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A Comparative Electrochemical Behaviour Study of p-nitrophenol Using GC and Pt Electrode

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ABSTRACT

The work reports a comparative electrochemical behavior study of p-nitrophenol using GC and Pt electrode. For this purpose, Cyclic Voltammetry was employed, where the redox mechanisms could be compared for reduction processes of p-nitrophenol by analysis of the voltammetric responses. Voltammetric curves of p-nitrophenol in aqueous-methanol medium on different pH using B.R. buffer for various concentrations (0.05mM, 0.1 mM, 0.15mM, 0.2mM) and scan rates at GC and Pt electrode was obtained. The very complicated reduction of p-nitrophenol revealed three reduction peaks out of which two peaks are irreversible and one peak is reversible.

Equation 1

$HOC_6H_4NO_2 + e^- \rightleftharpoons HOC_6H_4NO_2 \cdot^-$

Equation 2

$HOC_6H_4NO_2 \cdot^- + HOC_6H_4NO_2 \rightleftharpoons HOC_6H_4NO_2H\cdot + {}^-OC_6H_4NO_2$

Equation 3

$HOC_6H_4NO_2H\cdot + HOC_6H_4NO_2 \cdot^- \rightleftharpoons HOC_6H_4NO_2H^- + HOC_6H_4NO_2$

Equation4

$HOC_6H_4NO_2H^- + HOC_6H_4NO_2 \rightleftharpoons HOC_6H_4NO + {}^-OC_6H_4NO_2 + H_2O$

The result obtained from GC electrode proved to be better than Pt electrode. Hence the GC electrode can be considered a suitable tool for determination of redox mechanism of p-nitrophenol.

Keywords: Electrochemical reduction, p-nitrophenol, Cyclic Voltammetry, TLC., IR spectra.

INTRODUCTION

Nitrophenols are used extensively in production of pesticides, dyes and pharmaceuticals. Therefore they broadly distribute in soil and aquatic environment and difficult to degrade because of their high stability. In particular p-nitrophenol is one of the priority pollutant includes in the US environmental protection agency [1-3]. The p-nitrophenolhas been detected not only in industrial waste water but also in fresh water and marine environment. It is considered a hazardous pollutant with toxic effects on human health and the environment [4].

Numerous investigations have been made on the reduction of aromatic nitro compounds [5-7]. The nitro compounds one of the best electrophores as regards to both ease of reduction and versatility of derived products. By electro reduction [5] of nitrophenol isomer using tationary and rotating Cu electrodes and $Ti(S0_4)_2$ as additional agents, aminophenols were obtained in good yield. Depending on the electrolysis conditions, a great verity of products can be obtained by electro reduction of p-nitrophenol [8-17]. The present work deal with the comparative voltammetric studies of p-nitrophenol at GC and Pt electrode were carried out in acidic, basic and natural medium for different concentrations and scan rates.

EXPERIMENTAL

Solutions were prepared from AR methanol and double distilled water. Reagents used were of AR grade. p-nitrophenol was crystallized from methanol and the colorless (m.p.114^{0}C) were used. The purity was checked by single spot TLC. IR spectra of p-nitrophenol to confirm the Sstructure.

Cyclic voltammetric studies were carried out using a three electrode cell assembly having GC/Pt as the working electrode, Ag/AgCl as reference electrode and Pt wire as the counter electrode. Voltammograms of p-nitrophenol are recorded in 1:1 (v/v) water : methanol at 0.05, 0.1, 0.15 and 0.2 mM concentrations. B.R. Buffer was used to maintain desired pH *viz.* 3.4, 7.01, 9.4, 12.

RESULT AND DISCUSSION

Cyclic voltammograms were recorded with an applied potential 0.0 V initial potential 0.5 V and final potential -1.3 V at different, pH, concentrations and scan rates. Table-1&2 summarized the voltammetric data for p-nitrophenol in acidic, basic as well as in neutral medium for 90mV/sec scan rate at GC and Pt electrode.

CONCLUSION

Electrochemical reduction of p-nitrophenol is tangible in basic medium for GC electrode and due to this three prominent reduction peaks are obtained out of which one reduction peak is reversible. This proves that the Glassy Carbon electrode is better explained the electrochemical reduction of p-nitrophenol than Pt electrode.

