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Electrochemical kinetic study of *Rauwolfia serpentina* xerophytic medicinal plants

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Abstract
The kinetic study of three varieties of *Rauwolfia serpentina* xerophytic medicinal plants have been carried out with electrode pair Ag-Zn in three different seasons by measuring their bio-electrode potential through redox process. The reaction velocity follow first-order kinetics but at higher span of time, becomes asymptotic to x-axis, showing zero-order of reaction. The complicated mechanism was observed due to the occurrence of oscillatory reactions in the system. The charge transfer enhance the activity of the system. Various thermodynamic properties were evaluated to explain the proposed mechanism in consistent with the derived rate law.

Keywords: Span, prevail, probe, polyphormic, excitation

1. Introduction

India is a heaven for medicinal plants [1-4]. There exists a large number of plants which have been used by Ayurved and Unani practitioners as medicines. The plant kingdom of the country has been playing a vital role in providing materials useful for human body and animal kingdom. The plants are consumed as our man's food and are used as medicines in curing several diseases. Indian documents, the Vedas emphasize the planting of trees for mythological and socio economic purposes.

The plant cell is highly sophisticated bio-chemical laboratory, where hundred of chemical reactions are occurring simultaneously, accompanied by absorption or release of heat to the environment. The xerophytic herbal plants are good source of ionic potential. Bose J.C. [5] (1926) the first Indian bio-physicsts has already been established the fact that the movements of ions in plants associated with electromagnetic waves. The bio-electrode potential originates from various sources of ions and may form assembly of bimolecular substrate.

The plant leaves contain a large number of bio-chemicals like amino acids with building block from which the proteins are made etc. are capable of forming charge complexes between electrodes that enhance activity [6]. Using electrochemical concept, few researchers- Sarabhai *et al.* [7] (2007) reported the kinetics of plant leaves of *Opuntia coccinellifera* k=7.24 $\times 10^{-6}$ (s^{-1}) and *Euphorbia neriifolia* k= 8.793 $\times 10^{-6}$ (s^{-1}); and Agrawal *et al.* [8] (2007) studied, *Calotropis procera* k= 3.390 $\times 10^{-6}$ (s^{-1}); Saket *et al.* [9] (2012) *Coleus amboinicus* and Swami *et al.* [10] (2015), determined rate of *Calotropis gigantea* k=1.96 $\times 10^{-6}$ (s^{-1}), medicinal plants in three different seasons employing C-Zn, Cu-Zn and Ag-Zn pairs of electrodes.

However, literature survey shows that there seems to be no work of kinetic investigation done in context of *Rauwolfia serpentina*. Hence inspired by this the authors intended to probe the problem by selecting three kinds of above mentioned plants abbreviated as RS_1, RS_2, and RS_3 respectively.

2. Experimental

Rauwolfia serpentina is a xerophytic plant belongs to Acopynae family found everywhere. It is polymorphic, polyannual and is a coloyal herbal plant. It is widely used in a treatment of cardiac, urological, nephrological, dropsy, respiratory, leprosy insanity, opthalmological, urological and nephrological diseases.

The medicinal plant's leaf seems most suitable organ which possesses a lucrative quantity of ions and give uniform surface area of system [11]. The leaves are cut to the size of bio-electrodes. The epidermis on both the sides is scrapped to get the smooth contact with Ag-Zn. The injured leaf of the system is sandwiched between electrode pair Ag-Zn of size 2×2 cm dimension pressed by non-conducting clips. (Fig.1)

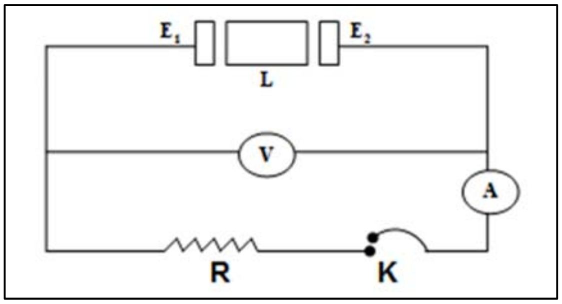


Fig 1: Circuit diagram of Bio-cell, E_1 and E_2 are electrodes, R, (Resistance), K (Key), A (Ammeter), V (Voltmeter) and L (Leaf)

The Bio-electrode potential (BEP) was measured through digital panelmeter having resolution of 1 mV with an accuracy of $\pm$ 0.1% D.C. in three different seasons.
The velocity rate constant was evaluated by using integration method (k= 2.303/t log a/a-x) at different intervals of time. The amino acids and chlorophylls were identified chromatographically by measuring their R_f values. The physical parameters such as pH, conductivity, density, surface tension etc. were determined from the bio-mass by modern existing techniques (Table 1). The various thermodynamic parameters were evaluated from the electrochemical kinetic data obtained (Table 2).

