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ELECTROCHEMICAL STUDY OF NITROFURANTOIN AT MICRO- AND NANOPARTICLES IN BLOOD MEDIUM USING CYCLIC VOLTAMMETRIC TECHNIQUE

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Abstract

In this study one of classical antibiotic compound nitrofurantoin was studied as micro and nano particles in electrochemical analysis by cyclic voltammetric technique using glassy carbon electrode in blood medium to observe the oxidative effect on the blood components. It was found oxidation – reduction current peaks of nitrofurantoin in blood medium at +1 and -0.75 V respectively. The oxidation current peak was disappeared for the nitrofurantoin nano particles in blood medium, but for micro particles is still oxidize the blood. Different concentration and scan rate were studied to observation the electrochemical behavior of nitrofurantoin nano particles in blood medium which has good analysis.

Keywords: nitrofurantoin nanoparticles; cyclic voltammetry; blood medium; GCE; redox process; antibiotic.

1. Introduction

Through the published researches in the important subject of human health, especially the effect of drugs on the blood composition using the electrochemical method to determine the extent of blood oxidation effect by these drugs [1-8].

Nitrofurantoin is an antibiotic was used to treat some diseases such as bladder and kidney infections which consider a classical treatment against to bacteria [9].

Nitrofurantoin has been activated for many bacteria such as: *E. coli, Staphylococcus saprophyticus, Coagulase negative staphylococci, Enterococcus faecalis, Staphylococcus aureus, Streptococcus agalactiae, Citrobacter species, Klebsiella species, Bacillus subtilis* species, It has been used in the treatment of infections caused by these organisms [10].

Nitrofurantoin was studied at different pH 2.0–12.0 using electrochemical method by cyclic voltammetry. Some electrochemical parameters were determined such as diffusion coefficients, heterogeneous forward rate constant and transfer coefficients [11]. On other hand, nitrofurantoin was observed in linear sweep voltammetric technique on the cobalt/glassy carbon electrode at pH=4 solutions, the detection limit have very low values with high sensitivity [12].

Cyclic voltammetry was used to generate the nitro free radical from nitrofurantoin in solution with glutathione and study the interaction of the mixture. The cyclic voltammetric result was proved that it is possible to generate the nitro free radical anion from nitrofurantoin in solution [13].

Nitrofurantoin as studied in cyclic voltammetric technique at boron-doped diamond film electrode. The detection limit of nitrofurantoin has a very low value in these conditions [14].

The electrochemical behavior of nitrofurantoin has been studied by cyclic voltammetric method using glassy carbon electrode for reversible couple $ArNO_2/ArNO_2^-$ [15].

In this work nitrofurantoin at micro and nanoparticles were studied in cyclic voltammetric technique using GCE in blood medium to

determination the oxidative effect on the blood components.

2. Material and method

2.1. Reagents and chemicals

Nitrofurantoin powder from Bioanalyse Company (Turkey), healthy human blood samples was received from the center of Iraqi blood bank (Baghdad) and other chemicals and solvents were of annular grade and used as received from the manufacturer. Deionize water was used for the preparation of aqueous solutions and dilution the blood samples.

2.2. Preparation of nitrofurantoin nanoparticles

There are two methods for preparation of nitrofurantoin nanoparticles from the micro particles in the laboratory:

2.2.1 Lyophylization (Freeze-drying method)

The first step is preparation a suspension of nitrofurantoin by dissolving 0.75g of nitrofurantoin in 150 ml of distilled water**.** The product suspension was cooled, and the ice crystals of pure water which formed at -18°C. The second step involves the sublimation of ice from the frozen product by passing heat air from shelf of lyophylization instrument to the frozen solution in the vial, the ice sublimes and the water vapor formed passes through the dried portion of the product to the surface of the sample, the water vapor is transferred from the surface of the product through the chamber to the condenser, and the water vapor condenses on the condenser. At the end of sublimation step a porous plug is formed. Its pores correspond to the spaces that were occupied by ice crystals. The third step is drying involve the removal of absorbed water from the product. All steps must be continuous about 48-72h [16].

