KANOPY TECHNO SOLUTIONS

K-LYTE 1.2

USER MANUAL

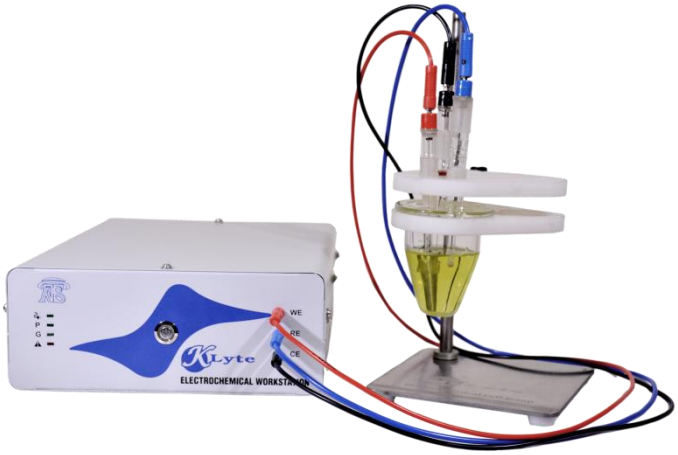


About the Company

Kanopy Techno Solutions is a renowned organization for high-quality research in physical electrochemistry, battery, sensors, corrosion and nanotechnology. Our core team includes experienced professors and alumunus of renowned technological institutes in India. We provide one stop solutions in the areas of electrochemistry, electrochemical reaction engineering and electrical instrumentation. We believe in high-quality research in a simplified manner.

Kanopy Techno Solutions is a spin off company from IIT Kanpur & also has successfully graduated from SIIC Incubation Center, IIT Kanpur. Currently company is situated at TechnoPark, IIT Kanpur (India's one of the largest research hubs) & also has deep collaborations with different research labs of IIT Kanpur for company's product R&D.

We provide a complete solution for electrochemical laboratory instruments and accessories, which include Potentiostat, Galvanostat, electrodes, and various electrochemical cells. We also offer undergraduate level kits in electrochemistry and nanotechnology for basic, intermediate, and advanced levels. Our consultancy service promotes research initiatives as well as back-end support to research institutes and industries for high-quality research.



Contact us:

www.kanopytech.com

contact@kanopytech.com

+91-9555410424, 8010779277

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1. Introduction to K-Lyte 1.2

1.1.About the K-Lyte 1.2 Hardware

K-Lyte 1.2 is a high-end Potentiostat, capable of performing many important electroanalytical techniques for physical electrochemistry, nanotechnology, corrosion, sensor. This instrument is quite suitable for measurements in both the aqueous and non-aqueous systems. It is sensitive enough to record electrical signals in the nano ampere range. Detailed specifications of the instrument are given below:

Techniques	Potentiostatic ▪ Linear Sweep Voltammetry (Potentiostatic) ▪ Cyclic Voltammetry (Potentiostatic) ▪ Chronoamperometry ▪ Pulsed Voltammetry (DPV) ▪ OCP Measurement ▪ Tafel Analysis ▪ Linear Polarization ▪ I-V Characterization	
Specifications		
Cell Connection	2, 3	
Compliance Voltage	±15V	
Slew Rate	Rising	1.5 V/µs
	Falling	8 V/µs
	Settling Time	7.5 µs
Input Impedance Reference	> 10 TΩ	
Unity Gain Bandwidth	1.4 MHz	
Input Bias/Leakage Current	±15 pA	
DAC and ADC bit	16	
Data Acquisition Rate/Sampling Rate	100 Ksps	
CMRR	106 dB	
Potentiostat		
Applied Voltage Range	±5 V, ± 10V	
Applied Voltage Accuracy	Within 0.05% of voltage scale	
Applied Voltage Resolution	Upto 150 µV	
Measured Current Range	8 Ranges (100 nA, 1 µA, 10 µA, 100 µA, 1 mA, 10 mA and 100 mA and 1A)	
Measured Current Resolution	15 pA @ 100 nA Range	
Scan Rate	1 µV/s to 1000 mV/s	
Chassis Information		
L x W x H	320 mm x 220 mm x 90 mm	
Weight	2.6 Kg	

1.2.About the K-Lyte software

K-Lyte software is a user-friendly software which is developed by keeping the user's comfort in mind. It is very lightweight that runs in your operating system smoothly. It allows the user to effectively set the experimental parameter for each technique and view/save data both as image and in *.xls*/.csv formats.

The K-Lyte software is available for different Windows platforms (Windows 7 or later versions) for flexibility over various kinds of computers.

1.3.User Interface

The application has a simple Graphical User Interface (GUI). It comprises of following regions as marked in Figure 1.1.

I. Menu Bar – Application options and help commands

II. Tool Bar – Frequently used command (Plot Options).

III. Experiment Tab – Options regarding the choice of experimental techniques

IV. Plot Window – Displays plot representation of the measurement variable. This window can be resized by dragging the mouse.

