European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 06, 2020

"Comparative Assessment Of Glucose Determination In Blood Using Fabricated Colorimeter And Strip-Based Commercial Glucometer"

Pankaj Varshney[1], Bhanu Pratap Singh[2], Maniram Kumar[3]

[1]Assistant professor, Dept. of Physics
[2,3]Assistant professor, Dept. of Civil Engineering
SRM Institute of Science & Technology, Delhi NCR Campus, Ghaziabad, India

Email: [1]pankajvarshney@ymail.com, [2]bhanu.gkv1989@gmail.com, [3]maniramkumar7@gmail.com

ABSTRACT: Present approach is an effort to develop a handy, less in cost, less power consuming and compact, colorimeter for quantitative colorimetry with diminished detector size. A relatively small electric current with improved power sensitivity photosensitive device: MORICA MP series-MH-208 photodiode has been used to diminish size of the assembled colorimeter. This detector has good signal to noise ratio and hence can sense very low level of intensity. The major challenge in assembling these portable analytical devices is to reduce detector size. Common photo resistor or other newly electronic component including silicon photodiodes can be used as detector in portable colorimeters. In the recent colorimeters, output current is amplified by connecting the detectors to operational amplifiers. Although the reports in the literature reveal a great deal of advances on colorimeters, still efforts are needed for simplifying the colorimeter for analytical applications in field conditions for estimation of various analytes.

The standard chemical solution, ranging between 2.5 to 80 mg/dl of Copper Sulphate in distilled water, was determined at 650nm wavelength of light by using self-designed colorimeter and the commercial Perkin-Elmer Spectrophotometer in correspondence of Beer-Lambert law. Both were compared for the calibration of self-designed colorimeter. A good Linearity in sensor output of the self-designed colorimeter was recorded. . A comparative study has been done for glucose estimation in blood in between a self-designed colorimeter and a strip-based commercial glucometer. A self-designed colorimeter was able to detect glucose using a very small amount 10µl of blood serum sample and could detect glucose in the range of 50 to 600 mg/dL. The Coefficient of variation for self-designed colorimeter was determined to be 4.171 % in comparison to16.671% (for a strip-based commercial glucometer).

Keywords: Compact Colorimeter, A silicon photoelectric detector, Calibration, Linearity, Glucose estimation.

1. INTRODUCTION

In the study we have used calorimeter to determine the best results. The colorimeter is an instrument used for measuring the absorbance of specific wavelength of light in a solution. This instrument is commonly used to determine concentrations of a previously selected solute in a given solution in reference of combined Beer- Lambert's law which states that the concentration of solutes is proportional to the absorbance. In its operation a light beam from a light source is passed through the colored sample kept inside of a chamber. The result is examined by comparing the absorption of specific wavelength of light by the solute, against color standards of known concentrations of the substance because different chemical substances absorb different frequencies of the visible spectrum. Monochromatic is used to separate the colour of light and select the light of specific colour that is mostly absorbed by the solute, so as to enhance the accuracy of the result. The detector measures the amount of light that passes through the amount entered into the solution, and a display reads the absorbed volume. The use of a colorimeter to measure the chemical reactions color provides objectivity and precise quantification for the aim of estimation. Largely due to the increase in the number of pigment methods and their widespread use for both scientific and clinical purposes, the demand for color workers has increased manifold. In present, several LED based compact colorimeters have been developed over the last three decades whereas incandescent lamps are used traditionally having drawbacks of wide bandwidth light emission. Here it is important that LED's are compact, robust, consume less power with less heat emission and economic as well. The current research is focused towards the development of a self-designed LED based compact colorimeter. The mechanism & theory involved, colorimeter types and their applications, have been studied and reviewed in detail.

