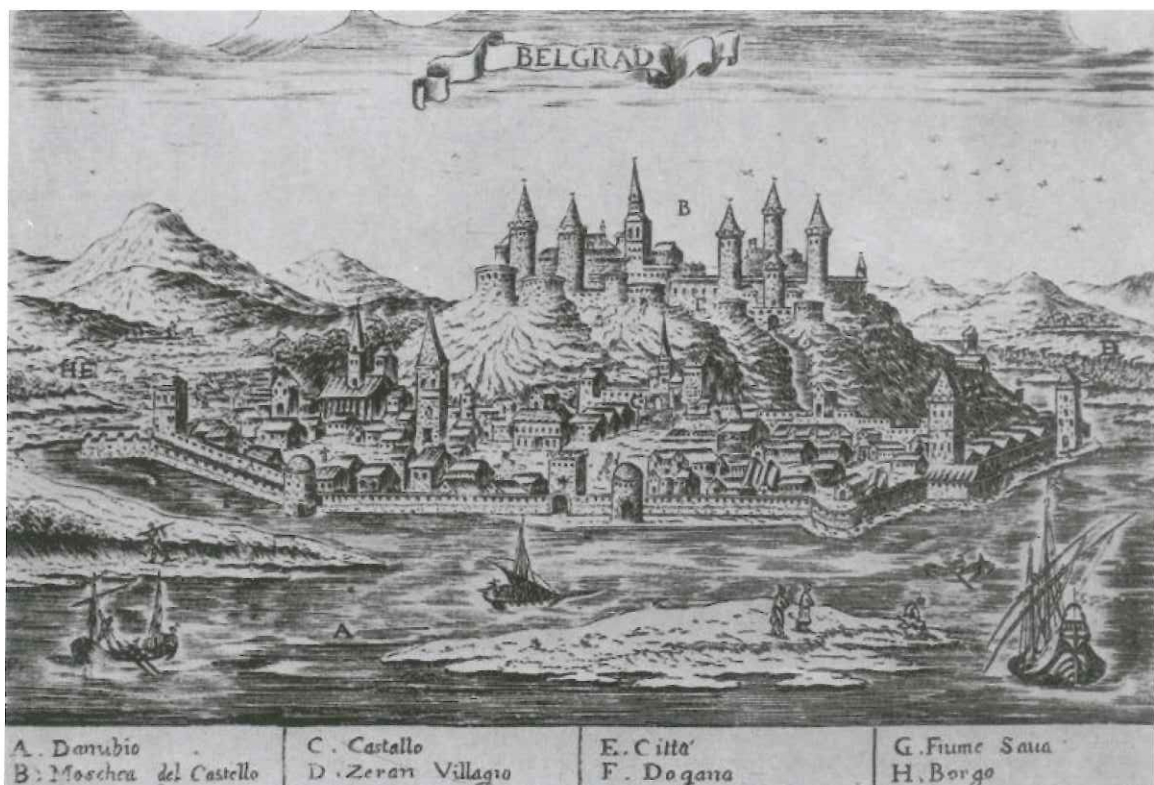




# PHYSICAL CHEMISTRY 2016

*13<sup>th</sup> International Conference on  
Fundamental and Applied Aspects of  
Physical Chemistry*



**BELGRADE**  
*September 26-30, 2016*

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## ELECTROCHEMICAL BEHAVIOR AND DETERMINATION OF SULFAQUINOXALINE AT GLASSY CARBON ELECTRODE

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### ABSTRACT

Electrochemical behavior of sulfaquinoxaline (SQN) was investigated using cyclic (CV) and differential pulse voltammetry (DPV) at glassy carbon electrode (GCE). CV was applied to investigate the effect of the supporting electrolyte pH on the SQN oxidation. In the pH range 2.0 – 10.0, the best current response was obtained at pH 7.0 in phosphate buffer. Results indicated that SQN is oxidized in irreversible process. DPV method was optimized, and the linear dependence of peak current vs. SQN concentration was obtained in the range  $3 \times 10^{-6}$ – $5 \times 10^{-5}$  molL<sup>-1</sup>, with limits of detection and quantification of  $1.53 \times 10^{-6}$  molL<sup>-1</sup> and  $5.10 \times 10^{-6}$  molL<sup>-1</sup>, respectively.