V. Log Window – Shows success logs, error logs, and warning messages

VI. Status Bar – Shows the status of a running operation being carried out by the software

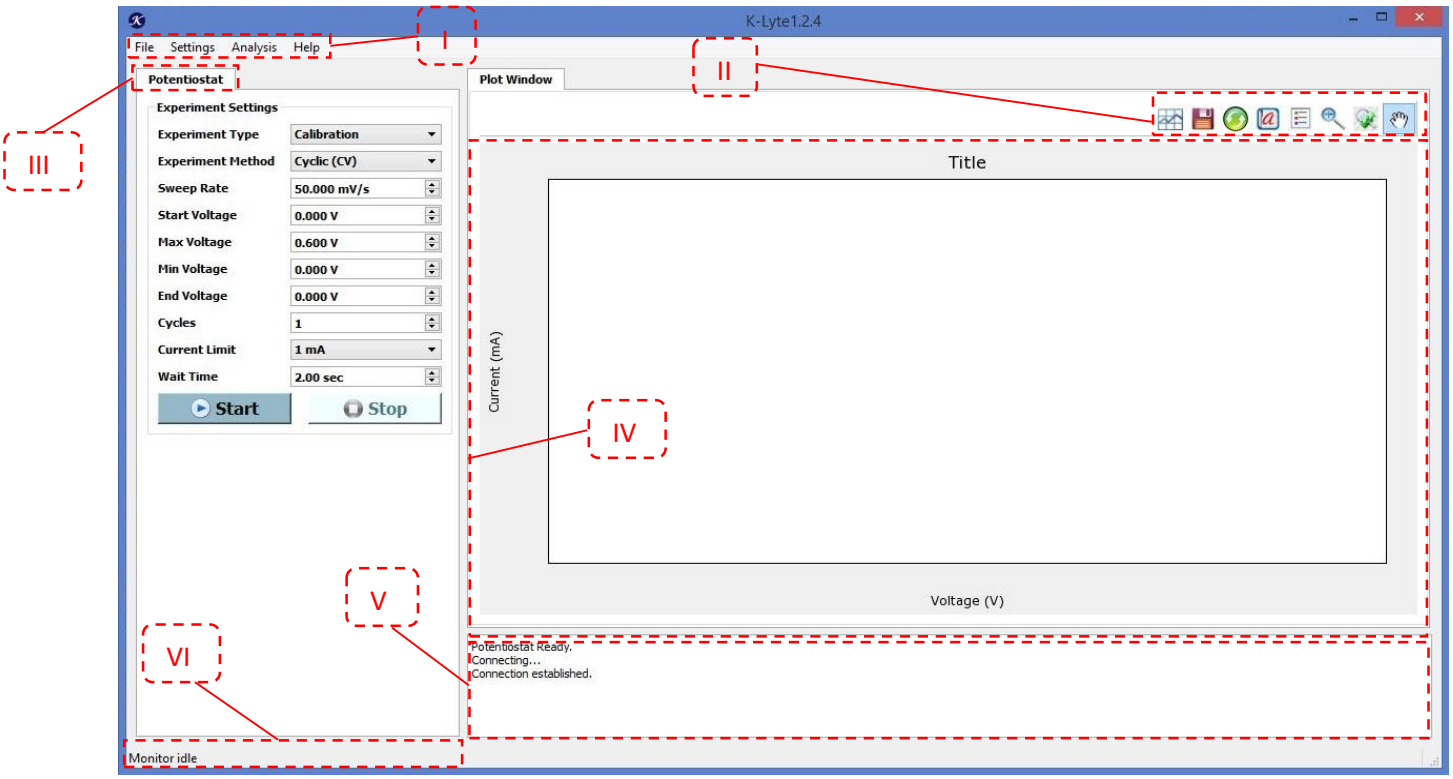
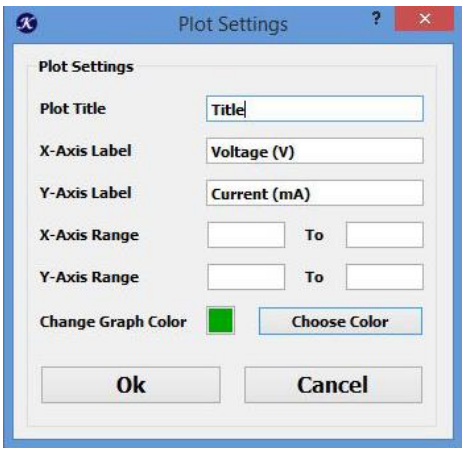


Figure 1.1 – User Interface of the K-Lyte 1.2 with different regions

1.3.1. Menu Bar:

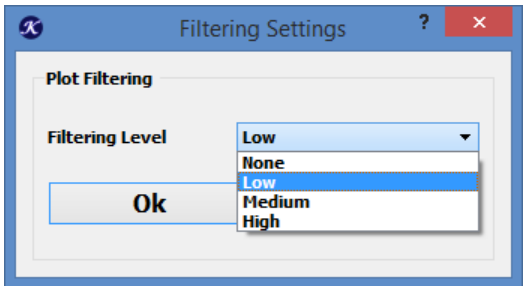
File	Settings	Analysis	Help
• Open • Save Plot Image • Save Data Points • Exit	• Plot Settings • Filtering Settings • Save Data settings • Voltage Settings • IR Compensation Settings • Data Sampling Rate	• Tafel Plot • Corrosion Analysis • OCP Window	• About • User Guide

Settings Options:



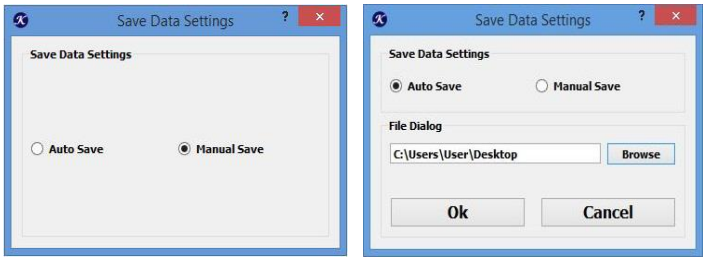
Plot Settings

This option helps to customize the plot interface as per the requirement of the user. With this option, one can set a title for the plot, choose the x-axis and y-axis variable, their appropriate range, and also the color of the graph as well.



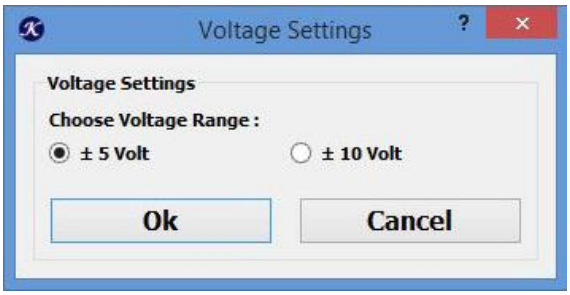
Filtering Settings

This option allows the user to control digital filtering through the software. Four options are available: *None*, *Low*, *Medium,* and *High* with an inbuilt filtering program. *Low* filtering is the default setting and the recommended one. An optimum filtering option can be chosen according to the noise observed in plotted data.



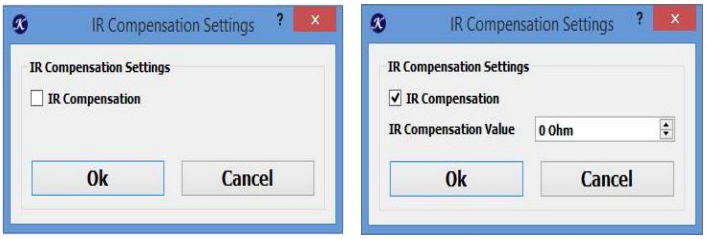
Save Data Settings

This option allows one to save the experimental data in two different modes: *Auto Save* and *Manual Save*. By choosing the *Manual Save* option, one can save experimental data manually to the desired location on the computer at the end of the experiment. Whereas the *Auto Save* option allows one to save data automatically at a pre-specified location.



Voltage Settings

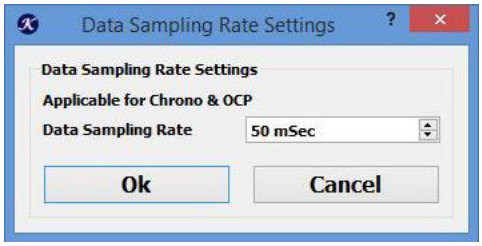
This option allows one to choose the required voltage range for an experiment. In actual practice, with ±5V voltage setting, the instrument can reach the voltage ±4.90V. Similarly, with the ±10V setting, it can reach the voltage ±9.90V.



IR Compensation Settings

Tish option allows one to set the desired value of the resistor for IR Compensation.

Note: IR Compensation includes the contact resistance and the solution resistance values, which are generally in the order of few ohms. IR compensation becomes more significant at a high currents measurement.



Data Sampling Rate

This option allows one to set the Data Sampling Rate (data recorded per unit time), and it is applicable only for Chronoamperometry, Chronopotentiometry, and OCP experiments.

Note: This setting is useful when the user wants to run a long duration experiment and interested in collecting the data for the same.

