

*In the name of god*



Razi University

**Faculty of Chemistry**  
**Department of Analytical Chemistry**

**M.Sc.Thesis**

**Determination of olanzapine and thiourea using electrodes modified  
by DNA and film of copper-cobalt hexacyanoferrate**

**&**

**Investigation of electro-oxidation of some catechol derivatives in the  
presence of 4-phenylsemicarbazid**

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کلیه حقوق مادی مترتب بر نتایج مطالعات، ابتکارات و

نوآوری های ناشی از تحقیق موضوع این پایان نامه

متعلق به دانشگاه رازی است.

*Dedicated to:*

**My Family**

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## Abstract

Part one: Investigations about the electrooxidation of catechol and its derivatives show that the obtained *O*-quinones from the oxidation of different catechols are unstable compounds and can be attacked as a Michael acceptor by different nucleophiles. In this work the Electrochemical oxidation of catechols (1a-c) have been studied in the presence of 4-phenylsemicarbazide as a nucleophile in water/acetonitrile (90/10) solution, by means of cyclic voltammetry and controlled-potential coulometry. The results indicate that the formation oxadiazine compounds (6a-c) based on Michael addition reactions between quinones derived from the catechols with 4-phenylsemicarbazide under ECEC mechanism. The electrochemical synthesis of these compounds has been successfully performed in a two-compartment cell. The products have been characterized after purification by IR, <sup>1</sup>H NMR, <sup>13</sup>C NMR and MS.

Part two: Olanzapine is a drug used commonly as an Antipsychotic agent against schizophrenia disease in world. DNA was utilized as a pre-concentration element for the determination of olanzapine based on its interaction with DNA. Initially, the interaction between olanzapine and DNA in 0.04 M pH 4 Britton–Robinson buffer solution was studied by cyclic voltammetry and Differential pulse voltammetry. Decreasing peaks was observed for olanzapine with increasing concentration DNA. The results indicated that olanzapine can bound to DNA. The binding constants *K* of binding with DNA were obtained by cyclic voltammetry and differential pulse voltammetry method. From the voltammetric data changes in limiting current with addition of DNA, the binding constant (*K*) of the olanzapine interaction with DNA was found to be  $3.3 \times 10^4 \text{ dm}^3 \text{ mol}^{-1}$ . Finally, sensor designed for the determination of olanzapine Short reaction times (2 min) was sufficient for determining range from  $5 \times 10^{-6}$  to  $1 \times 10^{-3} \text{ mmol L}^{-1}$ , with a linear correlation of  $r = 0.9977$  and a detection limit of  $2.47 \times 10^{-6} \text{ mmol L}^{-1}$ .

Part three: Copper-cobalt hexacyanoferrate (CuCoHCF) film are grown on a carbon paste electrode by electrodeposition method. The electrochemical behavior and electrocatalytic activity of modified electrode towards oxidation of thiourea were studied. The oxidation of thiourea occurred at the peak potential of 0.8 V vs. Ag/AgCl. The modified electrode was employed successfully for thiourea detection using linear sweep voltammetry. The modified electrode exhibited good catalytic activity for the oxidation of thiourea at a reduced overpotential with good sensitivity in the wide concentration range 3-120  $\mu\text{M}$  thiourea and detection limits of 2.6  $\mu\text{M}$ . A Tafel plot slope derived from voltammograms, indicated a one-electron charge transfer process to be the rate-limiting step and the overall number of electrons involved in the catalytic oxidation of thiourea was found to be 2. The CuCoHCF modified-electrode exhibited stable electrochemical responses in a wide pH range 3–9 and showed excellent electrocatalytic activity toward the oxidation of thiourea in 0.1M sodium phosphate buffer, pH 7. The diffusion coefficient of thiourea and rate constant for the catalytic reaction were also evaluated. The obtained attractive analytical performance together with high selectivity and simplicity of the proposed method provide an effective to develop a thiourea sensor.

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# **Part One**

**Electro-oxidation of catechols in the  
presence of 4-phenylsemicarbazide**



# **Chapter One**

## **Introduction**

## History

Electrochemistry and its applications play an important role in the industrial and commercial world. The applications are diverse and ever increasing and cut across many disciplines. An overall perspective of the scope of industrial electrochemistry is summarised as follows [1]:

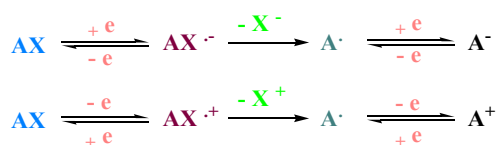
- Inorganic electrosynthesis
- Extraction and production of metals
- Organic electrosynthesis
- Metal finishing and processing
- Water purification and effluent treatment
- Energy generation
- Corrosion
- Sensors and monitors.

