# The Teaching of Theoretical Science Topics with Practical Scientific Experimentation and Application

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## Abstract

*We, as grade 11 AP Chemistry students, conducted a science project. In this science project, we harvested activated carbon from agricultural wastes, chestnut shells, avocado seeds, plum seeds, and walnut shells. The obtained activated carbon was then used to purify toxic heavy metals, copper, zinc, lead, nickel, and chromium, from water. This science project utilized some AP Chemistry topics. The concepts of molarity and moles were practiced while preparing the necessary solutions for the experimentation process. The topic of absorption and the Beer's Law were practiced while analyzing the results obtained from the spectrophotometer and making conclusions about our data. Throughout the project, we had to use various scientific equipment. This ranged from more complicated equipment like the spectrophotometer to more simple ones like the volumetric flask. Understanding the significance and function of these equipment helped us conceive how the AP Chemistry topics we learn in class are applied in a chemistry lab. At the end of the project, we found out that practicing and applying the topics we learned in class enhanced our understanding and expertise on the specific AP Chemistry topics. The revision of theoretical science by experimentation is especially beneficial for kinaesthetic learners. With such a project, students also realize the significance of the studied topics, since they demonstrate how the knowledge obtained from their courses can be used to tackle daily life problems.*

## 1. Introduction

As our society becomes more industrialized, toxic waste pollution becomes a more exacting problem. When toxic wastes mix with water, that water becomes contaminated with heavy metals. Cadmium, zinc, copper, nickel, lead, mercury and chromium are often detected in industrial wastewaters. The consumption of water that contains excess amounts of heavy metals poses a threat to the health of humans and animals. Therefore, it is important to omit heavy metals from water, in order to preserve environmental health. Various chemical methods have been used to separate heavy metals from wastewater. Absorption was found to be the most commonly used procedure for getting rid of these contaminant heavy metals. Activated carbon obtained from agricultural wastes has been previously used for water purification. Some of these agricultural wastes include; peach stones [1], , rice husk [3], sugar industry wastes [4]. These agricultural wastes have been used for the absorption of several heavy metals: gold, cadmium, and iron. Our project aims to investigate alternative active carbon sources that absorb different, not previously tested, toxic metals which are more common in industrial wastewater.

## 2. Procedure

The research for our topic started in September of 2015. While doing the research we used our school's library, Boğaziçi University's library and the internet. In addition, related essays and graduation projects were observed. The research was conducted by grade 11 AP Chemistry students. The experiments were made in our school's art room and chemistry lab. The different plants seeds and shells were burned in our school's ceramic oven. Obtained activated carbon samples were added to $Pb^{+2}$, $Cr^{+2}$, $Ni^{+2}$, $Cu^{+2}$, $Zn^{+2}$ solutions and afterwards filtered. The absorbance value of filtrated solutions was measured by UV Vis Spectrophotometer at our school lab. In order to minimize false data, measurements were taken twice and the values were averaged.

1) 4 different fruits, plant shells, and seeds have been used; avocado, plum seeds chestnut shells, and walnut shells. Avocado and plum seeds were plant seeds, and chestnut and walnut shells were used.
2) The plants seeds and shells have been burned in the ceramic oven (KK Ceramic Oven 340°C 950 L ) at 900 degrees for 1 hour.
3) After 1 hour, 4 different activated carbons were obtained.
4) After the obtained activated carbons were dried at room temperature, they were mixed with 100 ml 1M KOH solution.