2.2.2 Reduction method by silver nitrate

In this method was prepared 200ml of 1mM of silver nitrate solution ($AgNO_3$) by dissolve 0.169gm of $AgNO_3$ crystal in 200 ml of distilled water. The solution was kept in a 250 ml of reagent bottle. 0.005 gm of nitrofurantoin powder was dissolved in 1 ml of dimethylformamide (DMF) and then added to 20 ml of the silver nitrate solution. The 95% of bio-reduction of $AgNO_3$ ions occurred within 24 hours as shown in Figure 1b and the deep yellow solution in Figure 1a for the nitrofurantoin in DMF which it turned colorless slowly indicates the formation of nitrofurantoin nanoparticles [17].

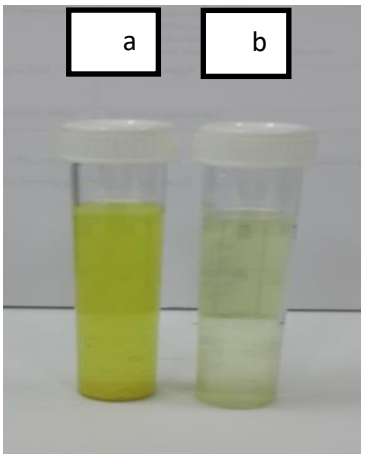


Figure 1. (a) Nitrofurantoin micro particles dispersed in DMF (b) Nitrofurantoin nanoparticle dispersed in distill water

2.3. Apparatus and procedures

Instrument of cyclic voltammetry

EZstat series (potentiostat/glvanostat) NuVant Systems Inc. pioneering electrochemical technologies USA. Electrochemical workstations of Bioanalytical system with potentiostat driven by electroanalytical measuring software was connected to personal computer to perform Cyclic Voltammetry (CV), an Ag/AgCl (3M NaCl) and Platinum wire (1 mm diameter) was used as a reference and counter electrode respectively. The glassy carbon working electrode (GCE) was used in this study after cleaning by polishing with alumina grand and keeps in ultrasonic water path about ten minutes.

Procedure: cyclic voltammetry cell was used in this technique by adding 10ml of electrolyte (human blood samples) in the 10 ml of quartz cell and immerse three electrodes in the blood medium (GCE as working electrode, Ag/AgCl reference electrode and platinum wire as counter electrode), then the three electrodes were connected with potentiostat to finding the results by the cyclic voltammogram (CV) using personal computer.

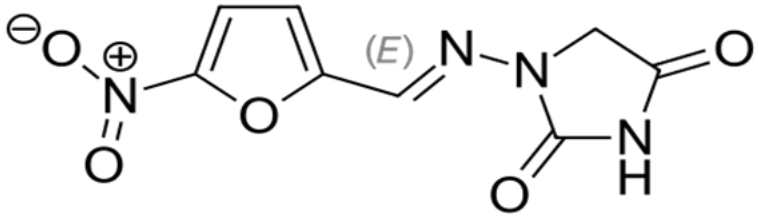
2.3.2 Lyophylization instrument

Lyophylization instrument from LABCONCO Company (U.S.A.) was used to preparation of nitrofurantoin nanoparticles from micro particles by deep freezing technique as shown in Figure 2.

Figure 2. Lyophylization instrument from LABCONCO Company (U.S.A.)

3. Results and Discussion

Nitrofurantoin in micro structure illustrated in scheme 1 was used at both micro and nanoform in blood medium to study the electrochemical behavior at different concentrations and scan rate, also the influence of different concentration of ascorbic acid (AA) on redox current peaks of nitrofurantoin in blood medium.



Scheme 1. Structure of nitrofurantoin

3.1. Effect nitrofurantoin at micro and nano particles on blood components

The comparison study between the micro and nanoparticles of nitrofurantoin was characterized in blood medium by cyclic voltammetric technique at GCE as working electrode and Ag/AgCl as reference electrode. Figure 3 illustrated the oxidation current peak of nitrofurantoin in micro particles at potential 1.0 V which disappeared in nanoparticles form of nitrofurantoin. But, the reduction current peak of nitrofurantoin in both micro and nanoparticles was still without any changing in blood medium. So, the nitrofurantoin nanoparticles act as antioxidant reagent in blood medium. It can be used as antibiotic for different bacterial diseases without any side effects [18].