Principle-Operation involved:
When a visible light beam of narrow wavelength ranging from 380-700 nm is passed through a medium having uniform properties throughout its volume then a part of it is absorbed within the medium, a part is reflected and rest certain part is transmitted. Hence we can say, Colorimeter is a device which works on the two photometric laws namely Beer's law and Lambert's law which states in their combined form that there is an exponential decrease in the energy of emitted light corresponds to the increase in the thickness and concentration of the transparent absorbing medium. If the thickness of the container and the medium is kept constant, the energy of the emitted light will be directly proportional to the concentration of that medium. By using these two scientific laws in colorimetry, the concentration of colored compounds in solutions can be determined by considering that the concentration of a solute is proportional to the absorbance.

EXPERIMENTAL WORK:
Materials and equipments like common Printed Circuit Boards for assembling circuits, soldering wire, an LED light source with changeable aperture, a set of colored optical filters, a silicon photodiode detector-MH-208, an LCD output display, Voltage regulator to minimize device voltage fluctuations, Copper sulphate (CuSO4), a cuvette, glucose and blood serum and reagent to determine serum glucose levels, were purchased from J. Mitra Company, Janakpuri, Delhi, CDH Hospital, Mumbai, M/s. Crest Biosystems of Goa, India respectively and all other electronic equipment from The Design Center for Biomedical Lab IIT-Delhi.

1. COLORIMETER ASSEMBLY WITH COMPONENTS

The Final photographic films of as fabricated colorimeter are shown in diagrams 1(a), 1(b) and 1(c).

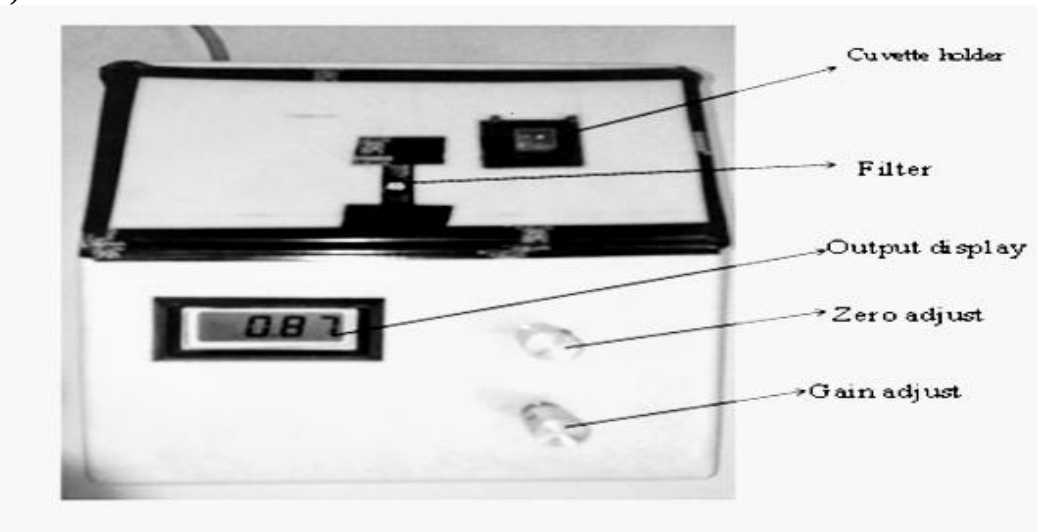

Figure 1(a): the photographic films of as fabricated Colorimeter

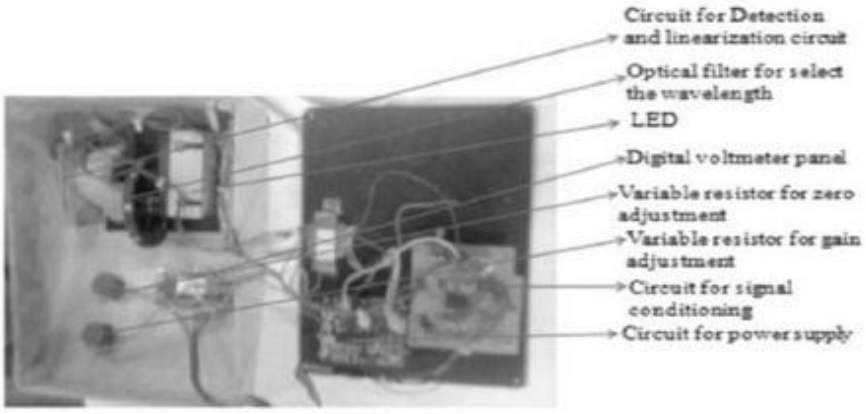

Figure 1(b) Photographic film of as fabricated colorimeter using LED as light source.