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(Tables & Figures)

Table 1 Current – Potential measurement in Cyclic Voltammetry at Glassy Carbon Electrode

X-axis = 0.1V/cm Applied E = 0.0V +E = 0.5V -E= -1.3V scan rate = 90mV/s

pH	Concentration (mM)	Fig.No.	Cathodic wave			Remark
			Wave no.	Potential (V)	Current ((µA)	
3.4	0.1	Fig. 1	I	Not appeared		All cathodic waves are irreversible
			II	-0.4	9.0	
			III	-0.75	16.0	
7	0.1	Fig. 2	I	-0.1	2.0	All cathodic waves are irreversible
			II	-0.6	15.0	
			III	-1.0	43.0	
12	0.05	Fig.3	I	-0.13	2.0	First cathodic wave is reversible and other two are irreversible
			II	-0.83	16.0	
			III	-1.13	26.0	

Table 2 Current – Potential measurement in Cyclic Voltammetry at Pt Electrode

X-axis = 0.1V/cm Applied E = 0.0V +E = 0.5V -E= -1.3V scan rate = 90mV/s

pH	Concentration (mM)	Fig.No.	Cathodic wave			Remark
			Wave no.	Potential (V)	Current ((µA)	
3.4	0.1					No cathodic waves obtained
7	0.1	Fig.4	I	-0.12	1.25	Only two cathodic waves are appeared and they are irreversible
			II	-0.62	9.5	
			III	Not appeared		
12	0.05	Fig.5	I	-0.14	1.75	Only two cathodic waves are appeared. I cathodic wave is reversible and II wave is irreversible
			II	-0.67	11	
			III	Not appeared		

Table 3 Comparison between Glassy Carbon and Pt electrode

pH	Concentration (mM)	Glassy Carbon electrode	Pt electrode
3.4	0.1	Two cathodic waves are obtained	No cathodic waves
7	0.1	Three cathodic waves are obtained	Only two cathodic waves are obtained
12	0.05	Three prominent cathodic waves are obtained in which I wave is reversible	Two cathodic waves are obtained in which I wave is reversible

Fig.1
Cyclic voltammogram of 0.1mM p-nitrophenol pH 3.4 at GC electrode for scan rate 90mV/s