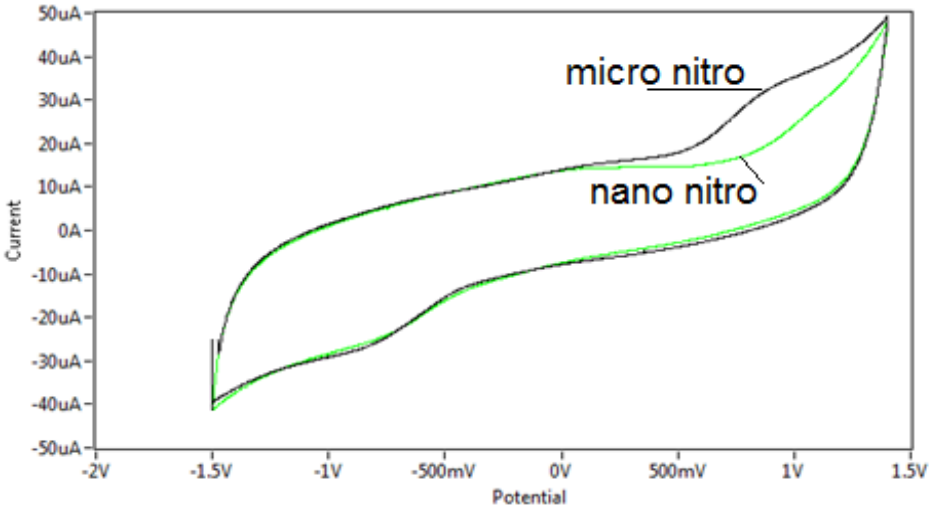


Figure 3. Cyclic voltammogram of micro nitrofurantoin in DMF and nano nitrofurantoin in blood medium at GCE.

3.2. Effect of different concentration of nitrofurantoin nanoparticles in blood medium

The behavior of nanoparticles in the blood medium was studied by cyclic voltammetric technique, when used different concentration of nitrofurantoin nanoparticles in blood medium as shown in Figure 4. It seems from the relationship between reduction current peak of nitrofurantoin nanoparticles (at -0.75 V) versus the different concentrations of nanoparticles as shown in Figure 5, a linear relationship y=0.2081 X + 25.254 with high sensitivity R^2= 0.9595. The results of nanoparticles in blood medium was indicated that a good conductivity in this medium and used as electro-catalyst [19].

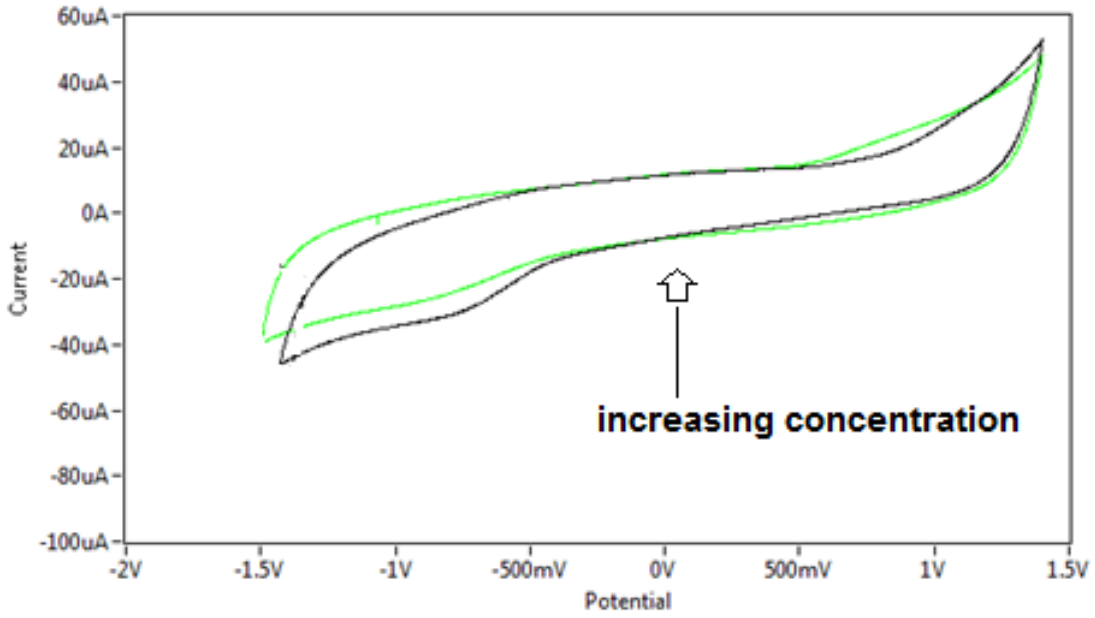


Figure 4. Cyclic voltammogram of nano nitrofurantoin at different concentration in blood medium on GCE.