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5) The mixture was dehydrated at 300$^0$C in an oven for 3 hours.
6) Obtained activated carbons were washed with pure water and dried at 200$^0$C in an oven for 2 hours.
7) By using 0.01 M, 100 ml $Cr(NO_3)_2$ , $Cu(NO_3)_2$, $Ni(NO_3)_2$ , $Zn(NO_3)_2$, $Pb(NO_3)_2$ solutions 5 different solutions were prepared. These other solutions were 0.005 M, 0.0025 M, 0.00125 M
8) Spectrophotometers wavelength arranged between 200-1100 nm
9) Using the spectrophotometer, 5 different solutions absorbance values were calculated.
10) The calculated results are shown in the results section of tables 1,2,3,4, and 5
11) For calculated absorbance values ion molarity graphs were drawn using Microsoft Excel.
12) 4 different samples of 15 ml were taken from 0.005 M $Cr(NO_3)_2$ solution
    - 0.28 grams of activated avocado carbon were added to the first solution,
    - 0.28 grams of activated plum seeds carbon were added to the second solution,
    - 0.28 grams of activated chestnut shells carbon were added to the third solution,
    - 0.28 grams of activated walnut shells carbon were added to the fourth solution
13) The same process was followed for 0.005 M Cu(NO3)2 , Ni(NO3)2 , Zn(NO3)2 , Pb(NO3)2
14) The prepared solutions rested for 5 hours.
15) The rested solutions were filtrated with filtration paper.
16) The filtrated solution's absorbance values were calculated with UV- Visible spectrophotometer.
17) With TI-84 Plus C Silver Edition the absorbance versus molarity values graphs were drawn.
18) The absorbed metal mass and mass of activated carbons ratio was calculated by the formula below.

$$\frac{Absorbed\ Metal\ Mass\ (g)}{Mass\ of\ Activated\ Carbon\ (g)} \times 100$$

## 3. Data

We prepared solutions that had 4 different concentrations: 0.01 M, 0.005 M, 0.0025 M, 0.00125M. The absorbance values of the $Cu^{+2}$, $Ni^{+2}$, $Zn^{+2}$, $Pb^{+2}$, and $Cr^{+2}$ metal ions that are present in these solutions were calculated and recorded. By using the recorded values, absorbance versus molarity graphs were drawn

We added the plum seed's activated carbon to 5 different ions; 0.005 M $Cu^{+2}$, 0.005 M $Ni^{+2}$, 0.005M $Zn^{+2}$, 0.005M $Pb^{+2}$ , 0.005M $Cr^{+2}$ and calculated the absorbance values. The new absorbance values of the metal ions are recorded for the activated carbon obtained from plum seeds. Using the absorbance vs concentration graphs drawn previously, the new metal ion concentrations were determined by the corresponding new absorbance values. The ratio of absorbed metal mass to activated carbon mass was calculated. (Table 1)

| Ion | New Molarity (M) | Absorbed Metal Mass (gram) | The Ratio of Absorbed Metal Mass and Activated Carbon Mass(%) |
|---|---|---|---|
| $Cr^{+2}$ | 0.00499638 | 2.82 x10-6 | 0.0010 |
| $Ni^{+2}$ | 0.00492938 | 6.21 x 10-6 | 0.0022 |
| $Cu^{+2}$ | 0.00499343 | 6.26 x 10-6 | 0.0022 |
| $Pb^{+2}$ | 0.00436605 | 1.96 x 10-3 | 0.7000 |
| $Zn^{+2}$ | 0.00480434 | 1.92 x 10-4 | 0.0685 |

Table 1

We added the avocado seed's activated carbon to 5 different ions; 0.005 M $Cu^{+2}$, 0.005 M $Ni^{+2}$, 0.005M $Zn^{+2}$, 0.005M $Pb^{+}$, 0.005M $Cr^{+2}$ and calculated the absorbance values. The new absorbance values of the metal ions are recorded for the activated carbon obtained from the avocado. Using the absorbance vs concentration graphs drawn previously, the new metal ion concentrations were determined by the corresponding new absorbance values. The ratio of absorbed metal mass to activated carbon mass was calculated. (Table 2)

| Ion | New Molarity (M) | Absorbed Metal Mass (gram) | The Ratio of Absorbed Metal Mass and Activated Carbon Mass (%) |
|---|---|---|---|
| $Cr^{2+}$ | 0.00480713 | $1.50 \times 10^{-4}$ | 0.0535 |
| $Ni^{2+}$ | 0.00498038 | $1.73 \times 10^{-5}$ | 0.0061 |
| $Cu^{2+}$ | 0.00440496 | $5.67 \times 10^{-4}$ | 0.2025 |
| $Pb^{2+}$ | 0.00499275 | $2.25 \times 10^{-5}$ | 0.0080 |
| $Zn^{2+}$ | 0.00480434 | $1.52 \times 10^{-4}$ | 0.0544 |

