Use of Polyaniline as an Indicator of Acid Base Titration

Neha Jain, Nitesh Sharma, Neha Patni, Shibu G.Pillai

Department of Chemical Engineering, Institute of Technology, Nirma University, S. G. Highway, Ahmedabad-382481, Gujarat, INDIA.

***Abstract*- Chemical sensors are of great significance for the modern life. Their application comes from their capability to analyze several environments, detecting which substances and compound are present and their quantities. Chemical sensors have an important role in monitoring the environment, providing information on industrial processes and manufacturing, leak detection, detection of explosive, combustible and flammable gases, quality control of food and beverages etc. Conducting polymers are used as sensitive layers in chemical micro-sensors.. Polymers are very extensively used in chemical sensors because their chemical and physical properties may be modified over a wide range of characteristics. The measurement of pH is an essential task required in clinical diagnostics and in environmental and industrial controls because many chemical or biochemical processes are pH-dependent. Here we have done number of experiments and found the substitution of methyl orange and Phenolphthalein.**

Keywords: **sensor, polyaniline, polymer, pH sensor, indicator**

I. INTRODUCTION

During the last 20 years, comprehensive research and development on the field of sensors has prolonged exponentially in terms of financial investment, the published literature, and the number of active researchers. Basic characteristic of a sensor is to give information on our physical, chemical and biological environment. Chemical sensors have an important role in monitoring the environment, providing information on industrial processes and manufacturing, oxygen depletion, leak detection, detection of explosive, combustible and flammable gases, quality control of food and beverages and contaminates in natural water by industrial effluents and run off from agriculture fields etc.[1]

A chemical sensor is a device that transforms chemical information, ranging from the concentration of a specific sample component to total composition analysis, into an analytical useful signal [2]. Different types of material are used for fabrication of chemical sensor such as metal oxide, conducting polymer with different composites, solid electrolytes etc. Here we are focusing only the polyaniline because of its characteristics.

Different indicators are used for this purpose. Most frequently used indicators are Phenolphthalein and Methyl Orange. Indicators are the substances which show whether the substance tested is basic or acidic. Phenolphthalein is slightly soluble in water and usually is dissolved in alcohols. It turns colorless in acidic solutions and pink in basic solutions. Similarly methyl orange, in an acid it is reddish and in alkali, it is yellow.

After making the polyaniline, the filtrate which was remaining and is waste, is being utilized as an indicator because its color changes. Hence, we can call this as acid-base indicator. We have done number of experiments with polyaniline and found that in acidic medium, it is dark green and in basic medium, it is blue.

II. POLYANILINE

Polyaniline was first discovered in 1834 by Runge, and it was referred to as aniline black. PANI is known as a mixed oxidation state polymer composed of reduced benzoid units and oxidized quinoid units [3].

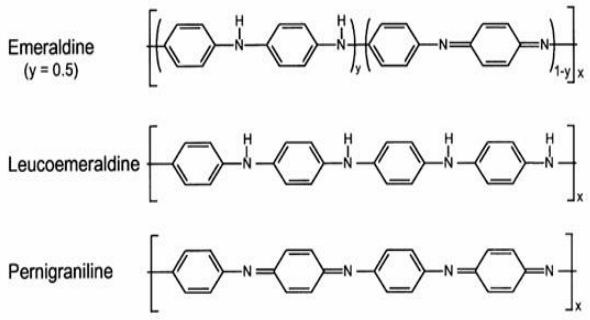

Fig: 1. Three oxidation states of Polyaniline

III .EXPERIMENTS PERFORMED IN OUR CHEMICAL LABORATORY

For making a chemical sensor, first we need to prepare polyaniline/polyaniline film. We have tried with different ways. General procedure of preparing polyaniline film that we require aniline and HCl and APS (ammonium per sulphate) as oxidant.

First, we have prepared aniline (purified with distillation) and HCl solution with varying concentrations, then mixed APS drop wise (6 gram APS in 50 ml distilled water) and stirred this solution manually for one an hour . We have put this solution for one day but after that we didn't get any color change. This may be due to the improper stirring or impure aniline.

Fig.3: Polyaniline lab preparation

Second, when we have used directly aniline hydrochloride (6 gm aniline in 50 ml of distilled water) instead of making a solution of aniline-HCl and mixed with different ratios of ammonium per sulphate, then we got the results given below:

1. Color observation:

When we have used APS and aniline hydrochloride in the different ratios (1:1, 1.25:1, 1:1.25) then with same ratio (1:1), we got the instant color change which was dark green (desirable).

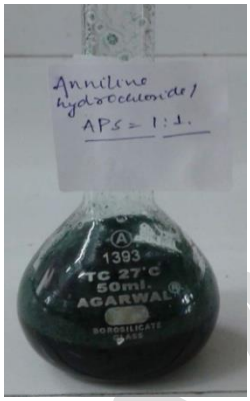

Fig.4 Equlimolar APS and Aniline hydrochloride (dark green color)

2. Conductivity Test

The sample with the ratio of 1:1 (aniline hydrochloride /HCl) showed the highest conductivity of 98.4 ms, which is almost same as reported.

Fig.5 Conductivity Test of polyaniline

3. FTIR (Fourier transform infrared spectrometry)analysis

FTIR gives an idea about the quantitative and qualitative analysis for organic and inorganic samples. Fourier Transform Infrared Spectroscopy (FTIR) identifies chemical bonds in a molecule by producing an infrared absorption spectrum. The spectra produce a profile of the sample, a distinctive molecular fingerprint that can be used to screen and scan samples for many different components. FTIR is an effective analytical instrument for detecting functional groups and characterizing covalent bonding information [4].

