mistake occurs as a result of human limitations. Since nobody can act at the exact moment, there may be delays in the recording due to reaction time. Using a sensor might help to measure the time correctly.

## Systematic Errors

Systematic errors, which are uncertainties caused by the apparatus or the procedure, lead to inaccurate values being obtained. To minimize systemic mistakes, some actions have been implemented during the experiment. Occasionally I had to start the experiment again because of outside influences or issues with the measuring equipment

Electronic Balance Measurements: The electronic balance was zeroed and the utilized beaker's tare was determined before to each trial. However, there were a few minor differences amongst the trials. The electronic balance's calibration mechanism was a little problematic, so I had to do it frequently. On the other hand, I made a box that covers the electronic balance to stop any airflow in order to minimize the impact of airflow.

Ambient Temperature: The rate of evaporation is directly influenced by changes in the ambient temperature. I tried to keep the temperature constant throughout the experiment. I covered the beakers with stopwatches to stop the evaporation. The air conditioning was turned off when I arrived at the lab one day due to an electric outage, and the temperature was 27 degrees Celsius with a dryness level of more than 65 percent. Because of outside factors or

problems with the measurement apparatus, I had to rerun the experiment. Additionally, the experiments were conducted over a period of nine consecutive days.

Airflow: The experiment was conducted in a lab with other students conducting their own experiments. Even though I tried to minimize the impact of uncontrolled airflow caused by wind or other people coming through doors by shutting them and locating the experimental equipment in a fume cupboard where air flow is difficult to enter, the experiment was nevertheless affected by the uncontrolled air flow. As a result, sometimes the samples evaporated faster than they should have.

# 6. Conclusion

Since lead is used in plastics to provide color, the concentration of lead in several painted versions of the same toy is studied in this study. Lead samples are first prepared at various concentrations, and then using UV-VIS spectroscopy, absorption values are obtained as reference points. The PVC is then identified by the Beilstein test, and toy samples are digested in an acid to prepare them for UV-VIS spectroscopy. After that, the absorption values of the samples are calculated using UV-VIS spectroscopy. Finally, this absorption number was transformed to percentage values.

This study assessed the lead content of variously colored toys in accordance with the research question's objectives. According to my hypothesis, the findings show that the lead concentration of various colored plastic constructions varies. From greatest to lowest values, the lead concentrations in Table 5 are reported as follows:

$$Green > Red > Yellow > White > Blue \quad (7)$$

The relationship between a toy's color and its lead content has nothing to do with where the color falls on the color spectrum. The relationship is not with the density of color since the white sample is not the sample with the lowest concentration of lead. One of Mateus-Garca & Ramos-related Bonilla's studies focuses on the relationship between a toy's paint and the nation in which it was produced (Mateus-Garca & Ramos-Bonilla, 2014). The results indicate that there is no statistically consistent link between the color and the lead concentration when the collected data is compared to those from this study. The same study shows that, toys made in China had the highest lead concentration. For my investigation, I chose toys made in China as examples.

According to the qualitative information shown in Table 4, there may be some implications. Concentrated lead solutions reacted to acid with a qualitatively more dense response. The fact that the paint on the toy has completely vanished at the end of the acid digestion indicates that the paint has successfully been dissolved in the solution. The fact that none of the filtered solutions had any color indicates that the pigment function of the dissolved paint has been lost.

This study helped me to understand a crucial aspect of science, namely its benefit to responsible production and consumption. I think one of a scientist's main motivations should be a desire to serve humanity. Even though the toy manufacturer employs professionals, some of them prioritize product cost over a child's nervous system impact. People must avoid harmful compounds like lead for their health due to the rising occurrence of cancer diagnoses. I took some risks, such as dealing with strong acids, but I am quite certain that every scientist

has already undertaken this kind of risk—not just for themselves, but for the whole of humanity. I greatly appreciate scientists who put the needs of people first. To comprehend doing something without expecting anything in return, these ideas were incredibly beneficial to me. As a high school student, I am pleased that revealing the findings of my research will encourage parents to select toys that are less dangerous.

### Further Investigations

In this investigation same brand 5 different colored legos are used as sample to find the lead concentration of them. Studying with different brands would prove the relation of color and lead concentration. In this investigation UV-VIS spectroscopy is used but different spectroscopies like AAS would be used to compare the utilized method.

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