Analysis Options:



Tafel Plot

This option is used to determine the Tafel slopes in the anodic and the cathodic region. The software further simulates to give the value of the intersection of these slopes. This option is useful for corrosion analysis where the intersection point can determine the I_{corr} and E_{corr} values.

Note: The Tafel plot, once drawn, cannot be re-drawn for the same experiment, so one should be careful about choosing the points to get the Tafel slopes and the intersection point.



Corrosion Analysis

This option allows us to calculate the corrosion rate of a particular sample using the Tafel or Polarization resistance technique. It takes I_{corr} as input and calculates the corrosion rate with the standard formula:

$$\text{Corrosion Rate} = \frac{3270 * Icorr * M}{A * n * 10}$$

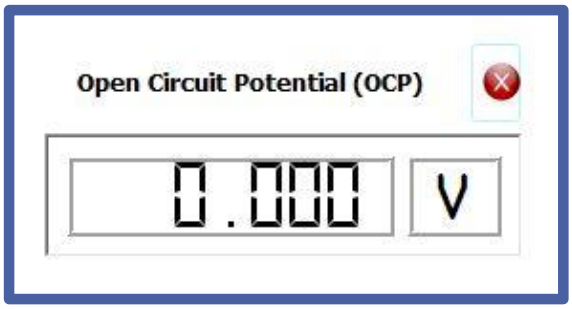
where

I_{corr} = Corrosion current

A = Area of the selected material

n = Valency of the material chosen

M = Molecular weight of the selected material



OCP Window

This option displays the measured Open Circuit Potential (OCP) value in volts. This value represents the potential at *Working Electrode* with respect to the *Reference Electrode*.

1.3.2. Tool Bar:





⇒ ***Save plot images***
Once the experiment is over, this click will save the plot image in png/jpeg format.



⇒ ***Save data points***
This option will save plot data points in any preferred location in MS Excel Format.



⇒ ***Reset to Autofit***
This option will refresh the plot in its default condition. It's used after zoom/drag command.



⇒ ***Annotation***
This option helps us viewing the latest point of the plot at run time and after the plotting is over.



⇒ ***Legend***
This option shows the units of the variables.



⇒ ***Box Zoom***
This option is a kind of box zoom which helps to zoom at a particular location in the plot. It is used to analyze data points at a specific region of the plot of interest.



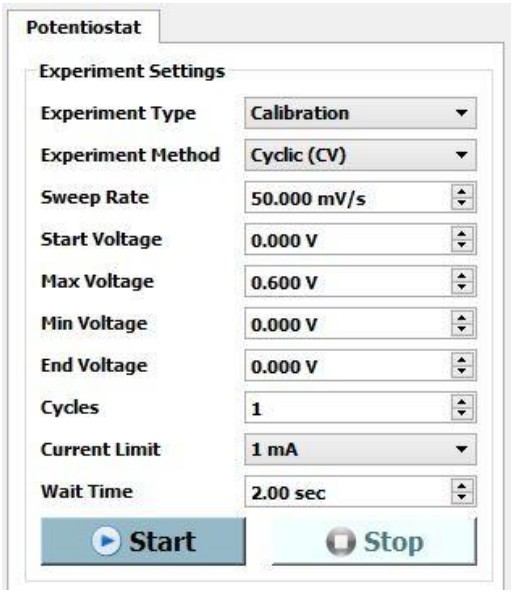
⇒ ***Drag Zoom***
This zoom option will zoom in/out with a scroll of mouse and also with the drag of the cursor of the mouse.



⇒ ***Pan Tool***
Pan tool allows one to move the plot in multiple directions. Mostly this option is used to drag the plot after zooming in at a particular location.

1.3.3. Instrument Mode:

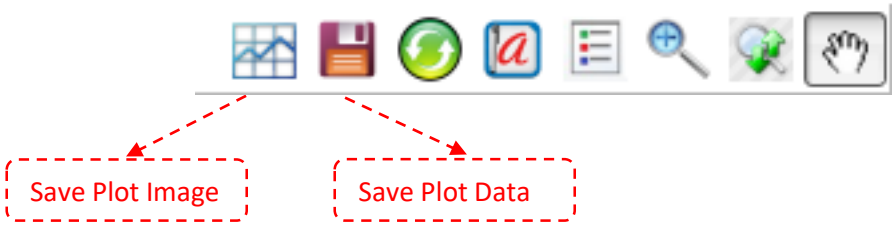
In the Potentiostatic mode, the user can choose an experimental technique along aith the parameter as per requirement.



1.3.4. Post-processing:

At the end of each experiment, the software automatically asks to save the data points in CSV format. If somehow one cancels the option, the data can also be saved later on by clicking on *save plot image* or *save plot data* options from the Tool Bar. For autosave options, please refer to settings options *Section 1.3.1*.

Both the plot image and the data points of an experiment can be saved by clicking the *Save Plot image* and *Save Plot Data* buttons, as shown below.



1.4.Experimental settings

After a connection has been successfully established (check the status bar), one has to go through experimental settings and set up the variables for a particular experiment. The various options that can be set are described in the following sections.

1.4.1. Calibration / External Cell

Calibration:

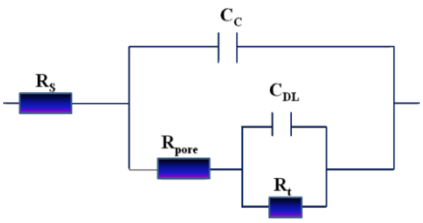
K-Lyte 1.2 includes a calibration facility with the help of an inbuilt **Dummy cell** having resistance 1kΩ. A consistent and standard result of the calibration experiments ensures the correct functionality of the instrument.

Calibration experiments have the following advantages:

- One can check the instrument's performance frequently before performing the experiments.
- One can check the absolute offset for the plot of a particular technique.



Q1: What is a Dummy Cell?



Dummy cell is an electronic circuit consisting resistances/capacitors which is compared with electrochemical cell (as shown in figure). The good thing about this dummy cell is that it gives consistent results for each method. Its performance is independent of experimental conditions unlike a real electrochemical cell.

The inbuilt dummy cell of K-Lyte 1.2 is a 1kΩ resistance.

External cell:

This option helps one to perform an experiment with any external electrochemical cell setup. Three leads are provided, namely, *Working electrode* (WE), *Reference electrode* (RE), and *Counter electrode* (CE).

These leads are first connected to the electrochemical cell setup in an appropriate manner. After this, the option, *External cell* can be chosen to carry out the experiment.

1.4.2. Experimental Methods

One may choose the experiment type which is to be performed.

In Potentiostat, eight different experimental techniques are included:

1) Cyclic Voltammetry (Potentiostatic)
2) Linear Sweep Voltammetry (Potentiostatic)
3) Chronoamperometry
4) OCP Measurement
5) Tafel Analysis
6) Linear Polarization
7) Pulsed Voltammetry (DPV)
8) I-V_Pot

2. Instrumental procedures

2.1. Linear Sweep Voltammetry :

This method is used when one needs to apply a unidirectional voltage scan. A typical waveform is shown below for LSV.