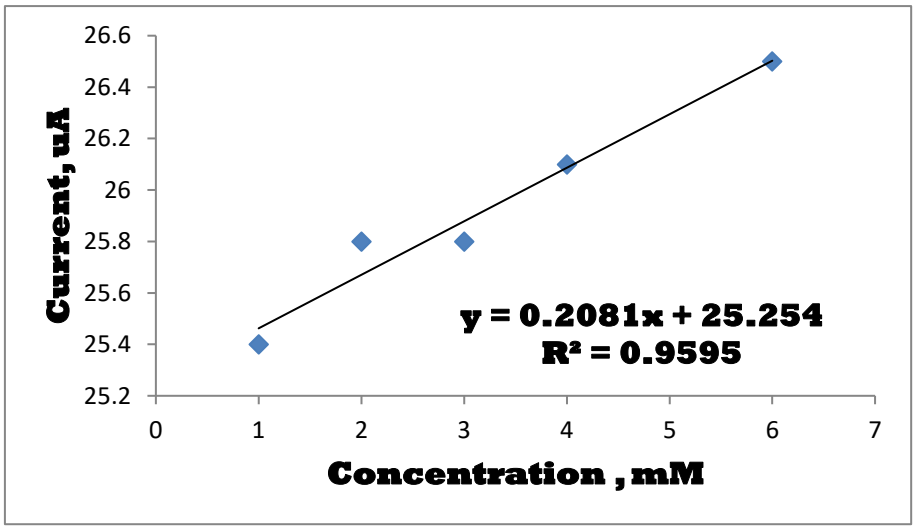


Figure 5. relationship between cathodic current peaks of nitrofurantoin nanoparticles in blood medium against to different concentration on GCE.

3.3. Effect of different scan rate of nitrofurantoin nanoparticles in blood medium

It can be ascertained that the results of cyclic voltammetric analysis in the blood medium as an electrolyte using at different scan rate (SR). It has been studied the nitrofurantoin nanoparticles in blood medium at different SR which has increasing the reduction current peak against to increasing the SR as shown in Figure 6. The good linearity of relationship between the cathodic current peak against to different SR was studied in the equation y = 121.14 X + 11.092 and R^2 = 0.9865 as shown in Figure 7. It is possible for using nitrofurantoin nanoparticles in safety because of its behavior in blood medium as anti-oxidative reagent [20,21].

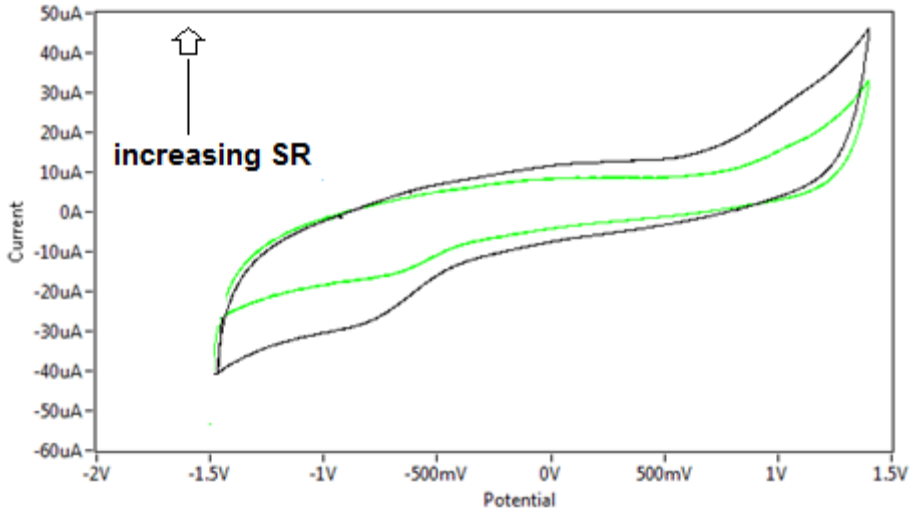


Figure 6. Cyclic voltammogram of nitrofurantoin nanoparticles at different scan rate (SR) in blood medium on GCE.