3. Results and Discussion

The electrochemical kinetic study of chemical constituents of *Rauwolfia serpentina* with Ag-Zn electrode pair have been carried out in three different seasons. Summer (308 K), winter (290 K) and Rainy (298 K) by considering their peak values of BEP measured. The kinetic rate of each plant follows first-order but at higher span of time beyond 140 hours shows zero-order. The graph drawn between log a/(a-x) vs. time of RS_1 as a typical kinetic study for winter (W) season at 290 K has been shown in Fig.1. The other plot made for dependence of rate on system with variations in three different seasons (Fig. 2). The study indicated oscillatory reactions occur which make the kinetics very complicated. The addition of Cu^{++} ions to the system, led to the retardation of rate in all the seasons. This shows deactivating effect on the physiological activities of tissues, whereas added respiratory substrate carbohydrate does not alter the rate. The absorption of primary salts (NaCl and KCl) by the system, provide an additional ionic contribution towards charge transfer reaction which causes slightly increase in rate.
It has been observed that multi-layers of waxy materials deposited around the injured portion of the system, reflecting incident solar radiation which causes less dehydration. The surface of the leaf becomes less shiny being photosensitive giving higher potential at the injured site. The study shows that rate of healing is equal to rate of injury at equilibrium i.e. the number of tissues present in sap varies to the potential that follow redox process. The factor humidity, pH, conductivity, ionic transport plays important role in kinetic investigation.
The rate is highest in the morning as mesophyll cell of leaf gets activated due to start of photosynthesis, pushing electron to higher energy state by photic excitation, vis-a-vis swelling and shrinking of chloroplast has been observed across the membrane. During redox process the dipolar Zwitter ions decompose into cations and anions.

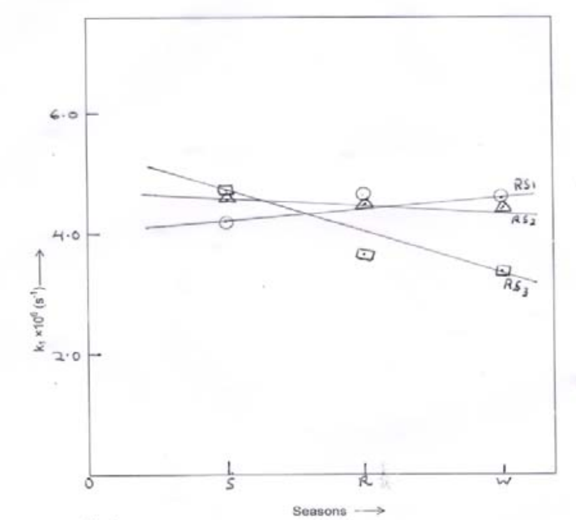
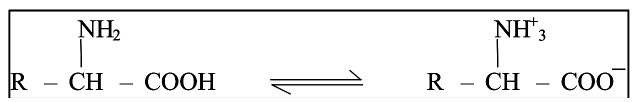
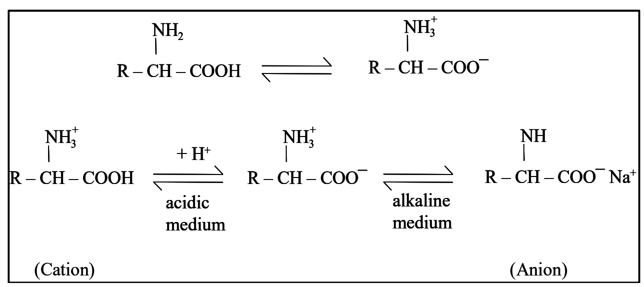


Fig. 2 Showing dependence of rate of system in three different seasons
Plot of k Vs. seasons
System : Raw Alphia Serpentina (RS_1, RS_2 and RS_3) ;
Electrode pair : Ag-Zn ;
Season : Summer (S), Rainy (R), Winter (W) ;
Temperature : 308 (S) : 298 (R) : 290 (W)

The chlorophylls exist in cell, as a building blocks of protein. The amino acid molecules comprise both acidic and basic groups in the ionic form. The proton migrate from the carboxyl to amino group, thus producing carboxylate (COO^-) and ammonium (NH_3^+) ion,





Rate Law

Amino acid	$\underset{}{\overset{K}{\rightleftharpoons}}$	Zwitter ion	……………..(1)
Zwitter ion	$\xrightarrow{k_1}$	Cation	……………..(2)
Zwitter ion	$\xrightarrow{k_2}$	Anion	……………..(3)

The rate law was derived as:

1. Rate = k_1 [Amino acid] ($k_1 + k_2$) ………….. (4)

The Zwitter ions is responsible for flow of current because it possesses additional charge. Similar mechanism that prevail in bio-system, have already been reported by a couple of workers [7-10]
The younger cells increase the rate of permeability of ions whereas the older cell hinder the physiological process reducing conductance and ionic potential.

4. Conclusion

The study may be extended in the field of pharmacodynamics, food preservation and social forestry. The concept may be used in extraction of low voltage energy from non-conventional xerophytic plants on earth planet.

Table 1: Physical parameters

S. No.	System	Weight (gm)	Density gm/Cm^3	Surface Tension dynes/Cm	pH	Conductivity Siemen(s)
1.	*Rauwolfia Serpentina* (RS_1)	3.00	0.982	46.00	6.10	3.61
2.	*Rauwolfia Serpentina* (RS_2)	3.00	0.971	47.20	5.98	2.34
3.	*Rauwolfia Serpentina* (RS_3)	3.00	0.990	48.10	5.96	2.29

Table 2: Thermodynamic parameters

S. No.	System	Season	Ea (kJ)	A (s^{-1})	$\Delta H^{\#}$ (kJ)	$\Delta G^{\#}$ (kJ)	$-\Delta S^{\#}$ (JK^{-})
1.	*Rauwolfia Serpentina* (RS_1)	Summer (S)	16.88	3.42×10^{2}	90.89	106.63	52.24
2.	*Rauwolfia Serpentina* (RS_2)	Rainy (R)	93.29	1.54×10^{4}	65.06	103.68	130.46
3.	*Rauwolfia Serpentina* (RS_3)	Winer (W)	54.46	2.76×10^{5}	43.88	101.31	200.09

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