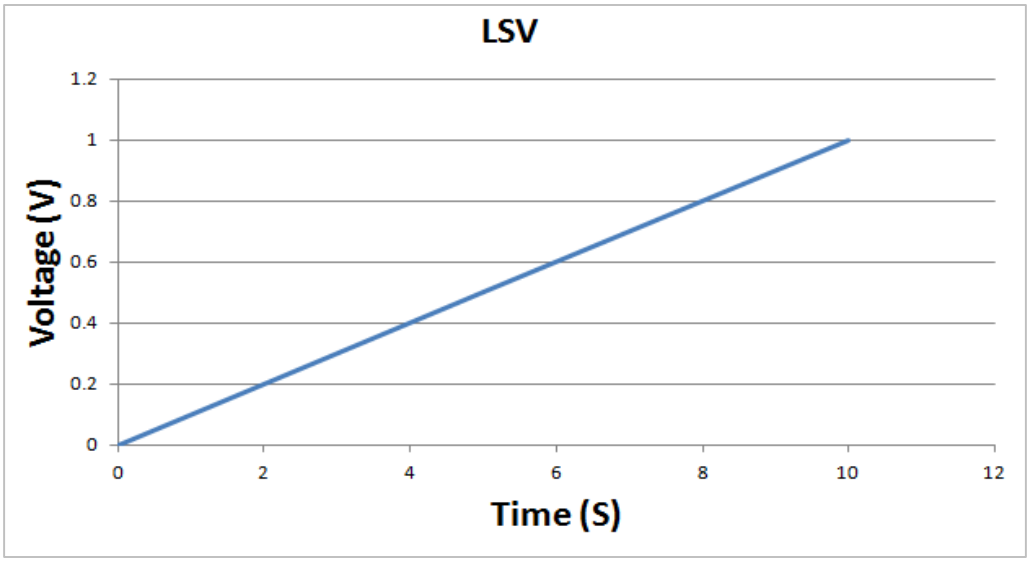


Figure 2.1 – Waveform of the Voltage scan applied during LSV

Variables Associated with LSV:

Variable	Significance	Min Value	Max Value
Sweep Rate	Rate of change of voltage with time during the scan.	0.001 mV/s	1000 mV/s
Start Voltage	The value of the voltage where the scan starts from	-4.95V/9.90V	+4.95V/9.90V
End Voltage	The value of the voltage is the last applied voltage of a cycle	-4.95V/9.90V	+4.95V/9.90V
Current Range (Refer Q3)	This variable is instrument dependent. The instrument performs best if the selected current range falls nearby the maximum current flowing during an experiment	100 nA	1 A
Wait time	It represents the time instruments waits just before it starts the scan.	1 Sec	60 Sec

2.2. Cyclic Voltammetry :

Cyclic Voltammetry is a kind of voltammetry method where voltage sweeps in a particular direction and reverts to the initial value making it a complete cycle.

Variables Associated with Cyclic Voltammetry:

Variable	Significance	Min Value	Max Value
Sweep Rate	Rate of change of voltage with time during the scan.	0.001 mV/s	1000 mV/s
Min Voltage	The minimum value of voltage during the scan	-4.95V/9.90V	+4.95V/9.90V
Max Voltage	The maximum value of voltage during the scan	-4.95V/9.90V	+4.95V/9.90V
Start Voltage	The value of the voltage where the scan starts from	-4.95V/9.90V	+4.95V/9.90V
End Voltage	The value of the voltage is the last applied voltage of a cycle	-4.95V/9.90V	+4.95V/9.90V
Cycles	It represents the number of repetitions of one cycle	1	10000
Current Range (Refer Q3)	This variable is instrument dependent. The instrument performs best if the selected current range falls nearby the maximum current flowing during an experiment	100 nA	1A
Wait time	It represents the time instruments waits just before it starts the experiment	1 Sec	60 Sec



Q2: How to determine cyclic voltammetry voltage window?

To understand how one can determine the voltage window, let's have one example with a scan rate of 0.1 V/s:

Voltage option	Min Voltage	Max Voltage	Start Voltage	End Voltage
Value	-1.0 V	+1.0 V	0 V	0 V

Here, with the above variables, the voltage applied on Working Electrode starts from 0 V and sweeps towards maximum value +1.0 V. Then it reverses back towards minimum voltage -1.0 V. Just after reaching the minimum voltage, it sweeps back towards the end voltage which is again 0 V in the above example.

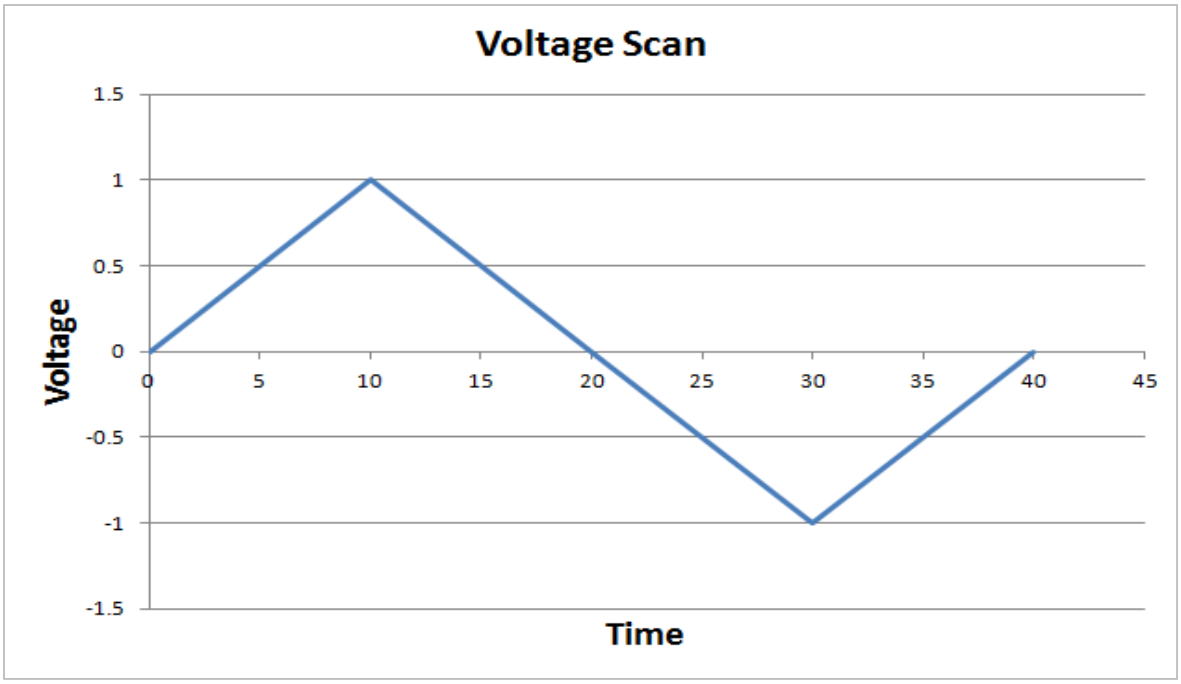


Figure 2.2 – Voltage waveform during cyclic voltammetry



Q3: How to determine the correct value of Current Range in the experiment settings?