### **1.1.2. Organic electrosynthesis**

Organic electrosynthesis (electrolyses) can be classified as either oxidations or reductions with the reaction being comprised of the substrate, electrodes, electrolyte, solvent and various additives. In a galvanic cell (two electrodes connected by a salt bridge composed of a solution of an electrolyte), oxidations take place at the anode and reductions at the cathode. What makes electrochemical reactions unique from many ionizing reactions is that they take place on the surface of the electrode and produce highly reactive intermediates such as radical-cations (via oxidation) and radical-anions (via reduction) that diffuse into solution [2]. A variety of secondary reactions can ensue from the initial radical-ion species.

Molecules are activated by the addition or removal of electrons at an electrode. This must involve addition to a LUMO (reduction at a cathode) or removal from a HOMO (oxidation at an anode); it is relatively easy to identify which compounds are likely to be reducible or oxidizable qualitatively. Benzene can thus be oxidized to benzoquinone and reduced to 1,4-dihydrobenzene. Many relevant books and reviews are available which cover these and other basic aspects [3-4].

The most important reactive intermediates formed by electrochemical reduction and oxidation are radical-ions, radicals, carbocations and carbanions; radical-ions are usually the first-formed species but fragmentation can lead typically to radicals which may be further reduced or oxidized (Scheme. 1.1.1).



**Scheme.1.1.1 Common species formed electrochemically**

### 1.1.3. Trends in electroorganic syntheses

Since the development of Kolbe reaction in 1854, electrosynthesis has become more and more important in organic chemistry due to its following characteristics: unique selectivity because of in situ formation of active species at the interface, inversion in polarity by transfer of electron and variability in product formation by control of potential.

Electroorganic synthesis as a powerful method in organic chemistry has attracted several interest in recent years. Despite the long history of electroorganic chemistry most of the electroorganic reactions that could provide product selectivity have been developed within the last twenty years.

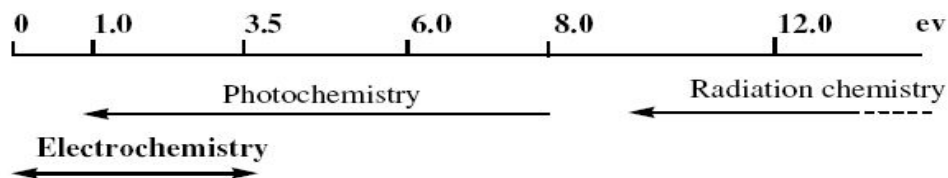
In addition to the aforementioned features there remains also some of advantages electroorganic syntheses which need to be highlighted as followings[2, 4]:

- (1) Utilizing very safe and less hazardous processes
- (2) Elimination or minimization of polluting by-products requiring laborious disposal
- (3) Process simplification (*e.g.* a multi-step chemical route can be simplified to one or two steps)
- (4) Use of cheaper and more readily available starting materials and solvents

(5) Significantly less energy requirement, the following diagram illustrates the range in energy of several types of methods in organic chemistry utilizing energy. This may be introduced into molecules by various high energy techniques

(6) The possibility of reaching very high levels of product purity and selectivity

(7) Development of valuable intellectual properties



**Scheme.1.1.2 Diagram energy of several types of methods in organic chemistry**

(8) Considerably improved capital and operating costs over conventional methods

(9) Convenience in work-up process (there is no chemical redox agents or their byproducts to be removed after completion of the reaction which means that work-up in many cases requires removal of only solvent and electrolyte)

(10) Yields, often adequate or excellent.

Electrochemical routes for organic synthesis must compete with more traditional industrial methods (e.g., heterogeneous and homogeneous catalysis), as well as with emerging methods (e.g., enzymatic catalysis and photocatalysis). All syntheses require application of energy to accomplish the transformation of raw materials. Electrochemical synthesis involves application of a potential, in the presence of active electrode surfaces, and the resulting flow of current drives the oxidation or reduction and subsequent recombination of reactants. [3, 5].

There are several features of electrosynthesis that are often cited as being environmentally favorable. First, electrons flowing as current may be regarded as one of the reagents. Second, reactions may take place in a low-temperature environment, reducing the local consumption of energy, and reducing the risk of corrosion, material failure, and accidental release. Also, reactions may occur in low volatility or no-volatility reaction media. The electrodes may be regarded as heterogeneous catalysts that are easily separated from the products. Supporting electrolyte and electrochemically active mediator species may be regenerated electrochemically and recovered.

Current research on green chemistry and engineering focuses on alternative solvents (such as supercritical carbon dioxide or ionic liquids), feedstocks, and new catalyst