Ascorbic Acid Detection Using Spectrometer and Deuterium and Halogen Light Source

Nur Nadia Bachok
Photonics Technology Laboratory, Department of Electrical, Electronic and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia
Bangi, Selangor
numadial@gmail.com

Norhafizah Burham
Photonics Technology Laboratory, Department of Electrical, Electronic and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia
Bangi, Selangor
hafizahburham@uitm.edu.my

Ahmad Ashrif bin Abu Bakar
Photonics Technology Laboratory, Department of Electrical, Electronic and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia
Bangi, Selangor
ashrif@ukm.edu.my

Norhana Arsad
Photonics Technology Laboratory, Department of Electrical, Electronic and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia
Bangi, Selangor
noa@ukm.edu.my

Dr. Nurul Huda Abd. Karim
School of Chemical Sciences & Food Technology, Faculty of Science and Technology, Universiti Kebangsaan Malaysia
Bangi, Selangor
nurulhuda@ukm.edu.my

Ahmad Razi Othman
Department of Chemical and Process Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia
Bangi, Selangor
ahmadrazi@ukm.edu.my

Abstract—The goal of this study is to determine the ascorbic acid (AA) refractive index using a digital refractometer and absorbance spectrum using Ultraviolet-Near Infrared (UV-NIR) spectrometer. The absorption technique was proposed to detect different ascorbic acid concentrations and their absorption wavelength. The mechanism of ascorbic acid detection is based on energy absorbed by the ascorbic acid solution. The results show that the refractive index of ascorbic acid solution from 0.2M to 1.0 M increases with the ascorbic acid concentration and correlates linearly. The absorbance spectra of ascorbic acid solution increase linearly with an ascorbic acid concentration in the 300.69 nm wavelength.

Keywords—ascorbic acid, absorbance, spectrometer, refractive index

I. INTRODUCTION

Ascorbic acid, also referred to as vitamin C or L-ascorbic acid, is a naturally occurring chemical compound that is high in antioxidants. Citrus fruits, tomatoes, and green vegetables contain ascorbic acid, which can be found in plants and food. Additionally, AA is frequently added to processed food items that contain fruit and vegetables as an antioxidant and anti-browning aid, either for enrichment or fortification or to prevent the oxidation of other nutrients (such phenolic compounds). Appropriate AA consumption improves the health of critically ill patients[1], [2].

As a result, one of the promising study fields is establishing a sensitive and rapid approach for the simultaneous detection of AA. To date, various approaches for detecting AA have been used, including electrophoresis, solid phase iodine, chemiluminescence, titrimetry, fluorescence, electrochemical and using spectrometer [3]–[9].

The purpose of this work is to develop an absorbance technique for ascorbic acid detection utilising a spectrometer. The result gained from the experiment will be compared with previous study [9]. The absorbance spectra of a sample are a measurement of how much light it absorbs. Their relationship is depicted in (1) and Fig 1.

\[ A = \log_{10}\left(\frac{I_o}{I_f}\right) \]  \hspace{1cm} (1)

where :
\[ I_o \] = Light intensity entering the sample
\[ I_f \] = Light intensity leaving the sample

Fig. 1. Light intensity before entering and after leaving the sample

The relationship between a solution's absorbance and its concentration is also can be described by Beer's Law. The concentration of the solution determines how much light is absorbed. The equation relates to (2)

\[ A = \varepsilon \cdot L \cdot c \] \hspace{1cm} (2)

where :
\[ \varepsilon \] = Molar absorptivity constant
\[ L \] = length of path traveled by light

ICSE2022 81
II. METHODOLOGY

A. L-Ascorbic Acid Preparation

AA powder was purchased from R&M Chemicals. The process started by measuring the AA powder using a KERN weighing scale. A volumetric flask of 50 ml was used to mix the measured AA and deionized (DI) water. There were five concentrations prepared for AA solution using the \( M_1V_1=M_2V_2 \) equation as shown in Table 1. Then, ATAGO digital refractometer was used to measure refractive index for each concentrations.