The instrument works accurately in a specific current range for a particular experiment. For example, when the expected maximum current is 2.0 mA, then one should choose the current range as 1.0 mA so that the instrument performs one specific experiment with the highest accuracy.

There are seven types of current ranges: 100nA, 1uA, 10uA, 100uA, 1mA, 10mA, and 100mA.

Peak Current Range	Optimum Current Range Option
Upto 400 nA	100 nA
400 nA to 4 µA	1 µA
4 µA to 40 µA	10 µA
40 µA to 400 µA	100 µA
400 µA to 4 mA	1 mA
4 mA to 40 mA	10 mA
40 mA to 400 mA	100 mA
400mA to 1A	1A

2.3. Chronoamperometry:

Chronoamperometry technique is used to analyze the current response of an electrochemical process with time at a particular voltage. The typical voltage waveform is shown below.

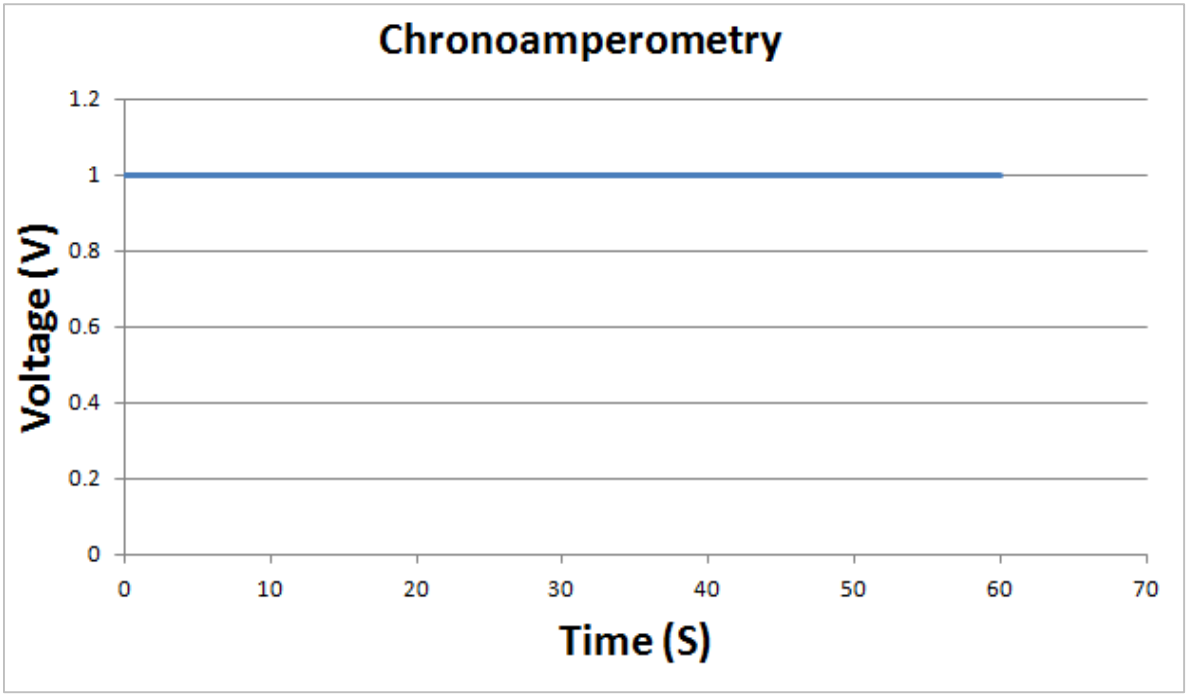


Figure 2.3 – Voltage scan applied during Chronoamperometry

Variables associated with Chronoamperometry:

Variable	Significance	Min Value	Max Value
Fixed Voltage	The value of the voltage to be applied	-4.95V/9.90V	+4.95V/9.90V
Duration	It represents the time duration for which the fixed voltage is to be applied	0 sec	30 days
Current Range (Refer Q3)	This variable is instrument dependent. The instrument performs best if the selected current range falls nearby the maximum current flowing during the experiment	100 nA	1 A
Wait time	It represents the time instruments waits just before it starts the experiment	1 Sec	60 Sec

2.4. OCP Measurement:

This method is used to measure the Open Circuit Potential of the working electrode with respect to a reference electrode in a three-electrode cell setup. Using a two-electrode setup, one can measure the OCP between any two electrodes.

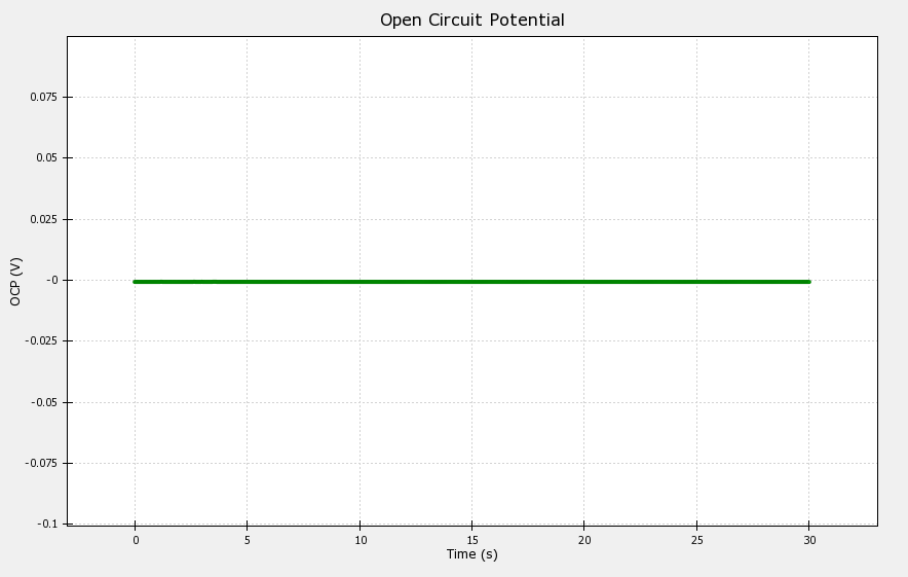


Figure 2.4 – Open Circuit Potential

2.5. Tafel Analysis:

This method is a part of corrosion measurement. Here corrosion current is calculated through extrapolation of Tafel lines in anodic and cathodic polarization.

