Absorbance Measurement of Dilute Chemical Solutions

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Abstract- Within the past few years a number of different designs of photoelectric calorimeters have been described in the literature. This paper addresses the absorbance measurement of visible light through different sample solutions at different range of wavelengths by using different colour filter and the results have been compared with the absorbance values obtained by a digital colorimeter. The Absorbance measurement has then been shown on an 16x2 LCD display by use of a PIC16F877a microcontroller.

Keywords: LED, LDR, colorimeter, absorbance, filter, wavelength, LCD, Microcontroller.

I. INTRODUCTION

Colorimeter is also known as filter photometer. In scientific fields the word generally refers to the device that measures the absorbance of particular wavelengths of light by a specific solution. Changeable colour filters are used in the colorimeter to select the wavelength of light which the solute absorbs the most, in order to maximize accuracy. The usual wavelength range is from 400 to 700 nanometres (nm). If it is necessary to operate in the ultraviolet range (below 400 nm) then some modifications to the colorimeter are needed. In modern colorimeters the filament lamp and filters may be replaced by several light-emitting diodes of different colours.

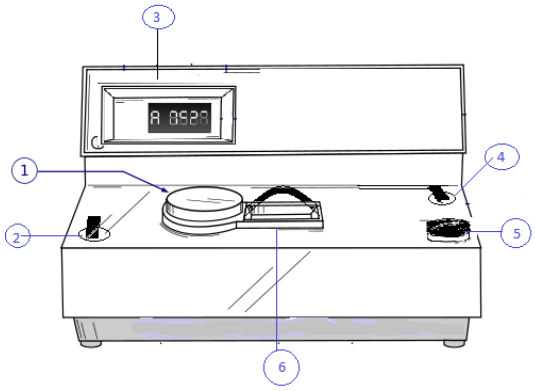

Fig 1. Schematic of a Digital Colorimeter

At its most basic, a Colorimeter works by passing a specific wavelength of light through a solution, and then measuring the light that comes through on the other side. In most cases, the more concentrated the solution is, the more light will be absorbed, which can be seen in the difference between the light at its origin and after it has passed through the solution.

Manuscript received October, 2013.

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II. ABSORPTION MEASUREMENT BY COLORIMETER

In the present work the absorbance of Visible light passing through different Sample solutions is measured by using a Bright LED as the transmitter and an LDR at the receiver end. LDR is an acronym for light dependent resistor whose resistance is dependent on light. Different dilute solutions such as Hydrochloric Acid, Sodium Hydroxide, Calcium Chloride, Sodium Nitrate, Ferric Chloride, Sulphuric Acid are mixed with 2% of universal indicator and tested. A small tube of square cross section, sealed at one end, made of quartz called a cuvette has been designed to hold samples for experiments.

The experimental setup comprises of Bright LED at transmitter end, an LDR at receiver, a quartz cuvette for the sample solutions, color filters a PIC16F877a Microcontroller and an 16x2 LCD Display.In a manual colorimeter the cuvettes are inserted and removed by hand.

PIC is a family of Harvard architecture microcontrollers, the name refers to "Programmable Interface Controller". PIC's are low cost, widely available and supports serial programming and reprogramming capability. Here PIC16F877a Microcontroller has been used. This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) 8-bit microcontroller packs into a 40 pin package .The PIC16F877A features 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter .

LCD (Liquid Crystal Display) screen is an electronic display module .A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines.This LCD has two registers, namely, command and data.

First, the intensity of light(I0) passing through a blank is measured. Blank is a solution that does not contain the solute that absorbs light, here Distilled Water has been used as blank solution. Second, the intensity of light (I) passing through sample solution is measured at different wavelengths. Here colour filters has been considered i.e Blue(492-455),Green(492-577),Yellow(577-597) and Red(622-700) for measuring intensity of light at four different range of wavelengths. Finally the experimental data is used to calculate the Absorbance (A).

$A = -\log(I/I_0)$

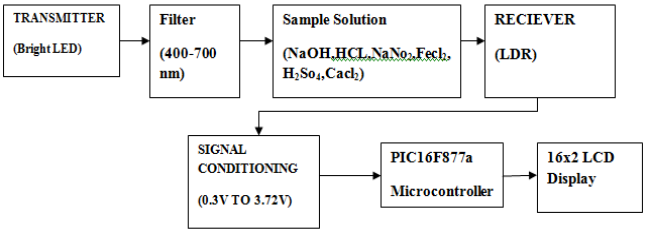

Fig 2.Block Diagram of the Experimental Setup.