The average modern infrared instrument records spectra from an upper limit of around 4000 cm^{-1} (by convention) down to 400 cm^{-1} as defined by the optics of the instrument (commonly based on potassium bromide, KBr) [5].

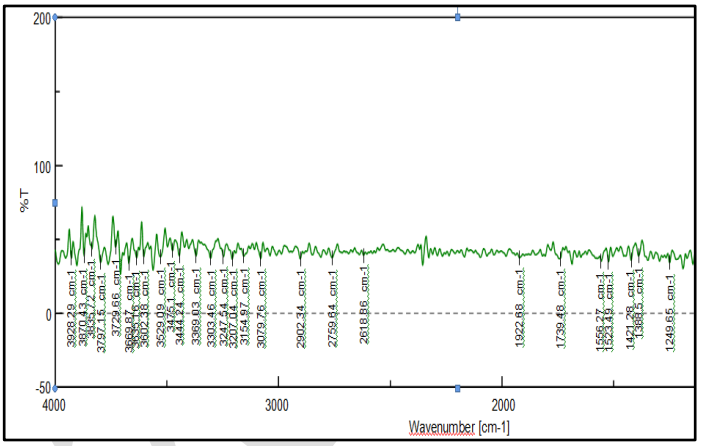

Fig.6. FTIR analysis

Data Information	Data Information
Creation Date--9/30/2015 1:29 PM	Model Name--FT/IR-6100typeA
Data array type--Linear data array	Serial Number--A000361020
Vertical--%T	Light Source--Standard
Horizontal—Wavenumber[cm-1]	Detector--TGS
Start--399.193cm-1	Accumulation—16
End--4001.57cm-1	Resolution--8 cm-1
Data pitch--1.92847 cm-1	Zero Filling--On
Sample Name-Polyaniline	Apodization--Cosine

Here in this FTIR of polyaniline, the peaks of functional groups are approximately same as we have seen in the standard table but here in the above result, noises are there, this may be because of impurities or moisture content.

IV. PANI AS PH SENSOR AND ACID BASE TITRATION INDICATOR

When we are using polyaniline (PANI) as a sensing material for the fabrication of chemical sensor, first we need to prepare the polyaniline film.

General procedure of formation of polyaniline is:

- Prepare aniline hydrochloride solution.
- Also make an APS solution.
- Mix the solution of APS in aniline hydrochloride drop wise.

- Stirrer with magnetic stirrer for half an hour.

After filtration, the filtrate which was initially waste, now we can utilized this as an acid base indicator.

Need of Blank Titration:

We are going for blank titration because of the free HCl present in the system so when we are using PANI as an indicator in acid we have to subtract the blank titration value from the final reading and add if we are using as an indicator in base.

Blank titration of PANI

	I	II	III
Initial Level	0	0	0
Final Level	0.7	0.7	0.7
Difference	0.7	0.7	0.7

We have performed number of titrations with PANI as well as both Phenolphthalein and methyl-orange.

System: Titration of NaOH(aq) with 0.1 N HCl

In burette – NaOH (0.1 N)
In flask- 10 ml HCl (0.1 N)
Observations are giver below:

PANI (turns from dark green to blue)

	I	II	III
Initial Level	0	0	0
Final Level	10.1	10.0	10.1
Difference	10.1	10.1	10.1

Phenolphthalein (colorless-pink)

	I	II	III
Initial Level	0	0	0
Final Level	9.9	10.0	9.9
Difference	9.9	10.0	9.9

Methyl orange (red- orange)

	I	II	III
Initial Level	0	0	0
Final Level	9.8	10.0	9.9
Difference	9.8	10.0	9.9

From the table we can compare the use of PANI as an indicator with phenolphthalein and methyl orange, and it is giving us satisfactory result, their end points are nearly same.

V. LIMITATIONS

Polyaniline has its own limitations when we are using as an indicator. These limitations are:

- It degrades with time, so we need to take blank titration every time.
- It doesn't show the satisfactory performance in coloured solution.

VI. CONCLUSION

Polyanilne is also known as PANI, is a polymer that has high conductivity compared to other conducting polymers. The filtrate left after filtering the polyaniline powder is used here, which is a waste. PANI can be used as a substitute for methyl-orange as well as phenolphthalein as it has long pH range so it can be used as acidic as well as basic indicator, similarly it has distinct end point color when compared with methyl orange which has tricky end point. However, it has limitation also that we need to calibrate PANI every time before we use it as it contain free HCl ions and we can't use it to sense the pH for colored solution.

REFERENCES

[1] Basudam Adhikari, Sarmishtha Majumda Polymers in sensor applications' Prog. Polym. Sci. 29 (2004) 699–766
[2] S.K. Dhawan, D. Kumar, M.K. Ram, S. Chandra, D.C. Trivedi, Application of conducting polyaniline as sensor material for ammonia, Sensors and Actuators B 40 (1997) 99-103
[3] .Kerileng M. Molapo, Peter M. Ndangili, Rachel F. Ajayi, Gcineka Mbambisa, Stephen M. Mailu, Njagi Njomo, Milua Masikini, Priscilla Baker and Emmanuel I. Iwuoha, Electronics of Conjugated Polymers (I): Polyaniline,Int. J. Electrochem. Sci., 7(2012) 11859 – 11875
[4] John Coates, Interpretation of Infrared Spectra, A Practical Approach, in Encyclopedia of Analytical Chemistry R.A. Meyers (Ed.), (2000) 10815–10837
[5] N.B. Colthrup, L.H. Daly, S.E. Wiberley, Introduction to Infrared and Raman Spectroscopy, Academic Press, San Diego, CA (1990),1–73