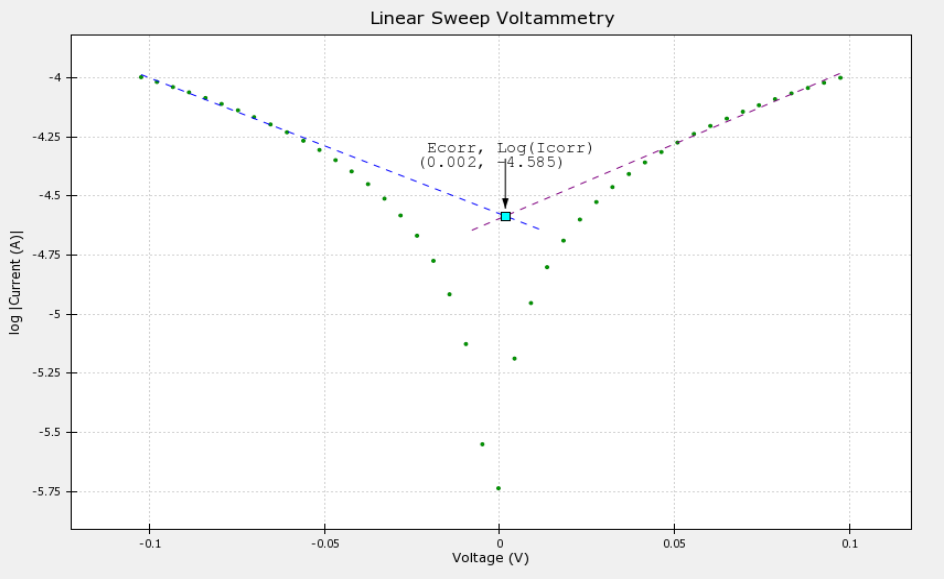


Figure 2.5 – Tafel Analysis

2.6. Polarization Resistance Method:

This method also is a part of corrosion analysis. Through this method, one can calculate the polarization resistance followed by Tafel analysis (optional), which further gives the corrosion current.

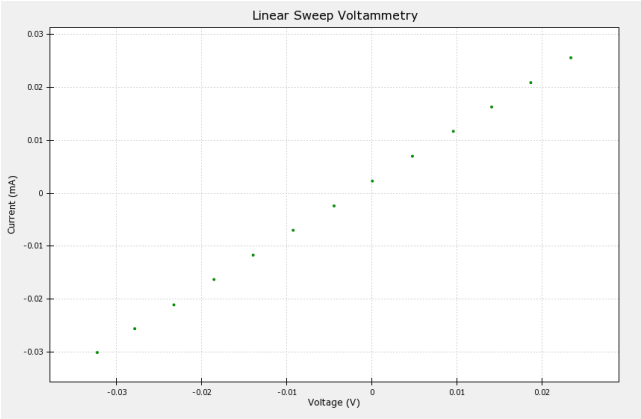


Figure 2.6.1 – Linear Polarization

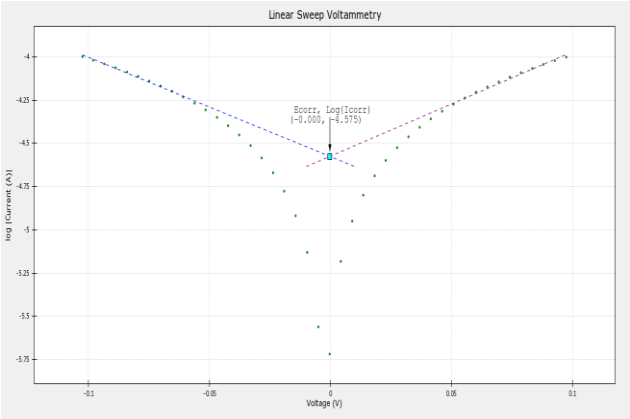


Figure 2.6.2 –Tafel Analysis

2.7. Differential Pulse Voltammetry:

In differential-pulse voltammetry technique, fixed magnitude pulses—superimposed on a linear potential ramp—are applied to the working electrode. The current is sampled twice, just before the pulse application and again late in the pulse life (when the charging current has decayed). The first current is instrumentally subtracted from the second, and this current difference is plotted versus the applied potential. The resulting differential pulse voltammogram, as shown in Figure 2.7, consists of current peaks, the height of which is directly proportional to the concentration of the corresponding analytes:

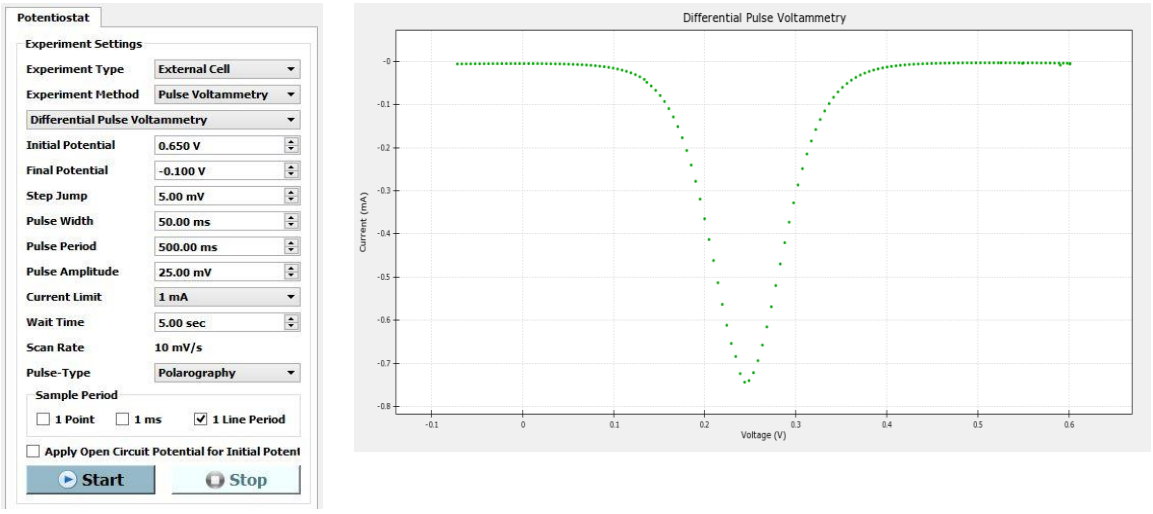


Figure 2.7 –Differential Pulse Voltammetric response

Note: Although K-Lyte 1.2 comes with the Differential Pulse Voltammetry (DPV) as the only pulse technique, the other pulse techniques, such as Normal Pulse Voltammetry (NPV), Square Wave Voltammetry (SWV), and Stripping Chronopotentiometry (SCP) can also be included on-demand basis.

3. Instrument standard calibration procedures

3.1. Tutorial on performing standard calibration with Internal Dummy Cell

Objective:

To perform linear sweep voltammetry at calibration mode with a voltage window as 0 V to 1 V at scan rate 50.000 mV/s to calibrate the instrument for the same experiment using external cell.

Experimental procedure and result analysis:

Connect instrument cable to computer > Switch on instrument Power > Open the Software in computer > Fix the setting and variables > Save data points and plot image at a specific location.