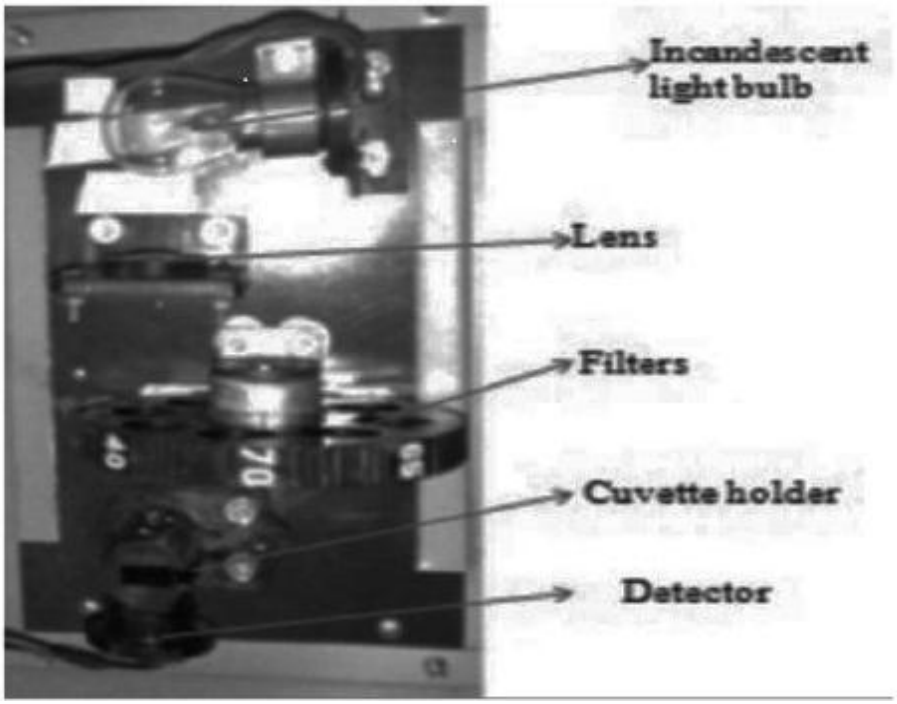

Figure 1(c) Photographic film of as fabricated colorimeter using incandescent light source.

2. COLORIMETERIC MESUREMENTS

The standard chemical reagent, CuSO4, was analyzed by following procedure for optimization of fabricated colorimeter

1. Distilled water was taken into the test tube and DVM readings were set to zero.
2. For maximum absorbency, a standard solution with highest concentration was taken.
3. An unknown concentration was sampled to record absorption.

3. OPTIMIZATION OF FABRICATED COLORIMETER

3.1 Determination of CuSO4 at 650 nm.

Table1: Represents the comparison between by the assembled colorimeter and the standard P-E Spectrophotometer to measure CuSO4 at 650 nm.

CONCENTRATION (in mg/dl)	**ABSORBANCE (fabricated Colorimeter)**	**ABSORBANCE (Spectrophotometer: Perkin Elmer)**
0	0.000	0.000
2.5	0.0125	0.034
5	0.025	0.070
10	0.095	0.160
20	0.220	0.310
40	0.495	0.580
80	1.050	1.030

