IOP Conf. Series: Materials Science and Engineering **434** (2018) 012088 doi:10.1088/1757-899X/434/1/012088

An approach to determine the concentration of coloured solution using android smartphones

F S Irwansyah[1*], I Susilawati[2], I Fitriyati[1], I Farida[1], B W Nuryadin[2] and M A Ramdhani[3]

[1]Department of Chemical Education, UIN Sunan Gunung Djati Bandung, Jl. A.H. Nasution No. 105, Bandung 40614, Indonesia
[2]Department of Physics, UIN Sunan Gunung Djati Bandung, Jl. A.H. Nasution No. 105, Bandung 40614, Indonesia
[3]Department of Informatics, UIN Sunan Gunung Djati Bandung, Jl. A.H. Nasution No. 105, Bandung 40614, Indonesia

*ferli@uinsgd.ac.id

Abstract. The purpose of this research is to determining the concentration of the coloured solution NiSO4 and to know the accuracy of smartphone application usage. Determining the concentration of a coloured solution using a smartphone can be an alternative to overcome the limitations of spectrophotometric or colorimetric instruments. An approach using the smartphone is based on hue colon is read by a smartphone application, then the data generated from the application is RGB value and will be processed to determine the concentration. Determining the concentration of the coloured solution is assisted by three standards solution and the concentration are known to make the standard curves. The methodology of this research is research and development. The results in this research have a fairly good accuracy percentage, for both unknown concentrations of NiSO4 solution the percentage of accuracy is 100% and 95% with a percent error is 0% and 5%. This indicates the application on the smartphone is suitable for use in determining the concentration of the coloured solution.

1. Introduction

Analysis concentration of coloured solution is one of quantitative analysis on analytical chemistry with colorimetry method [1]. Colorimetry method is commonly measured using instruments such as a Spectronic 20 (Spec 20), a UV−vis light spectrometer, or colorimeter that can quantify absorbance[2]. The existence of sophisticated instrument is tend to cause problems in terms of procurement for the needs of the laboratory [3]. Image processing has the ability to identify several parameters indicated by the colour of a material [4]. However, quantitative methods based on these principles have been developed using expensive commercial analysis systems by limiting their instrument, especially in universities in developing countries where instruments are not available [5]. One alternative to overcome the limitations of the instrument to determine concentration of coloured solution is using smartphone camera [1]. Because smartphones are easier to use, have an open operating system that allows smartphone users can add a variety of applications [6]. Smartphones are equipped with good cameras, available everywhere and nowadays have become very important from everyday life. This has become an innovation in the use of smartphone devices in chemistry learning [7]. The use of

smartphones can be very helpful for education because they combine real life and learning, this will make learning activities in school more interesting and meaningful [8].

The research which use a smartphone with colorimetry method has been done in previous research. A smartphone can be used for quantitative colorimetric analysis effectively, as previously reported [9]. The research is learning beer's law and spectroscopic absorption using a smartphone [10], quantifying gold nanoparticle concentration in a dietary supplement using smartphone colorimetry [1], and determining the amount of copper(II) ions in a solution using a smartphone [11]. A smartphone can be used for quantitative colorimetric analysis effectively, as previously reported[9]. The novelty of this research is to determined concentration of $NiSO_4$ solution with relationship absorbance and Beer-Lambert law using smartphone.

This experiment is to learn basic concepts such us how to conduct absorbance measurements and Beer- Lambert law using smartphone application to determine the concentration of colour solution [12]. The smartphone application here is colour analyser and is called RGB analysis (Red, Green, Blue) capable of determining average RGB value of images in the camera view, in real time, is used as the light detector, either light reflected from paper or coloured construction light from a computer screen or mobile phones screen used as light sources [10]. We can determine the concentration of colour solution by a low-cost analytical method using a smartphone as a laboratory experiment designed for analytical chemistry courses. Intensity values were obtained from the digital images by measuring the RGB values (on a scale of 0−255 in intensity) [13].

The purpose of this experiment is to determine the concentration of $NiSO_4$ solution and to know the accuracy of smartphone application usage. In this experiment, several standard solutions of $NiSO_4$ are known to be concentrated, then the standard solution is analysed using a smartphone so that the average value of R, G, or B can be converted to absorbance value by formula [12]:

$$A = -\log\left(\frac{\mathrm{I}}{I_0}\right) \tag{1}$$

The value I in the equation above shows the value of R, G, or B of solution and I_0 denotes the value of R, G, or B of aquades both obtained from the experimental image. Finally, plots of absorbance versus concentration were prepared and evaluated for linearity and used for determining concentrations of unknown $NiSO_4$ solutions [14].

2. Method

The method used in this research is Research and Development which aims to determine the concentration of NiSO4 solution using smartphone applications. The first procedure performed in this experiment is made 3 of standard solution $NiSO_4$ with concentrations of 0.05M, 0.15M and 0.25M. Then prepared a series of tools as shown in figure 1.

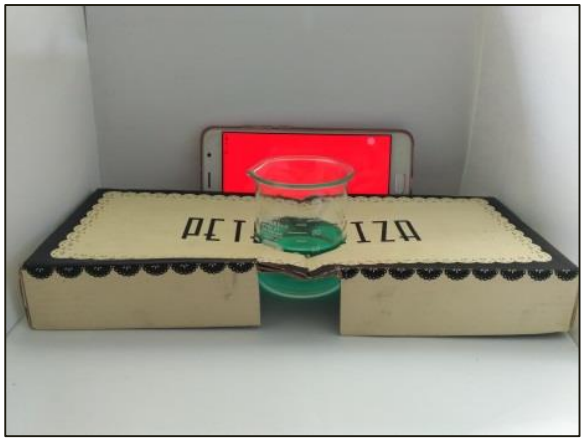

Figure 1. Set tools.

