

Electrochemical Study of Isatin-3-(methylenel)-hydrazone Schiff Base on Carbon Paste Electrode

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Abstract: This work explains the electrochemical behavior of isatin-3-(methylenel)hydrazone that is formed by the reaction of isatin-3hydrazone and formaldehyde. The electrochemical behavior of synthesized compound was investigated in phosphate buffer, LiCl as a supporting electrolyte and at carbon paste electrode by cyclic voltammetry. In this study we find oxidizing product of synthesized Schiff base strongly adsorbed on the carbon paste electrode and show quasi reversible nature at initial scan rate.

Keywords: Isatin-3-(methylenel)-hydrazone Schiff base, Redox behaviour, Carbon paste electrode

Introduction

The indole is strong pharmacodynamic moiety and possesses important biological properties such as anti-inflammatory, anti bacterial, anti convulsant, antioxidant properties¹⁻³. Indole derivatives such as melatonin and its related structure indole-3-propionic derivatives behave as important class of anti oxidant compound and potentially useful against Alzheimer disease⁴⁻⁹. Indole or its related compound like isatin *etc.* are well known electro active compound that are easily reduce and oxidize at carbon based electrode like glassy carbon electrode. Among the indole, indole-2, 3 dione is a excellent heterocyclic compound present in human, as a metabolic derivatives of adrenaline¹⁰ and mammalian tissue and body fluid^{11,12}. Isatin also work as modulator of different kind of biochemical processes like inhibitor of monoamine oxidase (MAO) and later on identified as a selective inhibitor of monoamine oxidase B^{11,13}. Isatin is a synthetically very important moiety that can be use for the preparation of different isatin derivatives, which possess broad clinical and pharmacological application¹⁴⁻¹⁶. Isatin hydrazone derivatives are important group of compound called hydrazones. Because of azometin proton these play an important role in drug discovery^{17,18} and it was revealed from literature that they have anti tumoral, anti TB, anti inflammatory, antiplatelet, analgesic, antimicrobial, anti convulsant activity¹⁹. In present time indole and its related compound have gained lot of attention due to its wide importance in synthetic and analytical purposes. Isatin attract organic chemist attention due presence of two carbonyl group. Electrochemical behaviour of isatin and analogous compound has been recorded using mercury electrode²⁰⁻²³.

Further study has shown that isatin and its derivatives possess broad range of application in synthetic, biological and clinical activity. It has shown oxidation and reduction at glassy carbon electrode. The oxidation of isatin was found to be pH dependent and the reduction of isatin was irreversible and show two consecutive electron transfer reaction, this study done by CV²⁴. The electrochemical determination of isatin²⁵ and other nitrogen containing heterocycles taking variety of electrode systems^{26,27} attain a distinguished position in recent years. 3-Arylimino derivatives (Schiff bases) obtained by the condensation of aromatic amines with isatin, are powerful antibacterial, anticonvulsant, antiviral and anti fungal agent²⁸⁻³⁰. Copper(II) complex of isatin Schiff base ligand are potential antitumor agent³¹. Recent achievement indicate isatin interact with wide range of monoamine in the biological systems³². Investigation of electrochemical behavior of biologically important compound by electrochemical technique like cyclic voltammetry, DPV, SWV have efficiency for giving valuable information like redox properties of biologically important compound, its reduction or oxidation potential and stability in the body fluid *etc.* for this purpose today, voltammetric technique have been successfully used due to its high sensitivity³³⁻³⁶. In this paper we synthesized isatin 3 hydrazone Schiff base and done its electrochemical study using carbon paste electrode and phosphate buffer.