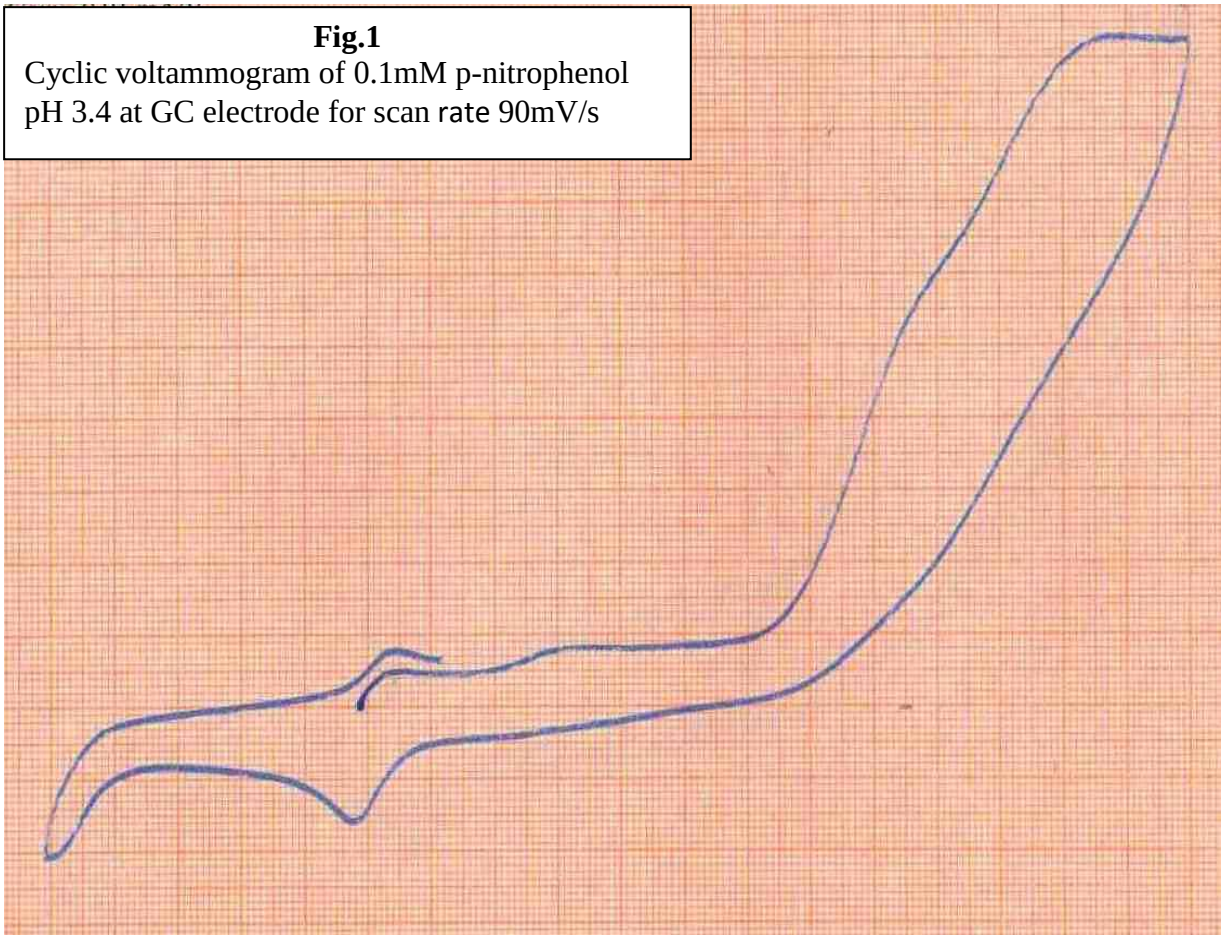


Fig.2
Cyclic voltammogram of 0.1mM p-nitrophenol pH 7 at GC electrode for scan rate 90mV/s.