The results are then displayed on an 16x2 LCD Display by interfacing it to a PIC16F877a Microcontroller. This calculated absorbance has then been compared with the absorbance value obtained through Digital Colorimeter Model no 12.

III. RESULT ANALYSIS

A.Tables

Sodium Hydroxide(NaOH)		
Filter	Absorbance value of Colorimeter	Calculated Absorbance[A=-log(I/I_0)]
Blue	0.49	0.40
Green	0.54	0.45
Yellow	0.32	0.22
Red	0.12	0.33

Table I .Absorbance value for sodium hydroxide

Hydrochloric acid(HCL)		
Filter	Absorbance value of Colorimeter	Calculated Absorbance[A=-log(I/I_0)]
Blue	0.13	0.22
Green	0.18	0.18
Yellow	0.03	0.06
Red	-0.01	0.15

Table II .Absorbance value for Hydrochloric acid

Sodium Nitrate($NaNo_2$)		
Filter	Absorbance value of Colorimeter	Calculated Absorbance[A=-log(I/I_0)]
Blue	0.22	0.28
Green	0.23	0.27
Yellow	0.18	0.17
Red	0.07	0.33

Table III .Absorbance value for Sodium Nitrate

Ferric Chloride($Fecl_2$)		
Filter	Absorbance value of Colorimeter	Calculated Absorbance[A=-log(I/I_0)]
Blue	0.25	0.32
Green	0.27	0.28
Yellow	0.15	0.12
Red	0.05	0.24

Table IV .Absorbance value for Ferric Chloride

Sulphuric Acid(H_2SO_4)		
Filter	Absorbance value of Colorimeter	Calculated Absorbance[A=-log(I/I_0)]
Blue	0.09	0.25
Green	0.14	0.19
Yellow	0.05	0.09
Red	0.00	0.18

Table V.Absorbance value for Sulphuric Acid

Calcium Chloride ($Cacl_2$)		
Filter	Absorbance value of Colorimeter	Calculated Absorbance[A=-log(I/I_0)]
Blue	0.14	0.23
Green	0.13	0.20
Yellow	0.11	0.12
Red	0.05	0.245