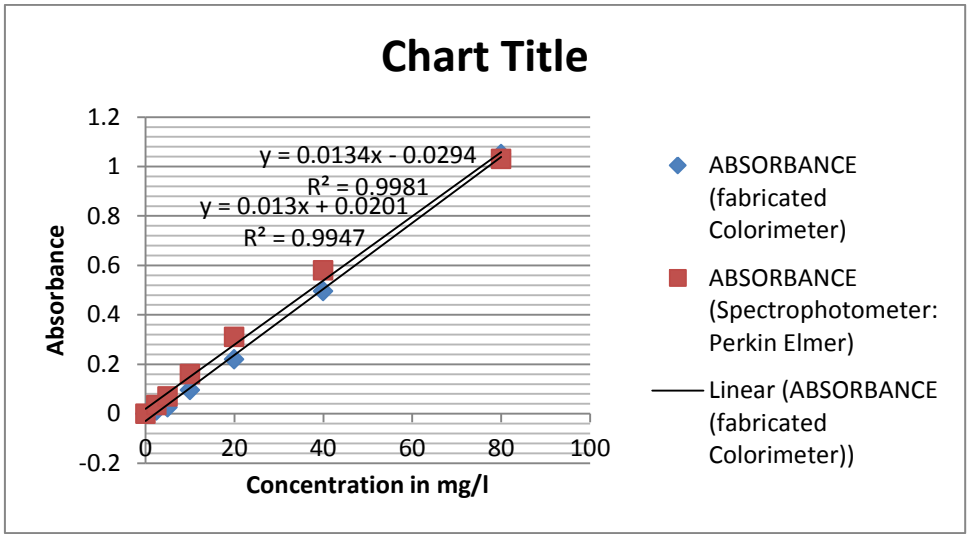

Chart 1: Determination of Absorbance with fabricated Colorimeter and Spectrophotometer Perkin Elmer.

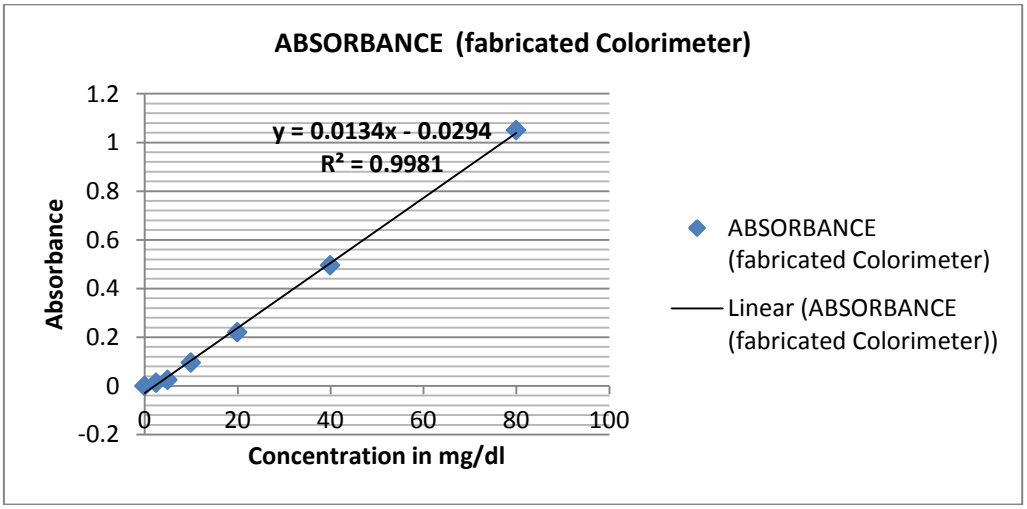

Chart 2: Determination of Absorbance with fabricated Colorimeter .

