International Journal of Advance and Innovative Research
Volume 6, Issue 2 (XXXIX): April - June, 2019
ISSN 2394 - 7780

DIELECTRIC STUDY OF PROPYLENE GLYCOL USING IMPEDANCE ANALYSIS TECHNIQUE

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ABSTRACT
Chemical preservatives are frequently used in processed food to prevent growth of bacteria, yeast or other microorganisms, while preventing the growth it also affect the quality of the food. So it becomes necessary to study the strategy of the chemical preservatives. The aim of present work is to estimate electrical properties of food preservative Propylene Glycol in aqueous solution. A low frequency TDR (Time Domain Reflectometry) unit is developed and used for the Impedance analysis. Eleven different solutions of different volume percentage (0% -100% PG) of Propylene Glycol with freshly collected distilled water were prepared and studied. All the solutions are kept in temperature controller unit, which was controlled and monitored by computer. These various solutions are kept under four different temperature (250C, 350C, 450C and 550C). It was observed that the Resistivity (RL) increases with the increase in temp while Dielectric constant decreases with increase in the concentration as well as temperature. There was no conductivity found in the propylene Glycol solution.

Keywords: *Propylene Glycol, Resistivity, Dielectric constant, Conductivity, Time Domain Reflectometry (TDR).*

I. INTRODUCTION
One of the most important functions of food additives is to preserve food products form spoilage. The preservatives prevent the spoilage of food caused by the certain action of microorganisms or oxidants. Along with natural preservatives synthetic chemicals are also used as preservatives. Due to the widespread use of these chemicals a broad variety of food is made available to people for long period of time. But Besides preservation it also affects the quality of the food. So it becomes necessary to study the strategy of the chemical preservatives.

Impedance spectroscopy is traditionally used in monitoring corrosion, testing effectiveness of drug preservatives [1,2] and electro-deposition processes in the coating and characterization assessment of many kinds of sensors and semiconductors [3,4]. Its application in biotechnology for the characterization of cell cultures [5] has, however, been notably expanded in the last decade. The impedance has been applied in the field of microbiology as a means of detecting and quantifying pathogenic bacteria [6,7]. TDR technique is also used in medical field. Blood sugar can be detected with the help of TDR technique.[8]

Impedance spectroscopy is a powerful tool for a fast bio-molecule diagnosis and for analysis in cell cultures [9, 10]. Its superiority over other laboratory techniques lies in that it uses a small signal, thus minimizing the alterations of the properties of the medium, in other words, applied stimulation does not alter the equilibrium conditions of the system. The signal applied to the samples makes it possible to link the properties of the liquid or solid being studied with the variations or changes obtained in its characteristic impedance. This is due to the physical structure of the material, the chemical processes occurring in it, or a combination of both. Consequently, electrochemical impedance spectroscopy is a non-destructive technique providing robust measurements. [10]

A low frequency TDR (Time Domain Reflectometry) unit is developed [11-13] and used for the Impedance analysis. In TDR technique, a voltage step is propagated down through the transmission line towards the sample under investigation and reflected voltage waves are monitored by oscilloscope at particular point on line.

II. EXPERIMENTAL SETUP
The developed TDR unit is of the range 200MHz and 5ns rise time. A co-axial transmission line with characteristic impedance of 50 ohm was used for study of the preservatives. Various rod type and strip types of probes were designed and studied to check the impedance and conductivity using standard solution of known factors. Out of those a strip type probe of 5.5cm length is used for the further study. For the study of the properties of liquid under consideration we immerse the probe in the liquid and collect the information on the oscilloscope.

Temperature controller unit was developed to control the temperature during the experiment. It consists of water bath with an electric heater and a test tube holder, PT100 to sense the temperature, computer to monitor and control temperature.

ISSN 2394 - 7780

The time domain technique has been used for the measurement of electrical parameters of the system. The experimental setup based on time domain technique has been developed for this study. A fast rising step pulse was transmitted through a coaxial cable, which reflects back from the end of cable. The incident and reflected pulses are sampled and displayed on the screen of sampling oscilloscope. The nature of reflected pulse gives the properties of the material at the reflecting end.

The sample cell placed at the termination plays an important role in reflection of incident pulse. In the present setup, a strip line is used as a sample cell. The strip line sensor probe is immersed in the sample of which properties are to be studied. Various types of sensor probes were developed and tested for their TDR response. The stripe line probe of 55mm was selected to carry out the measurements.

The probe calibration is important part of TDR system. The selected probe was calibrated using standard resistors and KCl solution of known conductivity. The result of calibration is the regression equation, which need to be used in calculation of parameters for which the probe is calibrated. In the present experiment, electrical resistivity, electrical conductance, and dielectric constant are calculated.

III. PROPOSED METHODOLOGY AND DISCUSSION

Propylene Glycol (PG) is a colorless, nearly odorless, syrupy liquid that is derived from natural gas. It is used in dozens of products that commonly used. It is used in food – cake mixes, salad dressings, soft drinks, popcorn, food colorings, fat-free ice cream and sour cream. It also protects food from freezing, and helps as a preservative. It is commonly used sweetener in pharmaceuticals.