Experimental

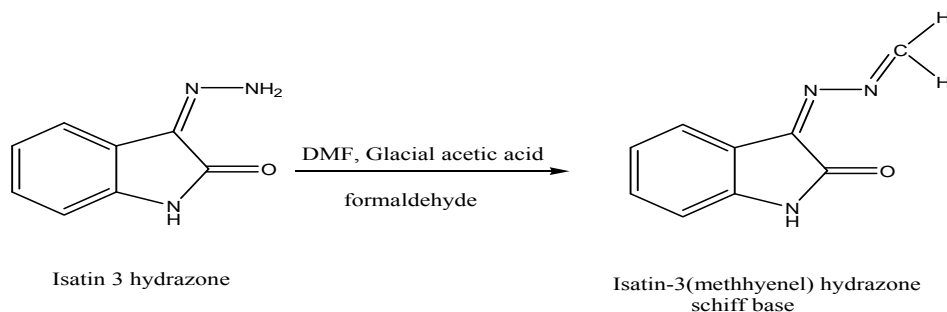
Cyclic voltammetry was performed using a Metrohm 797 V.A. Computrace (Swiss made). The working electrode used in this study was carbon paste electrode ($d = 0.2$ cm) which prepared by mixing graphite powder with paraffin wax in 3:7 ratio, then it was sonicated for 1 min in an ultrasound bath and again rinsed with water. Platinum wire used as a counter electrode and Ag/AgCl (3 M KCl) taking as reference electrode. All three electrodes taking in one compartment chamber, in which magnetic stirrer equipped. The electrochemical oxidation was performed under constant potential condition. The potential of working electrode measure against Ag/AgCl reference electrode. All study was carried out at 25 ± 2 °C temperature. Chemicals purchased from Sigma-Aldrich, Himedia and used without purification. Melting point was determined by using open capillary tube melting point apparatus. The IR spectra were recorded on a FTIR Shimadzu-8400S spectrometer using KBr pellets. The ¹H NMR and ¹³C NMR spectra were recorded on Varian 300 spectrometer taking TMS as standard and DMSO as a solvent. Sonication was done with the help of frontline sonicator (with a frequency of 22 KHz with a normal power of 225W). The pH measurement was carried out by μ pH system 361 digital pH meter.

Sample preparation

For cyclic voltammetry (CV) solutions were prepared by mixing 7.0 mL of 0.01 M stock solution and 1.0 mL of 0.1 M LiCl (as supporting electrolyte) and 2.0 mL of 0.2 M appropriate (phosphate) buffer. Nitrogen gas was passed in the solution for ~15 minutes and thereafter, a blanket of nitrogen gas was maintained throughout the experiment. During the experiment solution was subjected to controlled potential electrolysis.

Synthesis of Schiff base

Isatin-3-hydrazone and formaldehyde were dissolved in 30 mL DMF in presence of protonation reagent *i.e.* glacial acetic acid (.01 mL) was kept at 60 °C on water bath for 30 min with continuing stirring. The purity of compound was checked by TLC using Merck pre-coated gel GF aluminum plates. Benzene: chloroform: methanol taking as a mobile phase. The reaction mixture was poured into water (300 mL) and recrystallization done by ethanol as a solvent.



Scheme 1.

Characteristics of product

Isatin-3-(methylenel)-hydrazone: FTIR (KBr) (V_{\max} cm^{-1}): 1340 (C-N), 1668 (C=O), 1583 (C=C), 3450 (N-H), 1222 (C-O), 3305 (N-N), 1450 (H-C-H), ^1H NMR (300 MHz , DMSO , TMS, δ ppm): 7 (m, 8H, H_{Ar}), 3.8 (s, 2H, CH_2), 10.7 (s, H_{enolic}), 8.3 (d, 1H, NH); ^{13}C NMR (400 MHz , CDCl_3 , δ ppm) δ_c : 162, 131, 125, 138, 165.

Results and Discussion

Cyclic voltammetric studies

This paper explains the electrochemical behaviour of isatin-3-hydrazone Schiff base at a carbon paste electrode and this experiment were carried out in 0.2 M phosphate buffer and 0.1 M LiCl as supporting electrolyte. Isatin -3-(methylenel)hydrazone show voltammograms at pH 6.8. During the voltammetric measurement a constant flux of N_2 was kept over the solution surface in order to avoid the diffusion of atmospheric oxygen into the solution. In this study purging time is 15 s, deposition time is 50 s and deposition potential is -0.9V. Several peaks were observed. Study of effect of scan rate is made in order to find out the mechanism and the feasibility of the reaction.