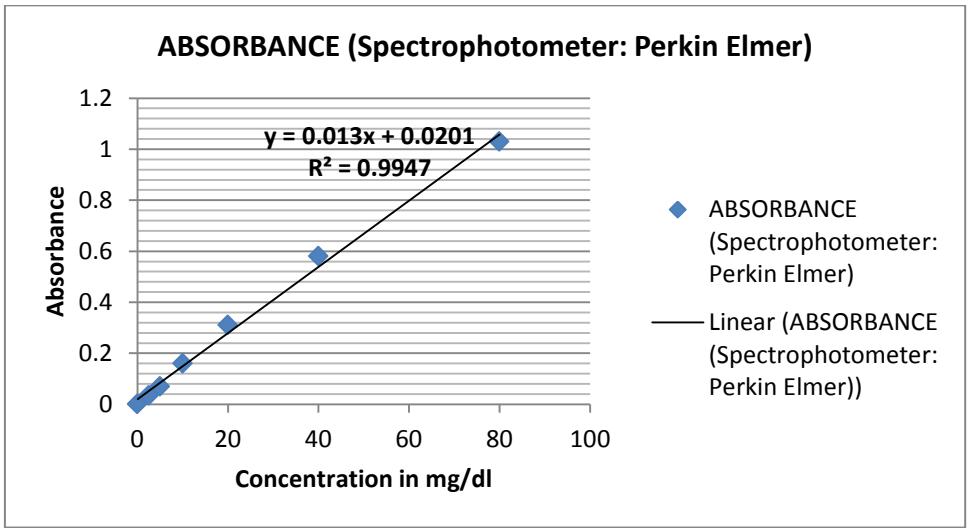

Chart 3: Determination of Absorbance with Spectrophotometer Perkin Elmer.

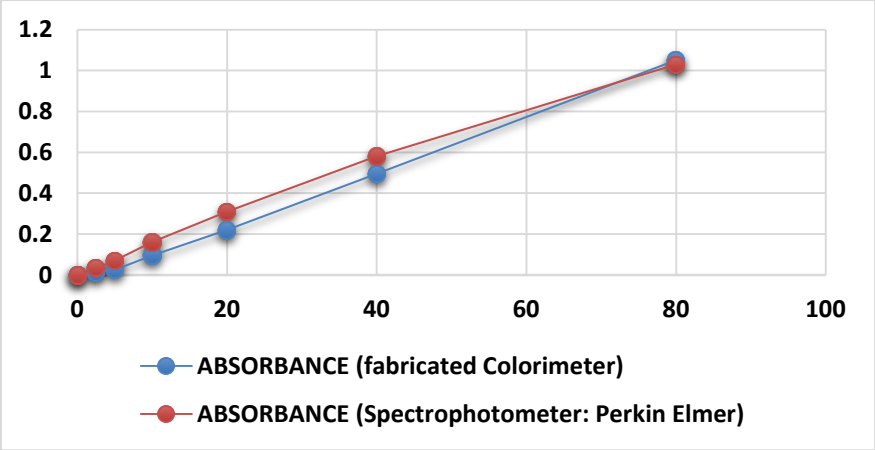

Chart 4: Linear curve shows the accuracy of the fabricated calorimeter and P-E Spectrophotometer.

3.2 ASSESSMENT OF FABRICATED COLORIMETER FOR GLUCOSE DETERMINATION IN BLOOD:

Table: 2- Blood-glucose determinations using fabricated colorimeter at 490 nm wavelength

Sr.No.	Blood Sample	Absorbance	Concentration from standard graph of glucose(mg/dl)
1	10µl serum+1ml glucose reagent	0.240	120
2	10µl serum+1ml glucose reagent	0.230	115
3	10µl serum+1ml glucose reagent	0.250	125

3.3. Comparative study of the concentration of blood using glucometer and colorimeter

Table 3: represents comparison of glucose determination in blood at 490nm between the fabricated colorimeter and standard glucometer.

Blood Sample(Sr. No)	Concentration from Glucometer (in mg/dl)	Concentration from fabricated Colorimeter(mg/dl)
1	120	120
2	140	115
3	100	125

3.4. Determination of reproducibility by Calculation of coefficient of variation
The reproducibility of the colorimeter and glucometer was determined using the formula:
Coefficient of variation (%) = (Standard Deviation ×100) / Average value
The Coefficient of variation (for developed colorimeter) is determined to be equal to 5×100 /120 = 4.171% and,

The Coefficient of variation (for strip-based glucometer) is determined to be equal to 20×100/120 = 16.671 %.

