Analytical Characteristics Study of Glass Electrode based pH Measurement System in Respect of mV Output and Internal Resistance

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Abstract: In tradition, pH measurement methods falls in to four categories, such as indicator reagents,, pH test strips, metal electrode methods(hydrogen electrode, quin hydrone electrode and antimony electrode method) and glass electrode. Glass electrode is one of the well known, inexpensive, easily available and commercially available method. However the use of these measurement type is subject to various sources of uncertainties and having limitation in many industrial applications. At present, pH sensitive glass electrodes are commonly used for determining the hydrogen ion concentration. A hydrated layer (gel layer) of around 10^{-4} mm is developed on the sensitive glass membrane from inside and outside when dipped in aqueous solution. However, there are unexplored avenues in the knowledge of physical mechanism in the formation of hydrated layer, potential developed, nature and different characteristics, methods of its thickness measurement etc. From the review, it is noted that electrical characterization technique may lead to better results with regard to the understanding of the basic physical mechanism in the pH sensitive glass electrodes. Hence the electrical parameter measurement technique is used and is reported in this paper.

Keywords: Glass electrode, pH sensor, electrical characterization, resistance, current

I. INTRODUCTION

The determination of pH (latin: pondus hydrogenil) is one of the most important analytical methods in chemical laboratory and industry. It is an important physico chemical property of fluid measured for many application in the various field of science and technology. As for instance in environmental monitoring and industrial process pollution control. Sometime pH is used as a process control parameter to find the optimum reaction condition. Different type of pH measurement system such as indicator strips, pH electrodes is one of the well known , inexpensive ,easily available and commercially available method. In tradition, pH measurement methods falls in to four categories, such as indicator reagents,, pH test strips, metal electrode methods(hydrogen electrode, quin hydrone electrode and antimony electrode method) and glass electrode. Glass electrode is one of the well known, inexpensive, easily available and commercially available method. However the use of these measurement type is subject to various sources of uncertainties and having limitation in many industrial applications.

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The pH sensitive glass electrodes are commonly used for determining the hydrogen ion concentration [1,2,3]. pH sensitive glass of the pH electrode is a special glass in which an electrode made up of silver wire coated with AgCl is placed in a suitable electrolyte such as KCl which acts as an electrode. One of the problems however has been the proper choice of the pH sensor and its trouble free operation involving comparatively complicated cleaning procedures[3]. Recently, there has been considerable interest in the development of semiconductor sensors using ion sensitive field effect transistor (ISFET)[4]. After a few hours exposure to aqueous media, the glass surface becomes swollen and hydrated. This hydrated layer (gel layer) which is sensitive to the concentration of H^+ ions , is mentioned to be a very thin layer of the order of 10^{-4}mm[3]. There are number of opinion about the development of potential across the membrane and associated phenomena in the gel layer and in the membrane. However, there are unexplored avenues in the knowledge of physical mechanism involved in the formation of hydrated layer, development of potential, nature and different characteristics, methods of its thickness measurement etc. It is found from the review that electrical characterization technique is not used for such study. Therefore, electrical characterization technique have been used for better understanding of the basic physical mechanisms in pH sensitive glass electrodes. In the process of this research, relationships between outputs in mV, current and internal resistance measurement and analysis has been carried out. Extensive measurements with different electrodes at different pH values have been carried out to get an idea of the physical mechanisms responsible for the characteristics of pH electrodes. pH is a measure of acidity or alkalinity of aqueous solutions. It is defined as negative logarithm of hydrogen ion concentration in a given solution. When pH glass electrode is dipped in an aqueous solution, the potential developed across it is given by

$$E=E_0 + (RT/NF)*Log(a_H)$$

where R= gas constant, T= Temperature in degrees Kelvin, F= Faradays constant,

a= Activity of hydrogen ion = γC where C=Concentration of hydrogen ion,

E_0= Reference potential which is constant. Sensitivity, span, time of response and repeatability represents the performance of pH electrode. The sensitivity of pH electrode is 59.16mV/pH at 25^0C. In this paper, sensitivity of pH sensor along with other parameters has been reported.

II. EXPERIMENTAL SET UP AND PROCEDURE

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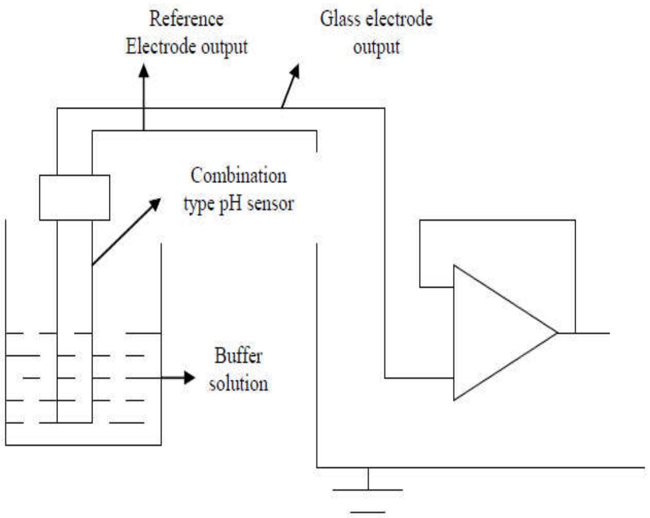