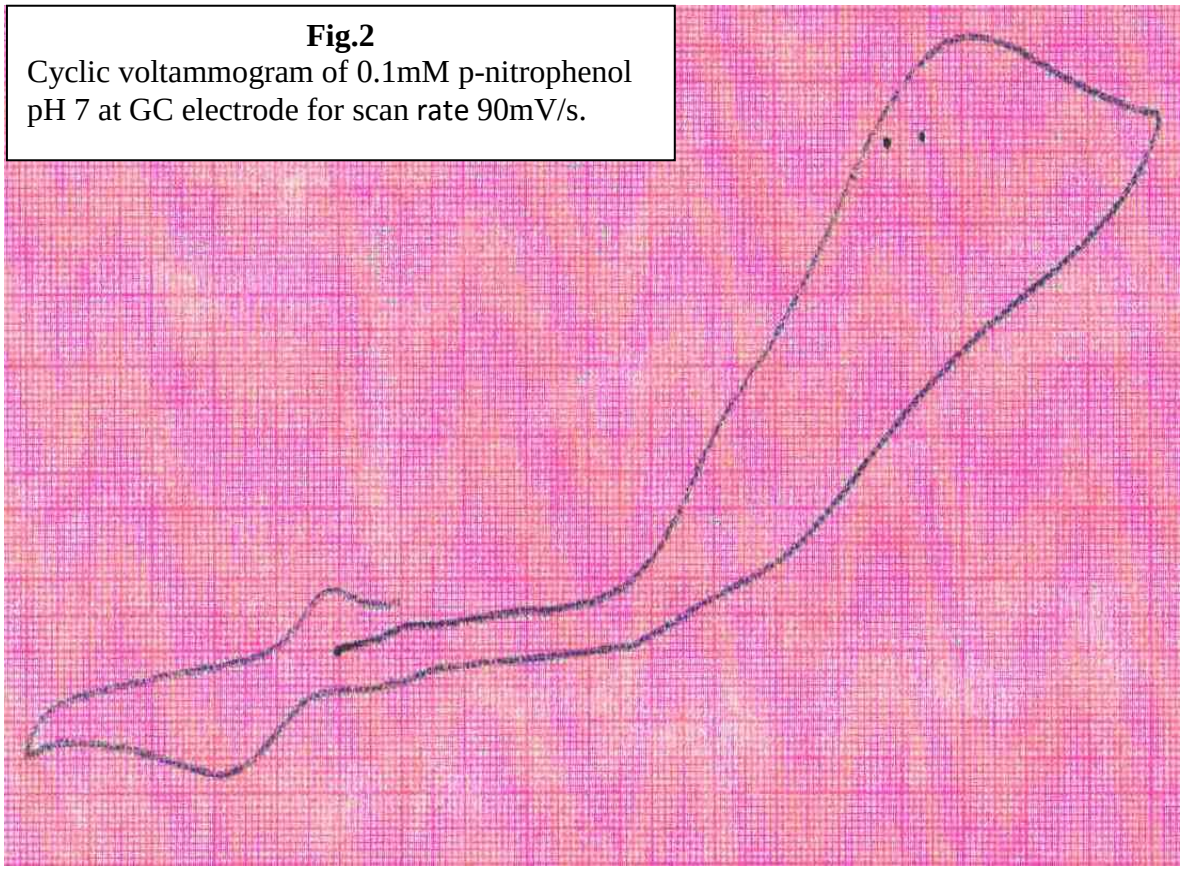


Fig.3
Cyclic voltammogram of 0.05mM p-nitrophenol pH 12 at GC electrode for scan rate 90mV/s.