### INTRODUCTION

The sulfonamide drugs (“sulfas”) had been discovered primarily as antibacterial agents and later on, their efficacy had been shown to extend to protozoan parasites. Sulfaquinoxaline was found to be a superior agent against sporozoan parasite, *Eimeria* spp., the causative agent of coccidiosis in domestic chickens [1]. Different methods such as liquid chromatography with ultraviolet detection [2], high performance liquid chromatography (HPLC) coupled to a mass spectrometer (MS) [3], and a new HPLC method that is based on zwitterionic hydrophilic interaction liquid chromatography (ZIC-HILIC) coupled with ultraviolet detection [4] were used to determine SQN. Electrochemical reduction of SQN at mercury electrode was reported [5] and used for its determination in veterinary preparations. There is no literature report about the oxidation of SQN. The aim of this work was to investigate SQN oxidation properties at GCE and to optimize DPV method for its determination.

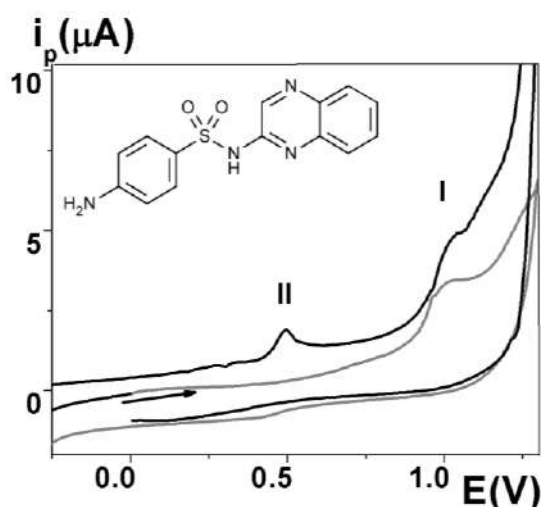
## EXPERIMENTAL

The voltammetric measurements were performed with  $\mu$ Autolab analyzer (EcoChemie, Utrecht, TheNetherlands). Three-electrode system was employed with GCE working electrode, Ag/AgCl reference and Pt-auxiliary electrode. Before each experiment the GCE was manually polished using the aqueous slurry of  $\text{Al}_2\text{O}_3$  powder (particle size  $0.05\mu\text{m}$ ) on a smooth polishing pad and sonicated in absolute ethanol. Chloride, acetate, phosphate and ammonia buffers were used as supporting electrolytes. An appropriate volume of supporting electrolyte of different pHs was placed in electrochemical cell, de-aerated for 15 minutes with high purity nitrogen and SQN stock solution ( $c_0=2\times 10^{-3}\text{ molL}^{-1}$ ) was added to make its final concentration of  $1\times 10^{-4}\text{ molL}^{-1}$  for CV and  $1\times 10^{-5}\text{ molL}^{-1}$  for DPV. The cyclic voltammograms were recorded at scan rate of  $100\text{ mVs}^{-1}$ . Parameters for DPV were: potential pulse width 50ms, pulse amplitude 75mV and step potential  $5\text{mVs}^{-1}$ . All experiments were performed at  $24 \pm 1^\circ\text{C}$ .

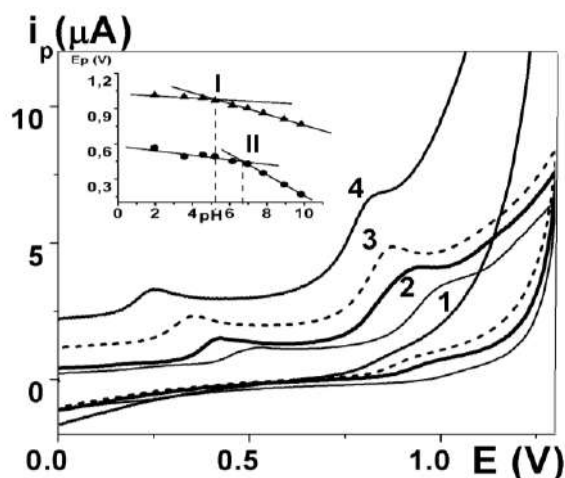
## RESULTS AND DISCUSSION

The oxidation of  $1\times 10^{-4}\text{ molL}^{-1}$  solution of SQN at GCE was preliminary studied in acetate buffer pH 3.5 by cyclic voltammetry. Cyclic voltammograms were obtained in repeated scans starting from 0 V towards +1.25 V and reversing to negative potential limit -1.2 V at a scan rate  $100\text{ mVs}^{-1}$ . On the first positive-going scan (Fig. 1, grey line) one anodic peak (I) was obtained at  $E_{pI} = 0.98\text{ V}$  and on the second scan (Fig. 1, black line) another anodic peak (II) was obtained at  $E_{pII} = 0.5\text{ V}$ . Changing the scan direction both anodic peaks were obtained (Fig. 2.) in the first scan. Peak II is probably due to oxidation of the SQN reduction product formed at the surface of GCE at negative potential values.