2. RESULT AND DISCUSSION

A cheap, less power consuming and compact colorimeter using LED, optical filter, a photoelectric diode, a logarithmic OPMP, and a digital voltmeter panel. Various circuits that used different components were designed to assemble colorimeter unit. This self-designed colorimeter was then tested for linearity and reproducibility and compared with a standard P-E spectrophotometer using simple analytical reagent CuSO4 and serum samples. An improved linearity of 0.998 was plotted using self-designed colorimeter. Glucose was estimated in blood samples using a calibration curve prepared for the developed coloration. The fabricated colorimeters were able to detect glucose using a very small amount (10µl) of blood serum sample and could detect glucose in the range of 50 to 600 mg / dL that was used in hypoglycemic and hyperglycemic (diabetic) patients. Enough to identify. The theater showed a coefficient of variation of 4.171% compared to 16.671% shown by traditionally used hand-held strip-based commercial glucometers.

REFERENCES:

[1] Mohammad & Masoud. Simple, Cheap, and Portable Colorimeter for Introductory Analytical Chemistry Laboratories, Chemistry, 18(2009). 176-182.
[2] Vallera Da, Bissel M G, Barron W: "Accuracy of Portable Glucose Monitoring,effect of Glucose level and prandial state", Journal of Clinical Pathology, Feb 95(2); 247-252.
[3] 3.James A Fain: Blood Glucose Meters, Differentstrokes for different folks", Nursing, Proquest Science Journals, Vol.No.34:11, Nov 2004,pg.48.
[4] O'. Toole, M., D. Diamond. Absorbance BasedLight Emitting Diode Optical Sensor and Sensing Devices. Sensors 8(2008), 2453-2479 .
[5] M.Srikanth, G.Venkateswara Rao and K. R.S.Sambasiva. Modified Assay Procedure for the Estimation of Serum Glucose using Microwell Reader. Saumya Apollo Hospitals, Saumya Medicare International Limited, Vijayawada. Diabetes Atlas,4th edition,2009.
[6] Leonard Walker and Elias Amador. A Solid State Fixed Wavelength Colorimeter for Continuous Flow Analyses. Clinica Chimica Acta, 46(1973)181-186
[7] O'Toole, M., D. Diamond. Absorbance Based Light Emitting Diod Optical Sensors and Sensing Devices. Sensors 8, 2453-2479 (2008).
[8] Fonseca, A., I.M. Raimundo Jr. A Multichannel Photometer Based on an Array of Light Emitting Diodes for Use in Multivariate Calibration. Anal Chim. Acta 522, 223-229 (2004).
[9] Deborah Jean Warner. bulletin of the scientific instrument society No.88 (2006)
[10] Robert A.Paselk.Scientific instrument museum,Humboldt state university,department of chemistry,Bausch and lomb optical co. no. 2451<1941
[11] Gordon, J., A. James, S. Harman, K. Weiss. A Film Canister Colorimeter. J. Chem. Educ. 79, 1005-1006 (2002).
[12] Richard A. Paselk. Practical Chemical Analysis of Blood. 2nd ed. (1924). C. V. Mosby Company, St. Louis .
[13] Gordon, J., S. Harman. A Graduated Cylinder Colorimeter: An Investigation of Path Length and the Beer-Lambert Law. J. Chem. Educ. 79,611-612 (2002).

[14] J.Res,Natl, Journal Research of the National Institute of Standards and Technology Inst. Stand. Technol. 112, 129-138 (2007)
[15] Treagust,D., A. Chandrasegaran. The Importance of Demonstrations in chemistry. Australian J Educ. Chem.Issue 65, 4 (2005).
[16] Skoog, D.A., D.M. West, F.J. Holler, S.R. Crouch. Analytical Chemistry – An Introduction. 7th Ed. Sounders College Publishing, Orlando, 2000, pp. 572-573
[17] Shimazaki,Y., S. Watanabe, M. Takahashi, M. Iwatsuki. A Portable Spectrophotometer Using a White-color Light-emitting Diode and a Charge-coupled Device and Its Application to On-site Determination of Iron. Anal. Sci. 16, 1091-1093 (2000).