ESP-JETA
ESP Journal of Engineering & Technology Advancements
ISSN: 2583-2646 / Volume 4 Issue 1 February 2024 / Page No: 51-52
Paper Id: JETA-V4I1P105 / Doi: 10.56472/25832646/JETA-V4I1P105

Original Article

Response of a Capacitor Formed by Different Electrolytic Solutions (Chemical or Biochemical) inside a Capillary Tube and Two Electrodes under DC Condition

Amitava Ghorai
School of Science, SGIL Residenza, Block 1/3G, 66/63 Jangalpur Road, Kolkata-700 081, West Bengal, India.

Received Date: 20 December 2023 Revised Date: 13 January 2024 Accepted Date: 14 February 2024

Abstract: *It is an interdisciplinary project where the variation of capacitance of a capacitor with a distance of separation between two electrodes is tested for different electrolytic solutions (viz. sugar, common salt, and ammonia) within a capillary tube under DC conditions as these are the ingredients of blood. The nature of graphs resembles the parallel plate capacitor.*

Keywords: *Capacitor, Electrolyte, Capillary Tube, Blood.*

I. INTRODUCTION

An electrolytic solution in between two electrodes forms an electrolytic capacitor. When a DC voltage is introduced across the electrodes an oxide coating forms between the electrode and the electrolyte and thus a capacitor is formed. There are three main ways to measure capacitance (i) DC charging/discharging, (ii) AC response, and (iii) bridge method. The simplest one is the use of a digital multimeter which is a device for measuring various quantities, viz. continuity of circuit test, voltage measurement, current measurement, resistance measurement, inductance measurement, capacitance measurement, diode test, h_{fe} measurement of transistor and pin configuration identification, frequency measurement, temperature measurement, etc. Present-day literature shows measurements by 1st order high pass filter [1], frequency response in AC circuits [2], and capacitance-voltage (C-V) measurements of MOS devices [3], etc.

Electrolytes are liquid dielectrics which have no or negligible charge carriers. A dielectric molecule may be polar having permanent electric dipole moment even in the absence of an electric field and non-polar where an induced dipole moment is created by an electric field. We consider only the simple situation when the induced dipole moment is in the direction of the field and is proportional to the field strength. Substances for which this assumption is true are called linear isotropic dielectrics.

The objective of this short note is a new and unique elementary technique of understanding where interdisciplinary scientific thoughts may be smoothly assimilated. The variation of capacitance of an electrolytic capacitor with a distance of separation between two electrodes is tested for different electrolytic solutions under DC conditions. We know blood and urine samples are required in different pathological tests and generally they contain ingredients, like sugar ($C_6H_{12}O_6$), common salt ($NaCl$), ammonia (NH_3), etc.

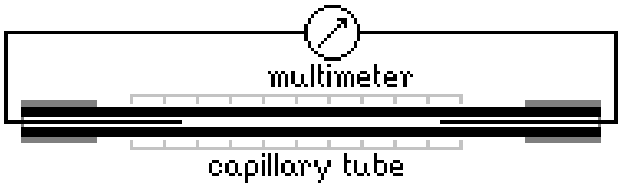

Figure 1: Experimental Setup

II. Experimental

A glass capillary tube of an almost uniform radius of about $0.5mm$ and length of about $50mm$ is taken as a container for the capacitor. Both ends of it can be closed by rubber cork through which two copper wires of $0.5mm$ radius are introduced inside the capillary tube. These wires are used as electrodes and different electrolytic solutions are placed inside using a syringe. So the capillary tube with electrolytic solution will act as a capacitor and the capacitance of it in between the electrodes is measured by a good quality multimeter (Figure 1). The distance between the electrodes is measured by a millimeter scale as shown in figure 1. Measurement of capacitance can also be done by using De Sauty's Bridge or Schering's Bridge [4]. It is found that the multimeter and the bridge measurements are almost the same.