These results correspond to already established redox mechanism of C=N quinoxaline core group [6]. There are no peaks at



**Figure 1.** CV of  $1\times 10^{-4}\text{ molL}^{-1}$  SQN in two successive scans: — first scan, — second scan ( $v = 100\text{ mVs}^{-1}$ )  
Attached: SQN structure



**Figure 2.** CV of  $1 \times 10^{-4} \text{ molL}^{-1}$  SQN at different pH values: 1 – pH 4.6; 2 – pH 6.1; 3 – pH 7.8; 4 – pH 8.9; (scan rate  $100 \text{ mVs}^{-1}$ )

Attached: Influence of the pH on SQN CV peaks potential, I ( $\blacktriangle$ ) and II ( $\bullet$ )

$\text{pKa(I)} \sim 5.2$  and  $\text{pKa(II)} \sim 6.7$ . First value corresponds to literature data ( $\text{pKa} = 5.1$  for sulfonamide nitrogen [7]).

This result indicates that oxidation of nitrogen in sulfonamide group is responsible for peak I and that it could be used for further research and SQN determination. Another  $\text{pKa}$  value corresponds to  $\text{pKa}$  of nitrogen in dihydro derivate of quinoxaline. It is assumed that this derivative is result of the oxidation of SQN reduction product [6].

For peak I the best current response was obtained at pH 7.0 in phosphate buffer. DPV method was optimized by varying important operation parameters, and the best obtained values were: potential pulse width 50ms, pulse amplitude 75mV and scan rate  $5 \text{ mVs}^{-1}$ .

The linear dependence of peak current vs. SQN concentration was obtained in the range  $3 \times 10^{-6} - 5 \times 10^{-5} \text{ molL}^{-1}$ , under optimal conditions, and expressed by the equation  $i_p (\mu\text{A}) = 0.510 \times c (10^{-5} \text{ molL}^{-1}) - 0.139$  ( $r = 0.9984$ ,  $\text{SD} = 0.026 \mu\text{A}$ ), with  $\text{LOD} = 1.53 \times 10^{-6} \text{ molL}^{-1}$  and  $\text{LOQ} = 5.10 \times 10^{-6} \text{ molL}^{-1}$ .

SQN represents one of two active components in veterinary medicine NEOCOCCYN WSP. According to our preliminary results another active component, amprolium hydrochloride, is not electrochemically active under

reverse part of scan indicating that processes corresponding to peaks I and II are irreversible.

Anodic peaks I and II are present in the pH range from 2.0 up to 10.0 at positive potentials. The influence of the pH on these peaks potential resulted in the shift to the less positive potentials with increasing of pH and that  $\text{H}^+$  ions are included in

the electron transfer process. Observing  $E_p$  vs. pH dependence, both peaks show two linear segments. According to their intersection, experimental  $\text{pKa}$  values were determined:

the conditions used for SQN determination, and therefore the proposed DPV method at GCE can be used to determine SQN in this veterinary medicine.

### CONCLUSION

An extensive study of SQN electrochemical behavior at GCE was done by applying CV and DPV. It is confirmed that oxidation of nitrogen from sulfonamide group is irreversible, pH dependent process. From  $E_{pvs}$ . pH relation, experimental pKa values were obtained. The selective/specific DPV method at GCE without pretreatment will be optimized for SQN determination in veterinary medicine NEOCOCCYN WSP, which contains amprolium hydrochloride, as active component too.

### Acknowledgement

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### REFERENCES

- [1] W. C. Campbell, The Journal of Parasitology, 2008, **94**, 934-945.
- [2] J. J. BerzasNevado, G. Castaneda Penalvo, F.J. Guzman Bernardo, Journal of Chromatography A, 2000, **870**, 169–177.
- [3] T. A. M. Msagati, M. M. Nindi, Talanta, 2004, **64**, 87–100.
- [4] M. Ghanem, S. Abu-Lafi, R. Karaman, H Hallak, Pharmaceut Anal Acta, 2012, **3**(7), 1-5.
- [5] J. J. Berzas, J. Rodriguez, J. M. Lemus, G. Castaiieda, AnalyticaChimicaActa, 1993, **273**, 369-375.
- [6] M. M. Aleksić, V. Radulović, D. Agbaba, V. Kapetanović, ElectrochimicaActa, 2013, **106**, 75– 81.
- [7] SPARC; pKa/property server. Ver 3. Jan, 2006. <http://ibmlc2.chem.uga.edu/sparc/>