Fig.1: Experimental set up and circuit for measurement f output in mV

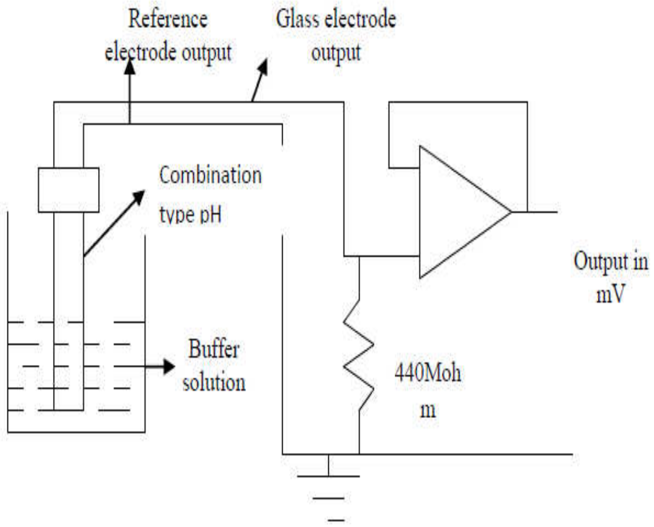

Fig 3: Experimental set up and circuit for measurement of output in mV

A. MV Output Measurement:

pH sensor has very high internal resistance. Therefore, a very special purpose amplifier is required to amplify the signal. This high input impedance signal is converted in to low impedance signal by using a high input impedance buffer amplifier specially designed and developed for this purpose. The output of the amplifier is measured on Keithley Electrometer (Model 614). Since the amplifier was connected in unity gain configuration, it gave actual output of pH electrode in different pH solutions. The circuit is shown in Fig.1. The sensitivity of the pH sensors for different buffer solutions is graphically represented in Fig .2.

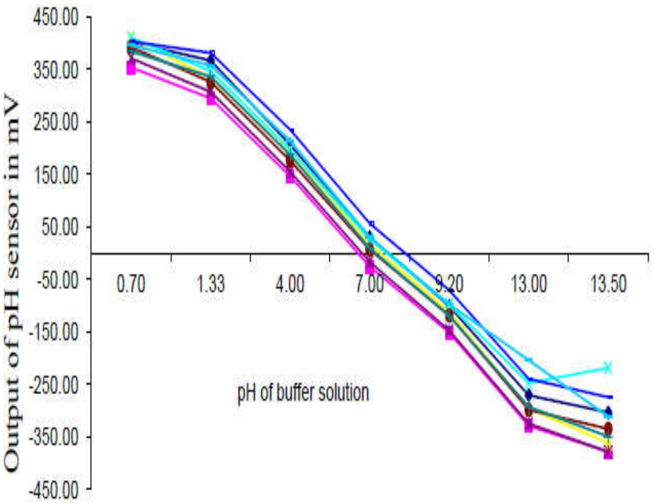

Fig.2: Variation of output in mV of different make (combination type) pH sensors with pH of solutions

B. Internal resistance measurement:

Since the internal resistance of pH sensor is very high, a high resistance of value 440 Mohm was connected across the pH sensor to get a measure of the loaded output as shown in Fig.3

Then output of amplifier was measured by maintaining the same physical conditions and buffer solutions, as was used under normal pH measuring configuration without load resistance. The output was noted and procedure was repeated for different make pH sensors and different buffer solutions. The resistance of different make pH sensors for different buffer solutions is graphically represented in Fig.4.

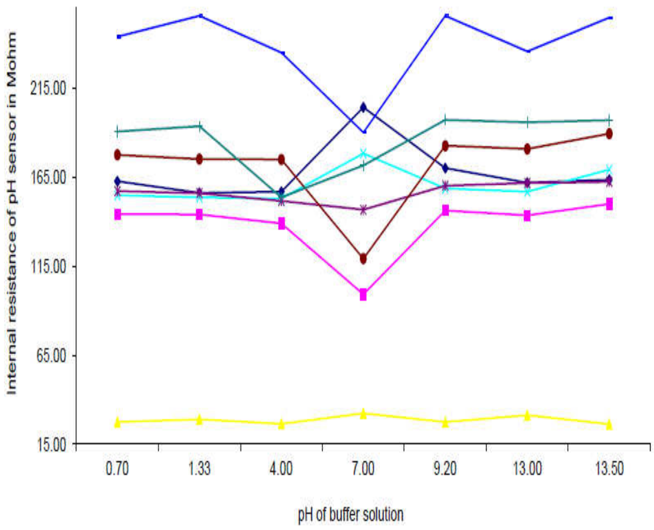

Fig.4: Variation in internal resistance of pH sensor in Mohm

III. CONCLUSIONS

Considering the different values for pH on different electrodes, it is observed that the sensitivity of the pH sensors varies from 56 mV/ pH to 59.23 mV / pH for standard buffer solutions of 4, 7 and 9.2 pH i.e. it follows the Nernstian behavior. The output of each pH sensor is approximately zero at 7 pH and increases linearly to positive side as pH decreases and increases to negative side as pH increases towards negative side. This variation of sensitivities may be due to the differences in the compositions of different pH sensitive glass electrodes as well as due to the variations of junction potentials of the reference electrode.

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REFERENCES

1. C Clark Westcott; mrasurements, Academic Press Inc
2. G K Mcmillan; pH Control, Instrument Society of America
3. Ingold; Practice and theory of pH measurement, An outline of pH measurement information and practical hints
4. J M Covelon, J J Fombon, P Clechet, N Jaffrezic-Renault, C Martelet, A Nyamsi, Y Cross; Sensitization of dielectric surfaces by chemical grafting: Applications to pH ISFETs and REFETs; Sensors and Actuators B,8(1991)221-225.