Table V I .Absorbance value for Calcium Chloride

B.Graphs

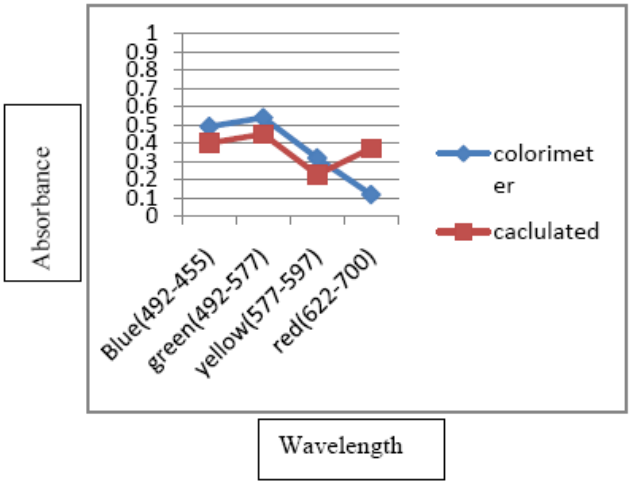

Figure3 .Compared absorbance value for sodium Hydroxide

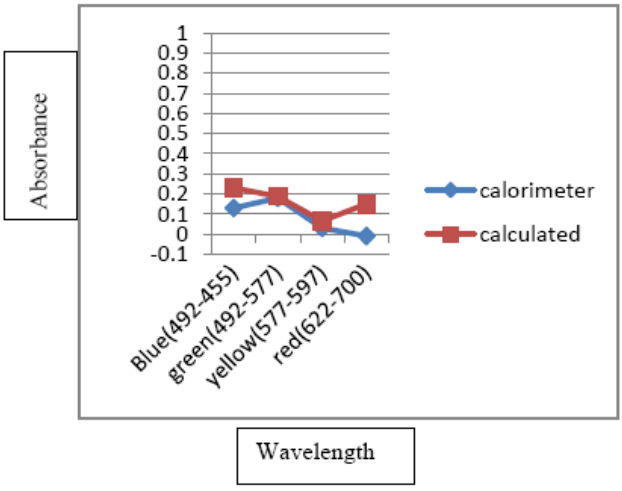

Fig 4.Compared absorbance value for Hydrochloric Acid

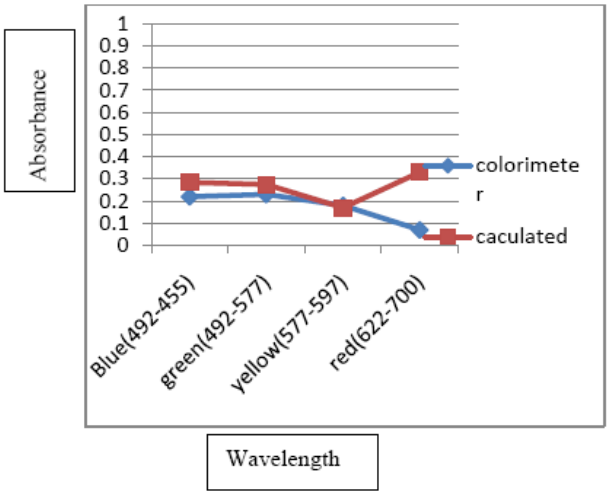

Fig 5:Compared absorbance value for sodium Nitrate

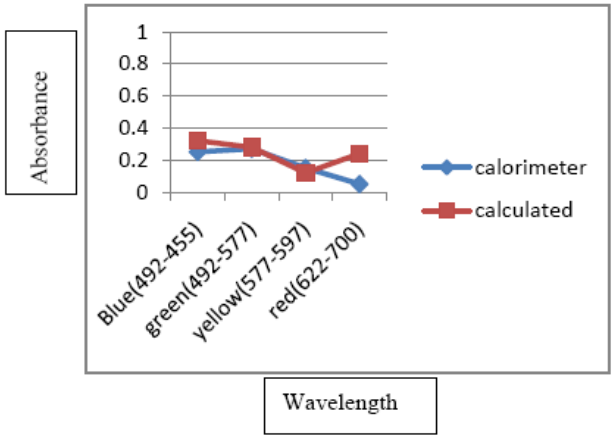

Fig 6.Compared absorbance value for Ferric Chloride

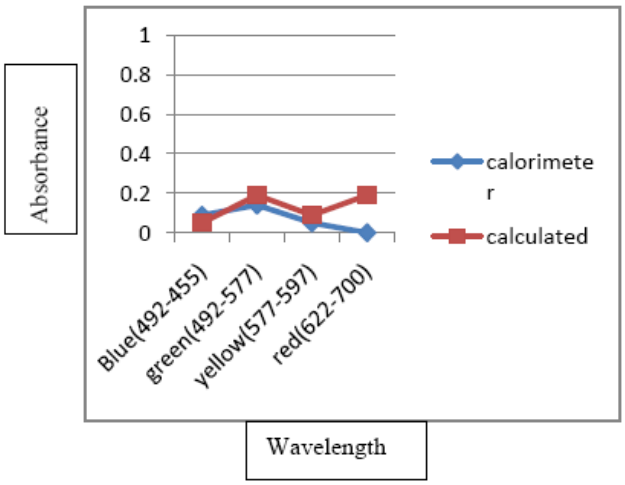

Fig 7.Compared absorbance value for Sulphuric acid

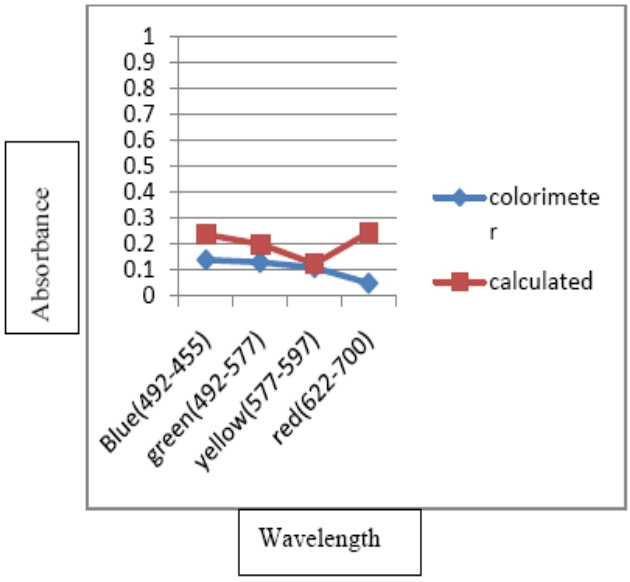

Fig 8.Compared absorbance value for Calcium Chloride

IV .CONCLUSION

The goal of the project was to measure the absorbance of different sample solutions at different wavelengths and display it on a 16x2 LCD by using a PIC16F877a Microcontroller. The details of an simplified colorimeter has been presented. Here the absorbance values for different dilute solution mixed with 2% of indicator has been taken on digital colorimeter Model No 12 and experimental setup, and has been compared and found to be similar.

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