As mentioned in section 1 three electrolytic solutions are prepared using sugar($C_6H_{12}O_6$), common salt($NaCl$), and ammonia (NH_3) with almost normal concentration of about10%. Normal concentrations of these three in $100 milliliter$ of blood are respectively$70-99 mg$, $300 mg$, and $17-43 mg$ [5-6]. We use them as electrolytic solutions for experiments.

III. RESULTS AND DISCUSSION

Figure 2 shows the variation of capacitance of the capacitor containing electrolytic solution in the capillary tube with different distances for sugar ($C_6H_{12}O_6$), common salt ($NaCl$), and ammonia (NH_3) with nearly normal concentrations of blood. The behaviour of the curves is nearly hyperbolic as shown. Any change in the variation of capacitance with distance from normal variation will indicate some malfunctioning and disease.

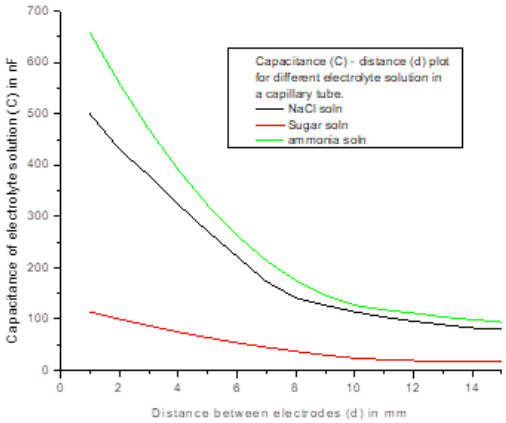

Figure 2: Variation of capacitance containing electrolytic solution in the capillary tube with different distances for sugar ($C_6H_{12}O_6$), common salt ($NaCl$), and ammonia (NH_3)

IV. CONCLUSION

The capacitance of a parallel plate capacitor $C = \frac{\varepsilon_0 \varepsilon_r A}{d}$ is directly proportional to the dielectric constant or relative permittivity ε_r and inversely to the distance of separation between the plates d. The nature of the graphs in Figure 2 resembles the same. This work is restricted to a fixed concentration of about 10%. Also, more work with AC signals where frequency variations are there can be done.

Interest Conflicts

There is no conflict of interest.

Funding Statement

There is no funding agency.

Acknowledgments

The author designed the whole experimental setup and the preliminary measurements of different distances and capacitances were performed by two second-year undergraduate students of session 2012-15 (Ilius Mondal and Md. Abul Kalam Azad Siddiki) of the Department of Physics, Maulana Azad College, 8, Rafi Ahmed Kidwai Road, Kolkata-13, West Bengal, India.

V. REFERENCES

[1] N. Angkawisittpan and T. Manasri, Measurement Science Review, 12(1) (2012) 8-13; Determination of sugar content in sugar solutions using interdigital capacitor sensor.

[2] Adela Bardos, Richard N. Zare, and Karin Markides, Chemical Physics Letters 402 (2005) 274–278; Inductive behavior of electrolytes in AC conductance measurements.

[3] Kevin J. Yang, Hideki Takeuchi, Tsu-Jae King, and Chenming Hu, International Conference on Solid State Devices and Materials, 17-19th Sept 2002, Nagoya Congress Center, Nagoya, Japan; Frequency Dependence of Capacitance Measurement for Advanced Gate Dielectrics.

[4] A. Ghorai, Three novel experiments on Wheatstone's Bridge, LAP LAMBERT Academic Publishing AG & Co. KG, Germany, Sat, May 22, 2010, ID 6489, ISBN-NR 978-3-8383-6710-1.

[5] M. E. Daly, C. Vale, M. Walker, A Littlefield, and K. G. Mathers, The American Journal of Clinical Nutrition 67, 6, 1186-96, 1998, doi:10/1093/ajcn/67.6.86; Acute effect on insulin sensitivity and diurnal metabolic profiles of a high-sucrose compared with a high-starch diet.

[6] D. H. Wasserman, American Journal of Physiology, Endocrinology and Metabolism 296, 1, E11-21, 2009, doi:10.1152/ajpendo.90563.2008; Four grams of glucose.