<table>
<thead>
<tr>
<th>Molarity (M)</th>
<th>Ascorbic Acid (g)</th>
<th>DI Water (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>1.7612</td>
<td>50</td>
</tr>
<tr>
<td>0.4</td>
<td>3.5224</td>
<td>50</td>
</tr>
<tr>
<td>0.6</td>
<td>5.2836</td>
<td>50</td>
</tr>
<tr>
<td>0.8</td>
<td>7.0448</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>8.806</td>
<td>50</td>
</tr>
</tbody>
</table>

B. Experimental SetUp

Fig 2 depicts a schematic diagram of the experiment. The absorbance level for each solution was measured using an Ocean Optic HR4000CG-UV-NIR Spectrometer and a DH-2000-BAL UV-VIS-NIR light source. With a light spectrum ranging from 200-1100 nm, this optical light source contains two bulbs: a Deuterium Bulb and a Tungsten-Halogen Bulb. The spectrometer can also detect wavelengths in the same range as the light source. A 1.5 mL plastic disposable cuvette was put between the light source and the spectrometer to conduct the experiment. The light travels from the light source to the spectrometer via the cuvette. The spectrometer is then connected to SpectraSuite, a spectroscopy software, which is used to determine the absorbance level of each sample.

III. RESULTS AND DISCUSSION

A straight-line graph was created and displayed in Fig 3 to show the relationship between Refractive Index (RI) and concentration of AA. With a correlation coefficient of 0.99642, the result in Fig 3 demonstrates a significant linear correlation from 0.2M to 1.0M. The refractive index increases as the molarity increases in this case. The following is the linear equation.

\[
y = 0.02425x + 1.3337
\]

Fig. 3. Relationship between refractive index and concentration of ascorbic acid

Here is a quick rundown of the absorbance values for each AA concentration. Figure 4 depicts the relationship between the absorbance value and the concentration of the AA solution. With increasing AA solution concentration, the output absorbance value gradually increased. The absorption spectrum spans the wavelength range of 280 nm to 320 nm. We extended the graph in Fig 5 to the specified wavelength and smoothed it to observe this link more clearly. As the concentration of the AA solution grew from 0.2M to 1.0M, the output absorbance value increased from 1.42 to 1.61. The graph reveals that the peak wavelengths for each concentration are 297.76 nm, 299.36 nm, and 300.15 nm for 0.2 M, 0.4 M, and 0.6 M, respectively, and 300.69 nm for both 0.8 M and 1.0 M. As can be seen from the figure, all of the peak wavelengths have been aligned to plot at 300.69 nm for easy comparison.
Fig. 4. Absorbance spectra of five concentration of Ascorbic Acid

Fig. 5. Absorbance spectra of five concentration of Ascorbic Acid at 280 nm to 320 nm after smoothing and aligning peak wavelengths

Fig. 6. Calibration curve of Ascorbic Acid

**TABLE II.** COMPARISON BETWEEN SCD-SPECTROMETER AND UV-NIR SPECTROMETER AND DEUTERIUM AND HALOGEN LIGHT SOURCE

<table>
<thead>
<tr>
<th>Results</th>
<th>SCD Spectrometer</th>
<th>UV-NIR Spectrometer and Deuterium and Halogen Light Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_{\text{max}}$ (nm)</td>
<td>450</td>
<td>360.69</td>
</tr>
<tr>
<td>Slope</td>
<td>0.0365</td>
<td>0.23711</td>
</tr>
<tr>
<td>Interception</td>
<td>-0.0164</td>
<td>1.38791</td>
</tr>
<tr>
<td>Beer’s Law</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

IV. CONCLUSION

The refractive index and absorbance spectra of ascorbic acid solution were experimentally determined by digital refractometer and absorbance technique using spectrometer. An analysis of absorbance spectra with five different concentration has been conducted over the spectral range from 200 nm to 1100 nm. The results show that the refractive index of ascorbic acid solution increases with ascorbic acid concentrations. Interestingly, there is a linear relationship between refractive index and ascorbic acid concentration. Absorbance spectra of five concentrations show different peak wavelength. After an adjustment to one peak wavelength, a linear relationship between absorbance spectra and ascorbic acid concentration. This study follows Beer’s Law within the concentration range.

ACKNOWLEDGMENT

This work was supported by the government through FRGS (FRGS/1/2021/TK0/UKM/02/17). The authors thank to laboratory members and staff in Photonics Technology Lab, UKM for support and guidance.

REFERENCES