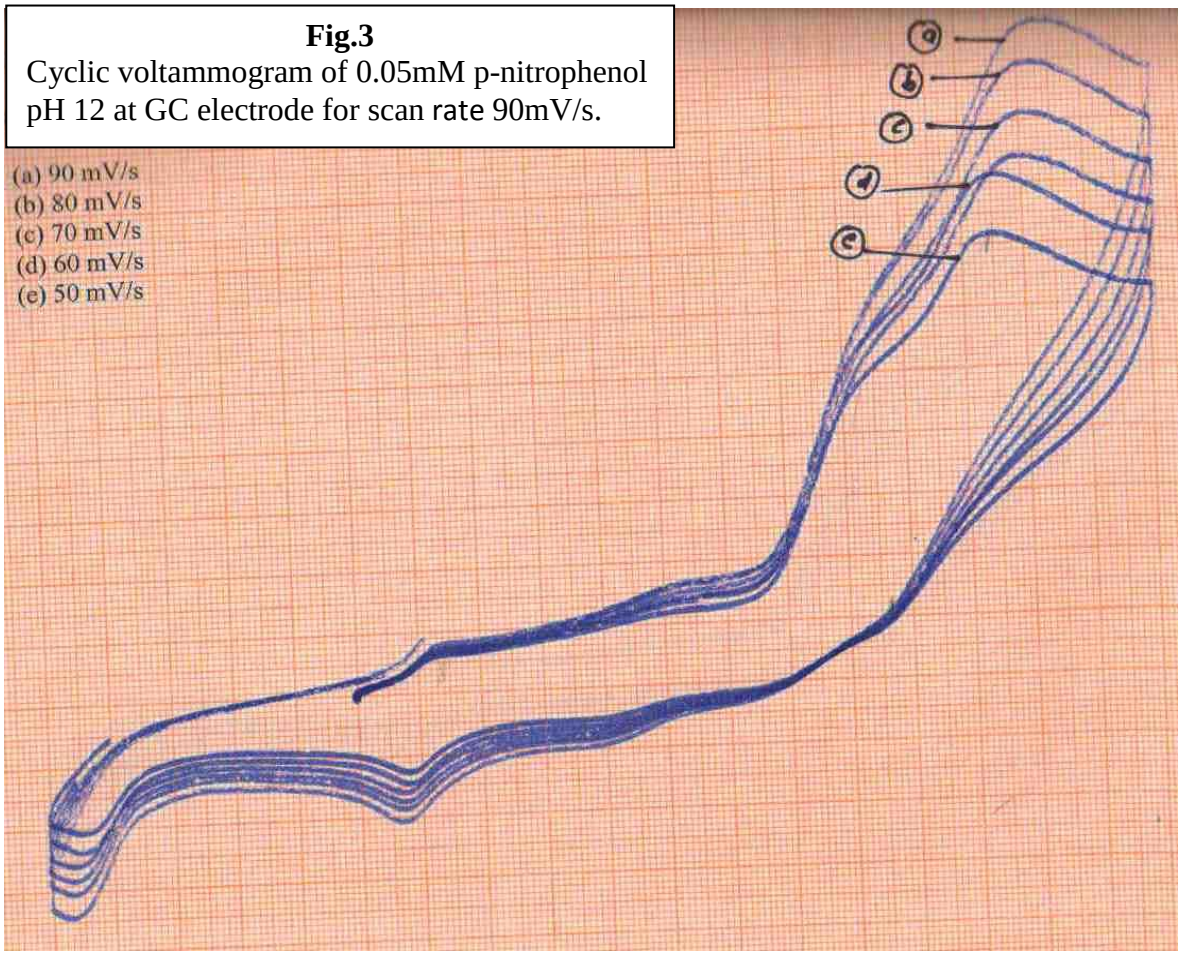
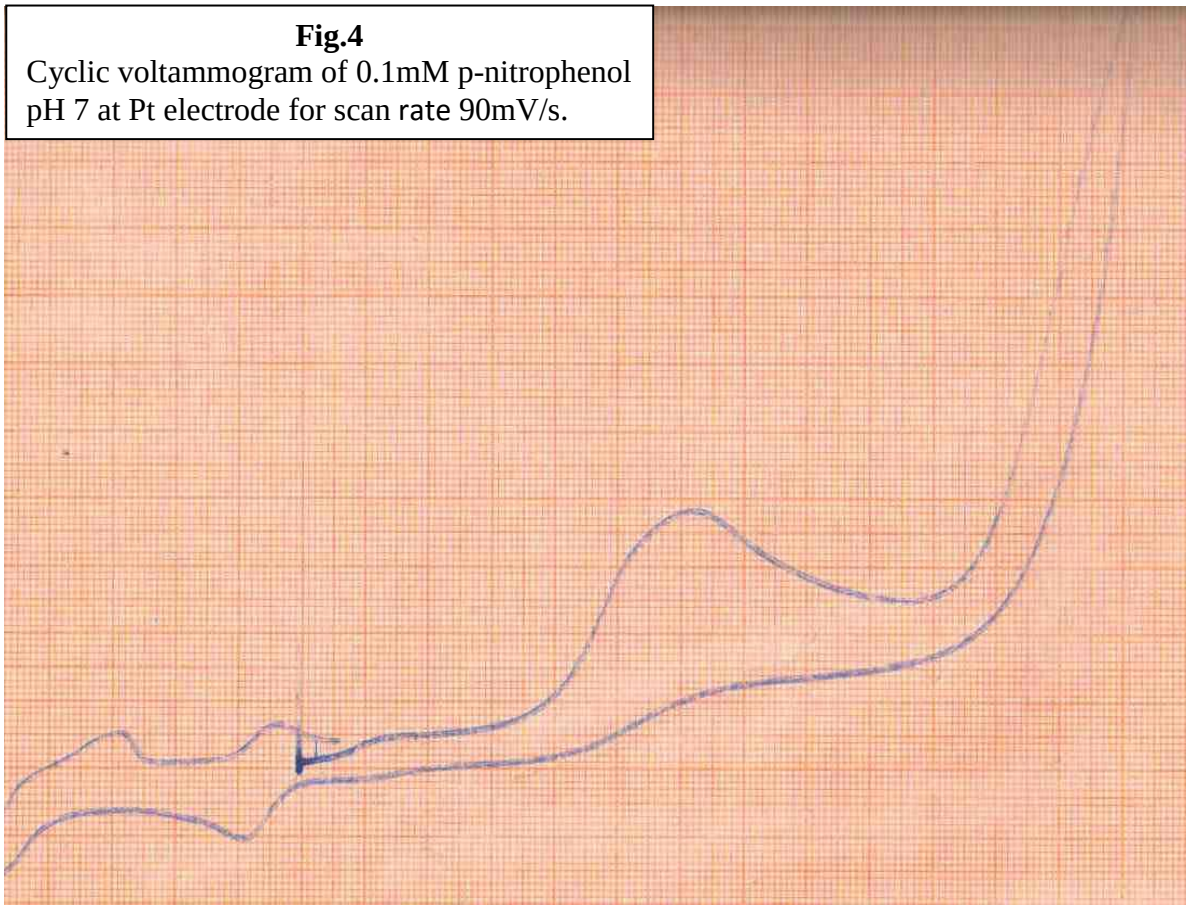