Food grade Propylene glycol (PG) is used to prepare the required solutions. Eleven different solutions of different volume percentage (0% -100% PG) of Propylene Glycol with freshly collected distilled water were prepared and studied. These different collected concentrations are kept in water bath at different temperatures, 25°C, 35°C, 45°C and 55°C. A probe connected with pulse generator through coaxial cable is immersed in the aqueous solution of Propylene glycol (PG). A fast rising pulse is applied through the coaxial transmission line. The rising pulse gets reflected back from the solution under consideration. The nature of the pulse is depends on the properties of the liquid. This pulse is observed and stored in the Digital Storage Oscilloscope i.e. DSO. This data was then collected in an external storage and further calculations were done. Each time the probe was thoroughly cleaned with acetone and dried.

IV. EXPERIMENTAL RESULTS

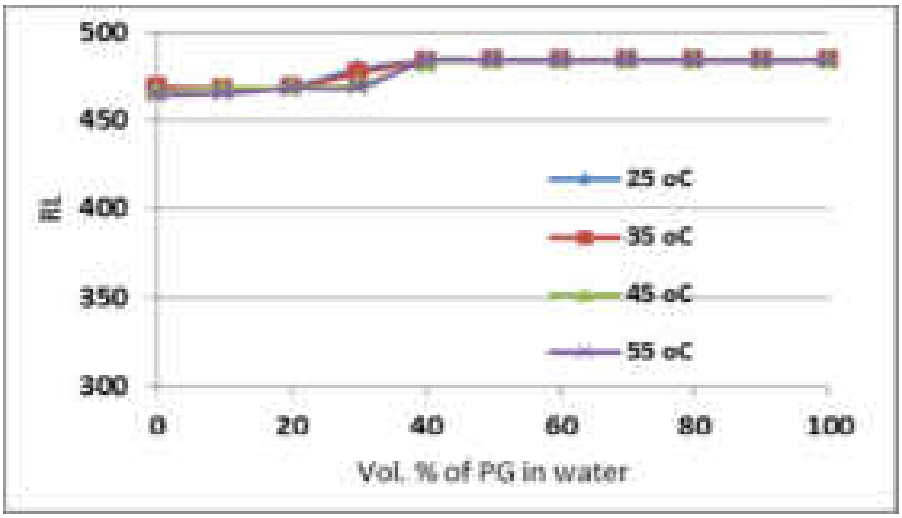

Fig-1: Variation of Resistivity with vol. % of Propylene Glycol in water.

The resistivity of aqueous solution of propylene glycol slightly increases after 20 % volume concentration. This change is about 29%. There is no measurable change in resistivity values with change in temperature from 25°C to 55°C. Overall, there is no remarkable change in resistivity of aqueous solution of propylene glycol with change in concentration and temperature.

The waveform final voltage for all concentrations is almost equal to final voltage of empty cell. This shows the non-conducting nature of propylene glycol.

The aqueous solution of propylene glycol shows decrease in dielectric constant with increase in concentration of propylene glycol in water. At 25°C the dielectric constant changes from 82 to 41. Same type of change is observed at 35°C, 45°C and 55°C.

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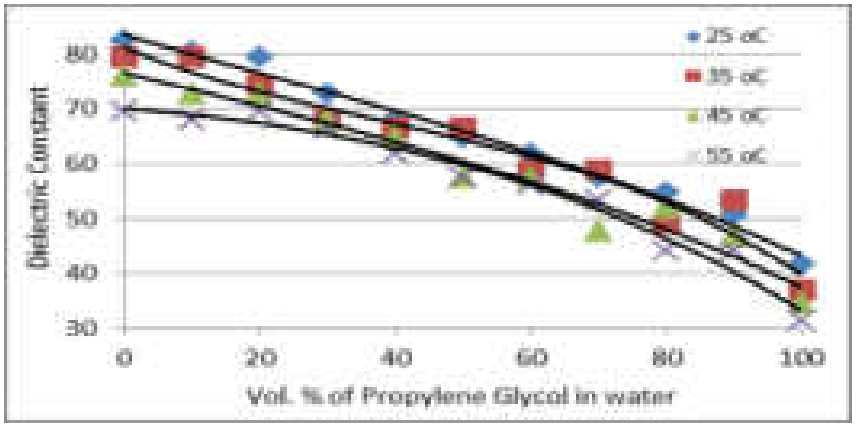

Fig-2 Variation of dielectric constant in aqueous solution of Propylene Glycol.

V. CONCLUSION

The resistivity of aqueous solution of propylene glycol slightly increases after 20 % increase in volume concentration. Propylene glycol is purely non-conducting solution. The aqueous solution of propylene glycol shows decrease in dielectric constant with increase in concentration of propylene glycol in water as well as increase in temperature.

ACKNOWLEDGEMENT

Authors are thankful to Dr. P. B. Patil, former Prof. and Head, Department of Physics, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (M.S.) India, also thankful to the Principal, Deogiri College, Aurangabad (M.S.) India for providing necessary laboratory and library facilities.

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