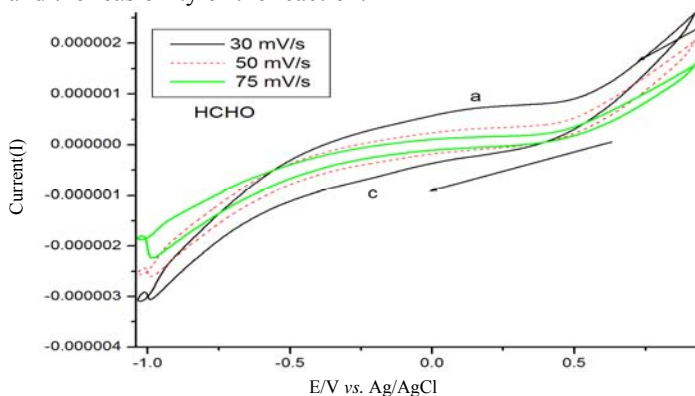
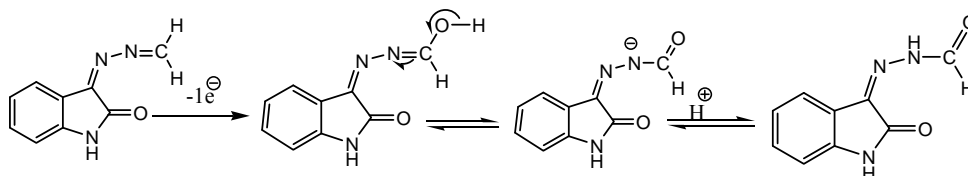


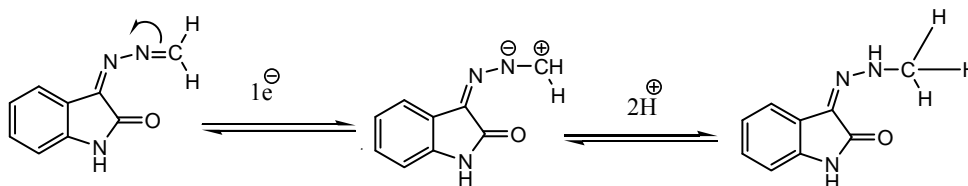
Figure 1. Cyclic voltammogram of isatin -3(methylenel)-hydrazone at carbon paste electrode in phosphate buffer solution (pH 6.8, c .01 M) scan rate 30-50 mV/s, temp= 25 ± 2 °C

Representative cyclic voltammogram of Schiff base (0.01 M) in phosphate buffer (pH 6.8, c .2 M) at carbon paste electrode. Ongoing scan in the positive direction, one oxidation or anodic peak appear, when scanning is reverse in the negative direction we get one reduction or cathodic peak at scan rate 30 mV/s. anodic and cathodic peak potential for such Schiff

base are + 0.164 and -0.232 V vs. Ag/AgCl reference electrode respectively at scan rate 30 mV/s this can be seen in Figure 1 and The E^0 value is -0.03 V. due to the adsorption of this oxidized compound on the electrode, resulting decreasing the oxidation current with successive increasing the scan rate and Such type of nature was previously explain for other compound that are similar to isatin or its derivatives^{37, 38}. Peak current ratio I_{p_f}/I_{p_r} are nearly unity that show quasi reversible nature of the system and this ratio moving toward unity on increasing scan rate and after repletion of cycle at different scan rate. We get same result then it can be consider as criteria for the stability of the oxidized or intermediate compound which formed at the surface of electrode under experimental condition³⁹⁻⁴¹. With increasing the value of v the experimental peak function ($I_p/Ac\nu^{1/2}$) for this peak decrease significantly thus with 0.01 M of Schiff base and scan rate 30, 50 and 75 mV/s the value of $I_p/Ac\nu^{1/2}$ are 0.109 mA, 0.0345 mA and 0.0127 mA. This behavior indicate that 1a Schiff base was strongly adsorbed at carbon paste electrode³⁷.



Scheme 2. Proposed oxidation mechanism of isatin -3-(methylenel)-hydrazone in pH 6.8, 0.2 m phosphate buffer



Scheme 3. Proposed reduction mechanism of isatin -3-(methylenel)-hydrazone in pH 6.8, 0.2 m phosphate buffer

Conclusion

Result of this work show that oxidation of Schiff base at carbon paste electrode is quasi reversible nature but successively increase the scan rate ratio of I_{p_f}/I_{p_r} become unity, so it become just like a reversible nature. During the reverse scanning of potential, due to oxidation of Schiff base, aldehydes is formed that strongly adsorbed on the electrode and show good stability because with increasing scan rate current decrease. During the forward scanning of potential $1e^-$ reduction is takes place and result a secondary amine is formed.

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