Table 2

We added the walnut shells's activated carbon to 5 different ions; 0.005 M $Cu^{+2}$, 0.005 M $Ni^{+2}$, 0.005M $Zn^{+2}$, 0.005M $Pb^{+2}$ , 0.005M $Cr^{+2}$ and calculated the absorbance values. The new absorbance values of the metal ions are recorded for the activated carbon obtained from the walnut. Using the absorbance vs concentration graphs drawn previously, the new metal ion concentrations were determined by the corresponding new absorbance values. The ratio of absorbed metal mass to activated carbon mass was calculated. (Table 3)

| Ion | New Molarity (M) | Absorbed Metal Mass (gram) | The Ratio of Absorbed Metal Mass and Activated Carbon Mass (%) |
|---|---|---|---|
| $Cr^{+2}$ | 0.00468533 | $1.83 \times 10^{-5}$ | 0.0065 |
| $Ni^{+2}$ | 0.00489243 | $9.47 \times 10^{-5}$ | 0.0338 |
| $Cu^{+2}$ | 0.00484552 | $1.47 \times 10^{-4}$ | 0.0525 |
| $Pb^{+2}$ | 0.00496880 | $9.71 \times 10^{-5}$ | 0.0347 |
| $Zn^{2+}$ | 0.00480434 | $1.9 \times 10^{-4}$ | 0.0678 |

Table 3

We added the activated carbon obtained from the chestnut shells to the 5 different ions and calculated the absorbance values. The new absorbance values of the metal ions are recorded for the activated carbon obtained from the chestnut. Using the absorbance vs concentration graphs drawn previously, the new metal ion concentrations were determined by the corresponding new absorbance values. The ratio of absorbed metal mass to activated carbon mass was calculated. (Table 4)

| Ion | New Molarity (M) | Absorbed Metal Mass (gram) | The Ratio of Absorbed Metal Mass and Activated Carbon Mass (%) |
|---|---|---|---|
| $Cr^{+2}$ | 0.00499638 | $2.82 \times 10^{-6}$ | 0.0010 |
| $Ni^{+2}$ | 0.00444703 | $4.87 \times 10^{-4}$ | 0.1739 |
| $Cu^{+2}$ | 0.00500000 | - | - |
| $Pb^{+2}$ | 0.00480272 | $6.13 \times 10^{-4}$ | 0.2189 |
| $Zn^{2+}$ | 0.00499206 | $7.8 \times 10^{-6}$ | 0.0027 |

Table 4

## 4. Conclusion and Discussion

The procedure we used to obtain activated carbon did not have an 100% yield. In order to designate which agricultural wastes showed activated carbon properties, a threshold ratio of 0.01% absorbed metal mass over activated carbon mass was chosen. Samples of agricultural wastes that showed a lower absorbed metal mass to activated carbon mass ratio less than 0.01% were considered not showing activated carbon properties. All toxic metal's activated carbons that were used gave a positive result and cleaned the toxic metals in the water at the end of the research. It was observed that plum seed wasn't effective at cleaning Chrome, Nickel and Copper; absorbed metal mass and activated carbon mass ratio was under 0.01%. Plum seed was effective at cleaning Lead and Zinc metals since the ratio of absorbed metal mass and activated carbon was over 0.01%. Nickel and Lead were the metals which had a ratio for absorbed metal mass and activated carbon mass over 0.01% for Chestnuts, and for Chrome, Nickel and Copper metal it was observed that they had a ratio below 0.01%. For walnut seed, the absorbed metal mass and activated carbon mass ratio was over 0.01% for Nickel, Lead, Copper and Zinc metals, however; for Chrome the ratio was below 0.01%. For avocado the absorbed metal mass and activated carbon mass had a ratio over 0.01% for Chrome, Copper and Zinc metals. On the other hand, for Nickel and Lead metals it had a ratio below 0.01% according to observations. The activated carbon obtained from walnut shells was proven effective, and passed the 0.01% threshold in 4 out of the 5 metals that were tested. Therefore, walnut shells showed the largest consistency to carry activated carbon properties. The activated carbon obtained from chestnut shells was proven effective, and passed the 0.01% threshold, in 2 out of the 5 metals that were tested. Therefore, walnut shells showed the least amount of consistency to carry activated carbon properties. The amount of time, 5 hours, that the activated carbon samples were left in the solutions was enough to obtain fruitful data.

## 5. References

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