In figure 1, the tools used are cardboard box, beaker, and red screen displayed on the mobile screen. At the top of the cardboard, a hole is adjusted to the size of the beaker, then the back and front of the cardboard box is given a hole, the hole on the back of the cardboard box serves as a gap to be traversed by a light source from the red screen mobile phone, while the hole on the front cardboard box serves as a gap to direct the smartphone camera to the solution. The distance between the smartphone and the cardboard box where the solution should be kept must be consistent. When all the preparations have been completed, the following measurements of RGB values on aquades, standard solutions of $NiSO_4$, and unknown $NiSO_4$ solutions are obtained so that R values can be converted to A values based on formula 1. After that, a graph of the relationship between the values of A with the concentration of standard solution is made linear equation y=ax+b using Microsoft Excel [15]. The unknown $NiSO_4$ concentration can be calculated by substitution the value of A into the linear equation, where the value of A is the value of Y in the linier equation and the value of x is the unknown concentration of $NiSO_4$.

3. Result and discussion

Based on the set of tools in figure. 1, the use of cardboard box as the tool is aimed at allowing the light to pass right through the sample when measured. Then the red screen on the back of the cardboard box serves as the light source, the maximum absorbance of the coloured solution occurs in the coloured area opposite to the observed colour, the colour of the $NiSO_4$ solution is green, it will expect maximum radiation in the red area. For this system, each colour is a composite of representing the colour that looks actually [16]. The distance between the cardboard box where the sample is placed in the smartphone position must be consistent for each measurement of the solution, because if the distance used is inconsistent, it will affect the accuracy of the RGB value obtained. The measurements of RGB values on aquades and $NiSO_4$ unknown solutions are presented in figures 2 and 3.

Figure 2. RGB value of aquadest.

Figure 3. RGB value of $NiSO_4$ unknown.

Figure 2 and 3 show the results of RGB aquades measurements and unknown $NiSO_4$ solutions using smartphone applications. This application records the mean values of R, G, and B as shown in the lower right of figures 2 and 3. From the figure it is seen that the R value of the aquades is 207 and the

R value of the unknown $NiSO_4$ solution is 112. The experimental results have been performed presented in Table 1 and figure 4.

Table 1. The result of the experiment.

No	Concentration of $NiSO_{4(aq)}$	R value (I)	$\frac{I}{I_0}$ value	$-\log\left(\frac{I}{I_0}\right)$ (A) value
1.	0.05 M	156	0.753	0.123
2.	0.15 M	85	0.410	0.387
3.	0.25 M	41	0.198	0.703
4.	Unknown	112	0.541	0.266
5.	Unknown	62	0.299	0.524

In table 1 the data taken from the measurement using the smartphone application is the data value of R. The value of R is taken because it can produce the graph with the highest linearity that is equal to 0.9973 as shown in figure 4. Based on the data in table 1, it can generate graphic link between value A with concentration of $NiSO_4$ standard solution as shown in figure 4. In figure 3 it shows that the value of R of $NiSO_4$ unknown is 112 and based on table 1 the absorbance value is 0.266, from this A we can determine the concentration of $NiSO_4$ unknown by substituting the value A into the linear equation y=2.9x-0.0307 in figure 4, where the value of A is the value of Y in the equation and the value of x is the unknown concentration of $NiSO_4$. So, in getting the concentration of $NiSO_4$ unknown is 0.19M and 0.2M with percent error of 0% and 5% then percent accuracy of 100% and 95%.

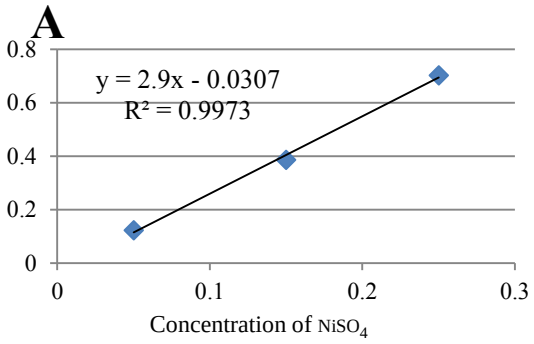

Figure 4. A graph of the relationship between the values of A with the concentration of standard solution $NiSO_4$.

This study shows that the use of android smartphones in the education process is increasingly showing positive things. Utilization of android smartphone can be used as an effective learning media and meet the criteria as laboratory equipment as defined in the study conducted Irwansyah et. al. (2018), namely: safety, improvement of practitioner's understanding, ease of use, the accuracy of level of equipment, and cost [17]. This is supported by various research results, which shows that the use of android smartphone in education has many advantages, including: android smartphone can be used as instructional media or personal learning media [18], available used anytime [19], create fun learning environments [20], improve learning motivation [21], enhance learning effectiveness [22], enhance understanding [23], promote student-centred instruction [24], and become an efficient investment of learning aid [25].

4. Conclusion

The experiment reported here provides a simple way to determine concentration of colour solution with equipment routinely found in chemistry laboratories. And we can get the concentration of $NiSO_4$ unknown is 0.19M and 0.2M with percent error of 0% and 5% then percent accuracy of 100% and

95%. This indicates the application on the smartphone is suitable for use in determining the concentration of the coloured solution. After that, the setup is simple, data collection is fast, and data analysis is straightforward. This experiment can be completed with excellent results using materials routinely found at home: clear plastic cups to change the beaker, cardboard boxes, and a smartphone. This experiment also has the potential to provide a solid experience in a distance learning environment, which has proven to be somewhat challenging for chemistry courses.

Acknowledgments
We thank to LP2M UIN Sunan Gunung Djati Bandung who has funded so that this research can take place.

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