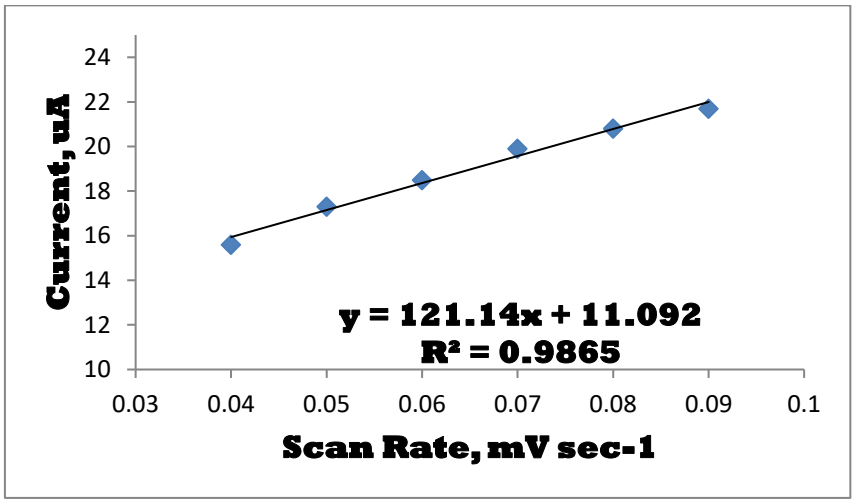


Figure 7. Relationship between cathodic current peaks of nitrofurantoin nanoparticles in blood medium against to different scan rate on GCE.

3.4. Effect of different concentration of ascorbic acid (AA) on nitrofurantoin in blood medium

One of the anti-oxidative reagent is AA which used in electrochemical analysis especially voltammetric technique to determine the behavior of reduction current peak of nitrofurantoin nanoparticles in blood medium. Figure 8 shows the influence of AA on the enhancement of the cathodic current peak of the nanoparticles in blood medium, the leaner relationship in Figure 8 illustrate an equation y = 0.3072 X + 26.155 with sensitivity R^2 = 0.8321. So, it was used to enhance the reduction peak of nitrofurantoin nanoparticles in blood medium especially as a safety drug [22].

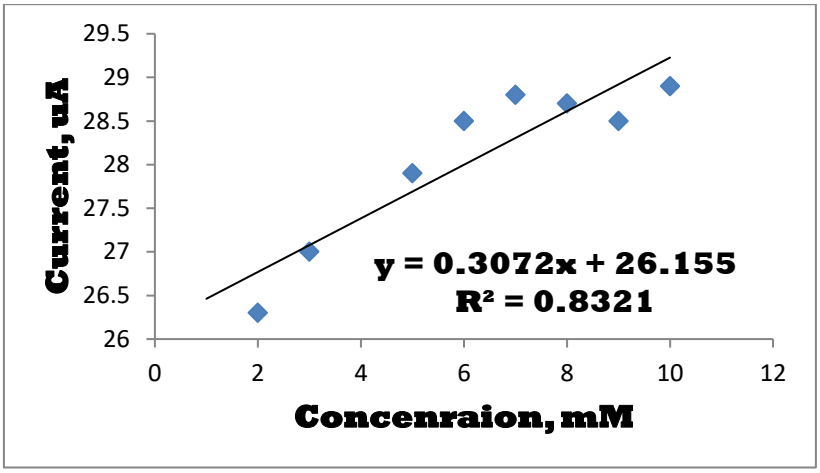


Figure 8. Relationship between cathodic current peaks of 10 mM nitrofurantoin nanoparticles in blood medium against to different concentration of AA on GCE.

4. Conclusion

In the current work, the extent of the influence nitrofurantoin nano-antibiotic on the blood components using electrochemical analysis method was determined by the cyclic voltammetry. The results showed that the nanoparticles act as anti-oxidative reagent using as good antibiotic drug for different chronic diseases. It was found the nitrofurantoin micro particles have oxidative current peak which causes oxidation the blood compound by reactant with hemoglobin to produce a complex with Fe ions, while nitrofurantoin nanoparticles in blood medium act as anti-oxidant and the oxidation current peak was disappear in blood medium. So, we can use nitrofurantoin nanoparticles as a safety active antibiotic against to the bacteria and other micro-organisms.

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