Fig.4
Cyclic voltammogram of 0.1mM p-nitrophenol pH 7 at Pt electrode for scan rate 90mV/s.



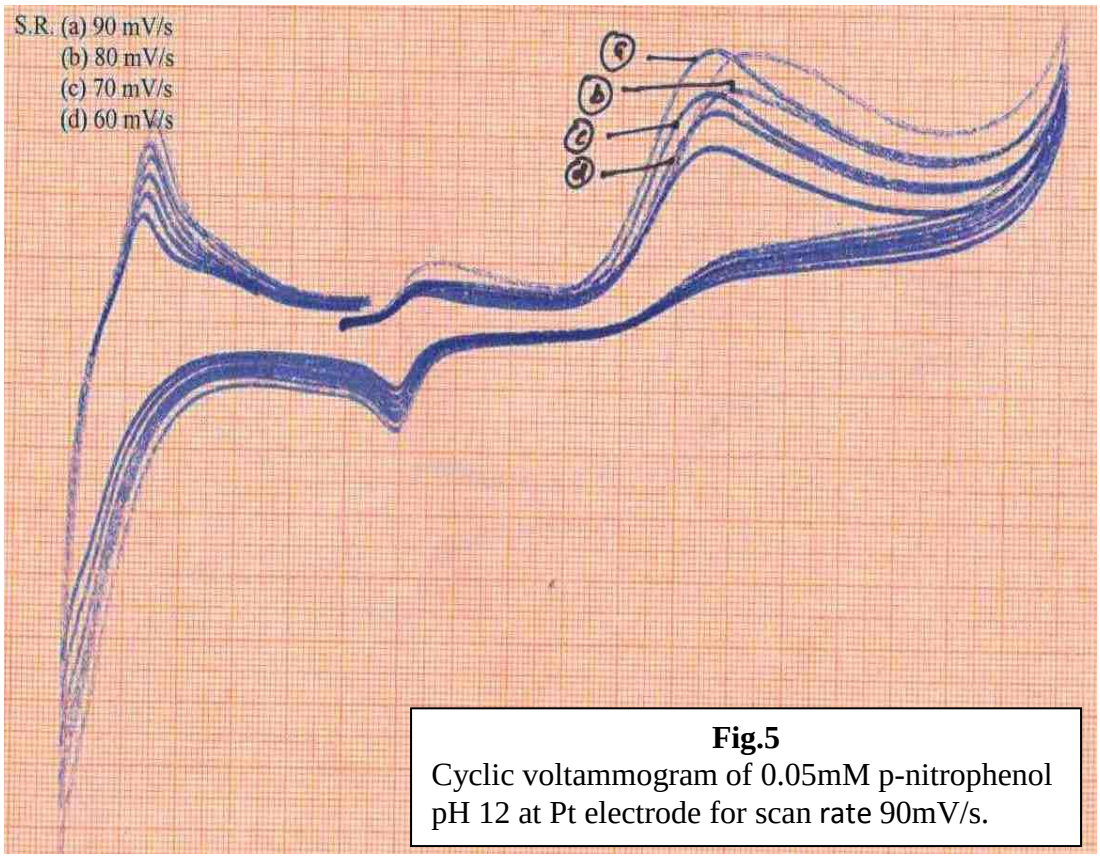


Fig.5
Cyclic voltammogram of 0.05mM p-nitrophenol pH 12 at Pt electrode for scan rate 90mV/s.