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A Low Cost High Precision Virtual Instrumentation for Potentiometric Titration

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Abstract We propose a high precision personal computer (PC) based virtual instrumentation for potentiometric titration technique using Advantech USB 4711A data acquisition module. The entire titration including online data acquisition followed by immediate online analysis of data to get information about concentration of unknown sample is completed within a couple of seconds. The test setup is developed in our laboratory using Advantech's data acquisition card, USB 4711A interfaced to the IBM compatible PC, operated under windows 7 operating system. A simple and inexpensive signal processing circuit is designed in our laboratory using off-the-shelf components, to amplify signal received from glass electrode. Powerful and effective data acquisition software VB.NET is used at back end as well as front end to accomplish data acquisition, parameter setting, file manipulation, control and synchronization of the other functions involved in the measurements. The control panel directly displays the strength of liquid under test at a given temperature.

Keywords: *glass electrode, data acquisition, virtual instrumentation, Titration, VB.NET*

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1. Introduction

A virtual instrumentation system can be regarded as computer software that a user would employ to develop a computerized measurement system, for controlling (from a computer screen) an external measurement hardware device, and for displaying or storing the measured data collected by the external device [2]. Virtual instrumentation can simply be defined as combining hardware and software with industry-standard computer technologies to create user-defined instrumentation solutions. In virtual instruments, the same set of stand-alone hardware components can perform different tasks imposed on them by the software [3].

The recent developments in the field of instrumentation have changed the principles of instrument design and construction since the software becomes the actual "instrument" (the so called "virtual instrument" or VI). So, instead of dedicated real instruments, a personal computer, equipped with a multifunction Data Acquisition (DAQ) [1] card (or appropriate interfacing devices) and appropriate software, is turned into a flexible instrument capable of controlling a variety of experiments with acquisition of required raw data [4]. The primary benefits of applying data acquisition technology to configure virtual instrumentation include costs, size, flexibility and ease of programming. It has been estimated that the cost to configure a virtual instrumentation system using a data acquisition board or cards can be as little as 25% of the cost of a conventional instrument [5].

2. Hardware description

A block diagram of the instrumental set-up for automated potentiometric titration measurements[6,7] is illustrated in Figure 1.

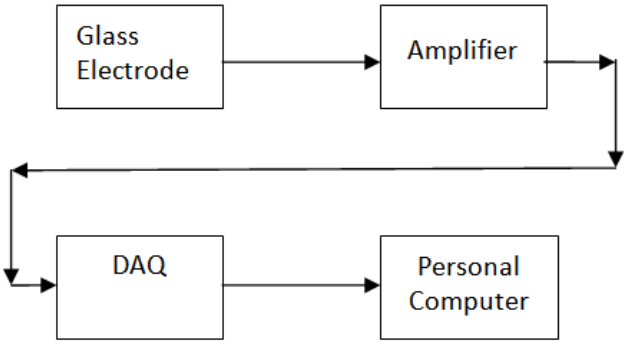

Figure 1. Block diagram of System

The instrumental set-up can be regarded as essentially being composed of three main components:

1. Electrode and Amplifier.
2. Data collection and processing interface.

The glass electrode is used to sense the potential [8] at a given concentration during titration. This potential may be amplified by an instrumentation amplifier. A data

acquisition card, USB 4711A is used to acquire this amplified signal. Data acquisition software at the back end is written in VB. NET is used for designing the GUI control panel screen to accomplish data acquisition, parameter setting, file manipulation, control and synchronization. The photograph of the actual experimental set up is given in Figure 2.

The data collection and processing interface of the instrumentation comprised of a personal computer (PC) equipped with Advantech USB 4711A Data Acquisition Card (or DAQ card) [9,10].

The PC used to control the instrumental set-up is equipped with software designed in VB.NET framework.

3. Experimental

The sample is placed in the titration vessel and 1 M HCL is added to give the starting volume required to the nearest 1.0 ml. The electrodes are allowed to equilibrate for 5 minutes and thereafter the titration with 1 M NaOH in 1 M HCL is done manually. The titration and measurements can be done at 1.0 ml interval of titrant addition.

Various software modules (referred to as Virtual Instruments or VIs) for automated titration experiments were developed in VB. NET for four tasks.

1. Calibration of electrode.
2. Controlling the titration.
3. Recording the potential.
4. Curve fitting.

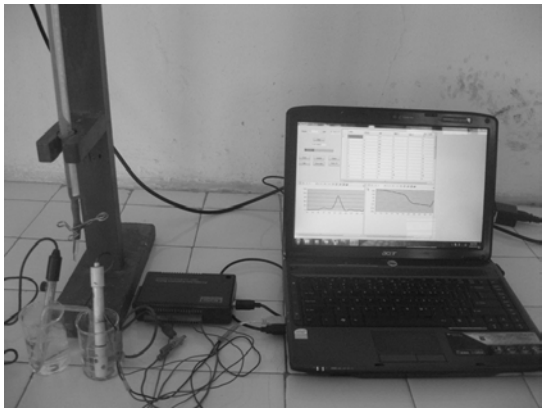

Figure 2. Photograph of the Experimental Setup

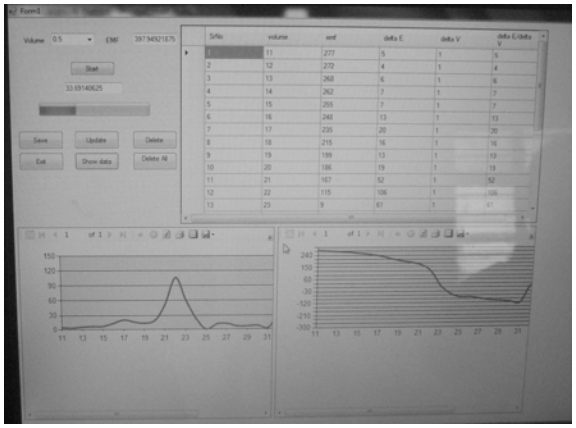

Figure 3. Screenshot showing graph and tabulation done using VB. NETprogram

4. Results

The results of the titration using the Virtual Instrumentation and calculations for various mixtures of a strong and weak acid in different concentration ratios are carried out in the laboratory. A sample table for the liquids 1M of HCL verses 1M of NaOH titration is given in Table 1. With the help of virtual instrumentation, the titration and estimations of strength of unknown solvent have become an easy, faster and much reliable. It is also possible to extend the measurements at the desired temperature using a refrigerating-heating circulating thermostat. The screenshot for the titration results is given in Figure 3.

Table 1. Volume of titrant added and emf generated

SrNo	Vol (ml.) V	Emf (mv.) E	delta V	delta E	delta E/delta V
1	1	277	1	5	5
2	2	272	1	4	4
3	3	268	1	6	6
4	4	262	1	7	7
5	5	255	1	7	7
6	6	248	1	13	13
7	7	235	1	20	20
8	8	215	1	16	16
9	9	199	1	13	13
10	10	186	1	19	19
11	11	167	1	52	52
12	12	115	1	106	106
13	13	9	1	61	61
14	14	-52	1	22	22
15	15	-74	1	17	17
16	17	-85	1	12	12
17	18	-97	1	7	7
18	19	-104	1	7	7
19	20	-111	1	8	8
20	21	-119	1	2	2

5. Discussions

Virtual Instrumentation designed for potentiometric titration for acid base liquids at a particular temperature using glass electrode, amplifier and a data acquisition card (USB 4711A), is simple in design, faster, reliable, cheaper and accurate with online/offline storage (for database) and processing capabilities. This virtual instrumentation finds extensive use in modern analytical chemistry lab.

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