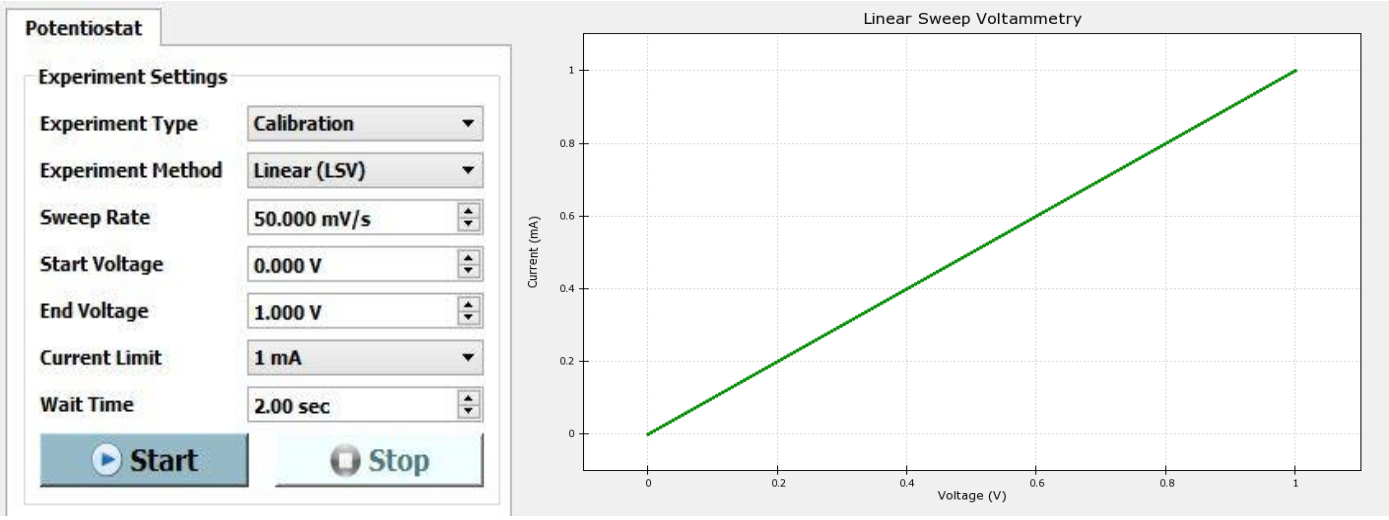


Figure 3.1 – Linear sweep voltammetry result at 50.000 mV/s

Since the inbuilt dummy cell has 1kΩ resistance, applying a voltage in the range 0.0-1.0V will result in the linear current response, as seen in figure 3.1. If the endpoints of this linear curve are exactly (0,0) and (1,1), for this particular measurement, then we can conclude there is no offset either in current or voltage. If a significant offset is observed, either in voltage or current or both, then the same should be corrected for the actual experiment using an external electrochemical cell.

3.2. Tutorial on performing standard experiments using external cell

In this section, a simple experiment using Cyclic voltammetry technique is described. It will provide the user with some initial guidance and assistance to perform experiments with K-Lyte 1.2 potentiostat using KLyte accessories. These experiments will also help the user to check the instrument's performance by using an external cell.

Materials required: $K_3[Fe(CN)_6]$ (Potassium ferricyanide), $K_4[Fe(CN)_6].3H_2O$ (Potassium ferrocyanide); KCl (Potassium Chloride); deionized water to prepare the solutions.

Experimental setup: The Cyclic voltammetry experiment is performed using three-electrode configuration: Platinum-wire as a working (product code KWE01), Platinum mesh as counter/auxiliary electrode (product code KCE01), and Ag/AgCl,3M KCl (product code KRE01) as a reference electrode. The electrochemical cell setup (product code KEC01) used for these experiments is shown in figure 3.2.

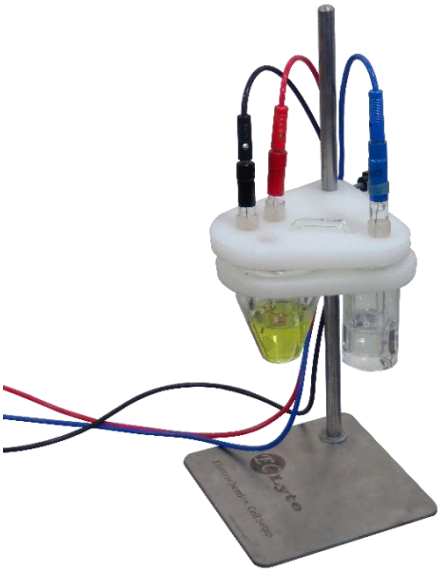


Figure 3.2. Electrochemical cell setup

Experimental procedure: A 50 ml solution of 5mM $K_3Fe(CN)_6$ + 5mM $K_4Fe(CN)_6$ + 1M KCl is prepared, and the solution is transferred to the conical beaker. The Pt-wire and Pt-mesh electrodes are inserted inside the conical beaker. The cylindrical beaker is half-filled with a 3M KCl solution, and the reference electrode is inserted inside it. The conical beaker containing the working and counter electrode, the cylindrical beaker containing the reference electrode, both are connected through a KCl-Agar gel salt-bridge (Figure 3.2).

3.2.1. Cyclic voltammetry Experiment

With this technique, the electrochemical oxidation and reduction of potassium ferrocyanide and potassium ferricyanide mixture in an aqueous medium have been demonstrated. The experimental parameters are chosen as shown in the dialog box (Figure 3.2.1a).

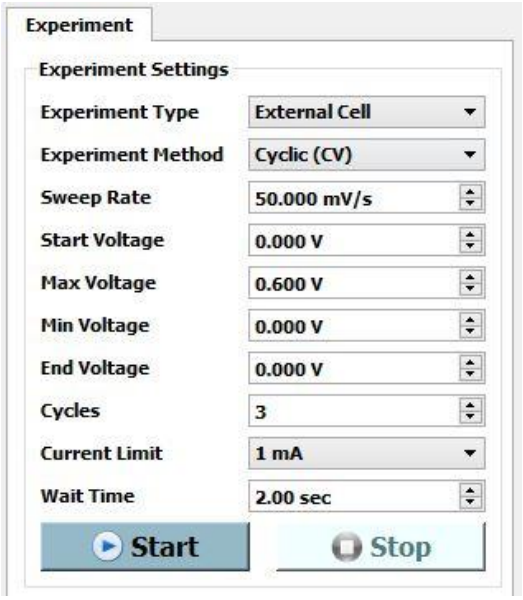


Figure 3.2.1a. Cyclic Voltammetry experimental parameter

Experimental results

Figure 3.2.1b shows the cyclic voltammetry response of the redox couple, $[Fe(CN)_6]^{3-}/[Fe(CN)_6]^{2-}$ in KCl aqueous solution. The occurrence of one forward peak (oxidation) at ~0.31V and one backward peak (reduction) at ~0.24V are observed, which are the typical characteristics of this reversible redox system.

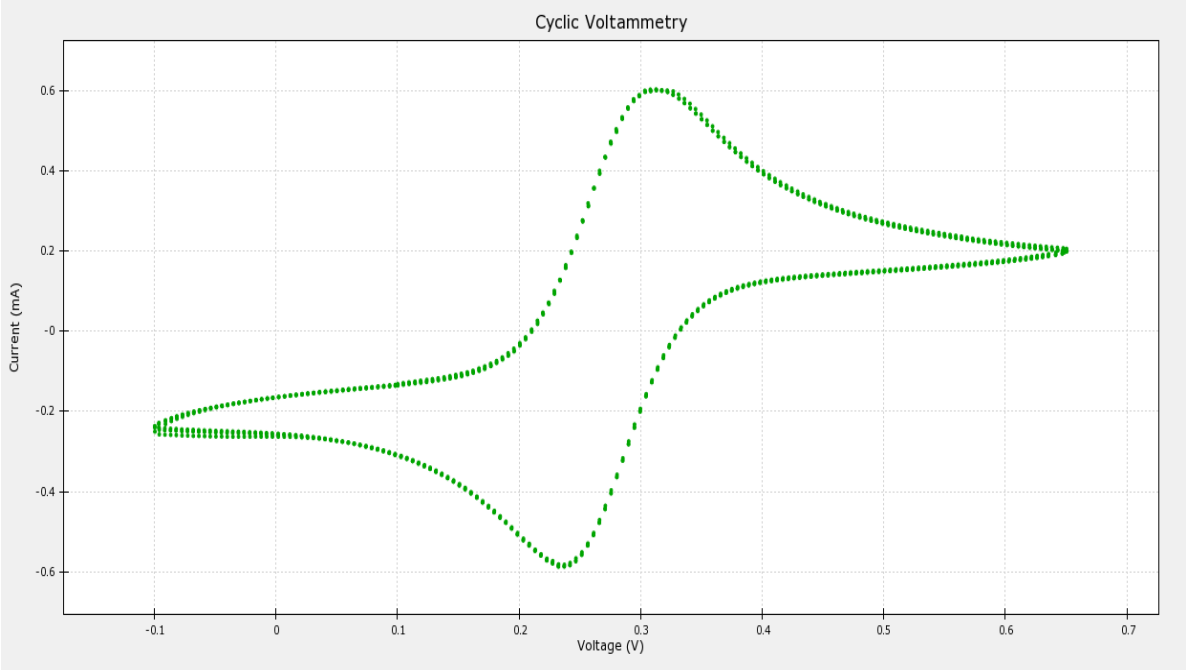


Figure 3.2.1b. Cyclic voltammetry result of potassium ferricyanide and potassium ferrocyanide redox couple at 50 mV/s vs. Ag/AgCl, 3M KCl at 27^{0}C.

Note: The peak-separation value depends on several factors, such as the cleanliness of the platinum working electrode, the temperature of the electrolyte solution, and the purity of the chemicals.

4. Instrument hardware

4.1.Introduction to the hardware:

K-Lyte 1.2 hardware is a robust solution for potentiostatic electrochemical analysis. This instrument includes auto cut protection circuitry to save the PCB from overvoltage and current values. Hardware circuitry consists of three components:

(1) Analog circuitry
(2) Digital circuitry
(3) Switching circuitry

K-Lyte 1.2 works at 220V AC power supply as input and consumes around 300 Watt. The instrument has an inbuilt cooling fan that controls the inside circuitry temperature.
It communicates with the computer through serial protocols and connects with specific drivers to the computer.

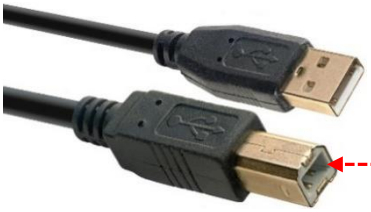
4.2.The electrode-lead connections:

The cables provided can be connected with sockets which have their marking as WE, RE, and CE for Working, Reference, and Counter electrode respectively, shown below (Figure 4.1):

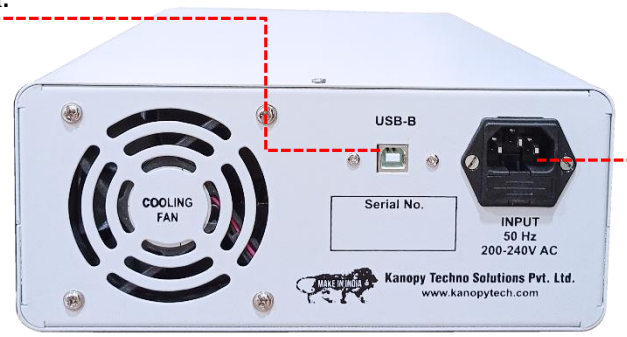


Figure 4.1 – Connector sockets for Working, Reference and Counter Electrodes

4.3.Cable connection:



The instrument includes a USB connection cable that has USB A type to B type convertor. It has one USB B type female connector on its rear side (see below diagram). The USB cable should be connected to the computer to send/receive data.



The instrument is powered with a standard C-13 IEC connector with a 3 pin plug on the other side of the cable. The power port is provided at the rear side of the instrument.



5. Instrument warranty and service

This instrument comes with a standard one year warranty, which covers any electronic component failure inside the instrument. The warranty does not cover if:

- The instrument is physically damaged
- The instrument is operated at extreme environmental conditions (temperature below 0°C and above 50°C).
- The instrument is operated at a higher current and voltage rating than the limit mentioned in the specifications.
- There is no warranty on accessories of the instrument

6. License of Software

K-Lyte software has a lifetime license. This license file is delivered along with hardware. Newer versions of the software will be made available on our website in the products section. More recent versions will work with old license settings.

7. Frequently Asked Questions



Is there any specific requirement of the computer hardware for instrument software?

K-Lyte software is a very lightweight software. So it needs general-purpose computer hardware to install and run. It is available for both 32 bit and 64-bit operating systems.

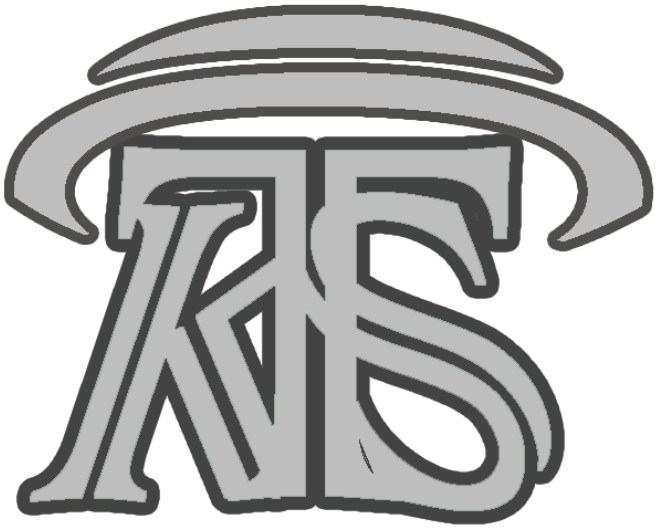


What are the optimum environmental conditions for the instrument to work?

The instrument works well in the temperature range of 15°C to 30°C. It has been calibrated at 25°C, so it is a recommended temperature to work. It has been tested in an even higher temperature range for hours and successfully passed. The instrument should be kept away from the wet environment.

Note: For any kind of query or doubt, feel free to write to us at **contact@kanopytech.com**. Your suggestions are always welcome.

***** Thank You for Choosing KLyte *****



Contact us:

Kanopy Techno Solutions Pvt. Ltd.

A 402, Nirman Exotica,
Ramnagar colony,
Bavdhan,
Pune - 411021, Maharashtra, India.

Mobile: +91 9555410424, 8010779277
Email: contact@kanopytech.com

