IPID4all Doctorate Research Exchange with Institute of Physical Chemistry, Polish Academy of Sciences, Feedback report

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Quinone films for organic active materials in batteries

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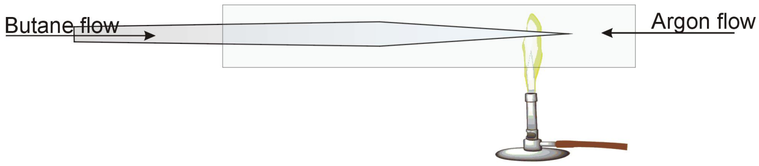
Introduction

This report summarizes a work done during a short research stay at the Institut of Physical Chemistry, Polish Academy of Sciences in Poland under the supervision of Prof. Dr. Marcin Opallo, Dr. Wojciech Nogala and my main supervisor Prof. Dr. Gunther Wittstock. During this exchange three main tasks were achieved: preparation of carbon nanoelectrodes (CNEs), characterization of CNEs and investigation of permeability using 4-dimensional scanning electrochemical microscopy (4D SECM) of the new quinone film. I briefly here describe the preliminary results as well as the possible perspectives and the experience gained.

Research Undertaken

1. Preparation and characterization of CNEs.

Briefly, a quartz capillary was pulled using a P-2000 laser puller. The tapered part of electrode was introduced into a bigger quartz tube connected to argon bottle. The other part of electrode was connected to the petroleum gas (60 vol % butane and 40 vol% propane). At the end the gas inside the nanoelectrode was pyrolyzed many times and chemical deposition carbon was observed into the tip of nanoeletrode (see the scheme 1).



Scheme 1: preparation of CNE using petroleum gas

Scanning electron microscope (SEM) and fast cyclic voltammetry (FCV) were used to examine the CNEs. Usually two different cases can be observed. Firstly, a nice CNE with well filled carbon material into the tip of capillary can be obtained. In this case a good chemical deposition of carbon is observed (see Fig. 1 A). In other hand it is usually possible to obtain a recessed CNE with the cavity of pico or nanovolume (Fig. 1 B). This recessed CNE are not suitable for further electrochemical investigation as a probe.

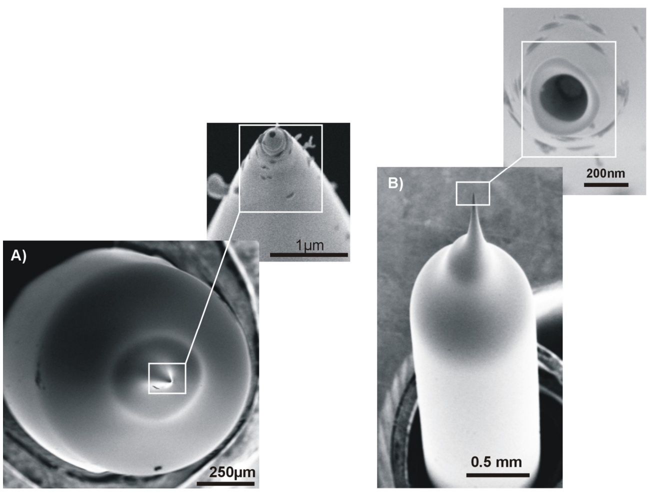


Fig. 1: SEM images of CNE (A) and recessed CNE (B)

Furthermore, with FCV it was easily possible to separate recessed CNEs to good CNEs since the recessed CNEs exhibit an unusual combination of the steady-state current at the extreme potentials with asymmetrical peaks (Fig. 2B).

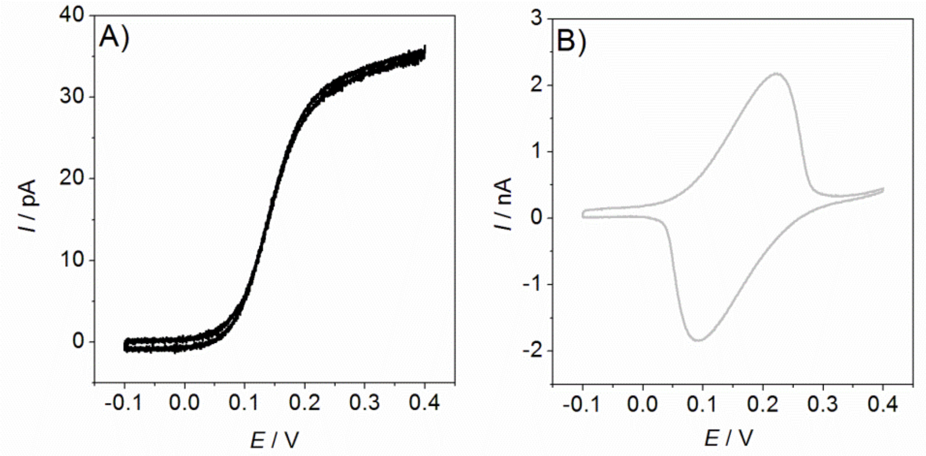


Fig. 2: FCVs of 1mM ferrocenemethanol in 0.1M KCl (A) CNE and (B) recessed CNE at 10V s^{-1}.

2. 4D SECM study of permeability of quinone film

Permeability of the film as well as the electron transport inside the film was studied using 4D SECM. Regeneration of redox mediators as ferrocenemethanol was not observed (known as negative feedback) but when the CNE was close enough or in the film we have obtained a rapid increase of current. During the 4D SECM at each point of the surface, an approach curve (current variation at the CNE depending of distance between subtract and the tip of CNE) was recorded in Z direction. To prevent the crash of CNE, which is extremely fragile, the program automatically retracted the CNE when the current decreased to 90% and move back to the first position. Then move in x direction to another point and z approach is again recorded (see Fig. 3). When the x axis is scanned, the CNE moves to Y direction and the same procedure is repeated.

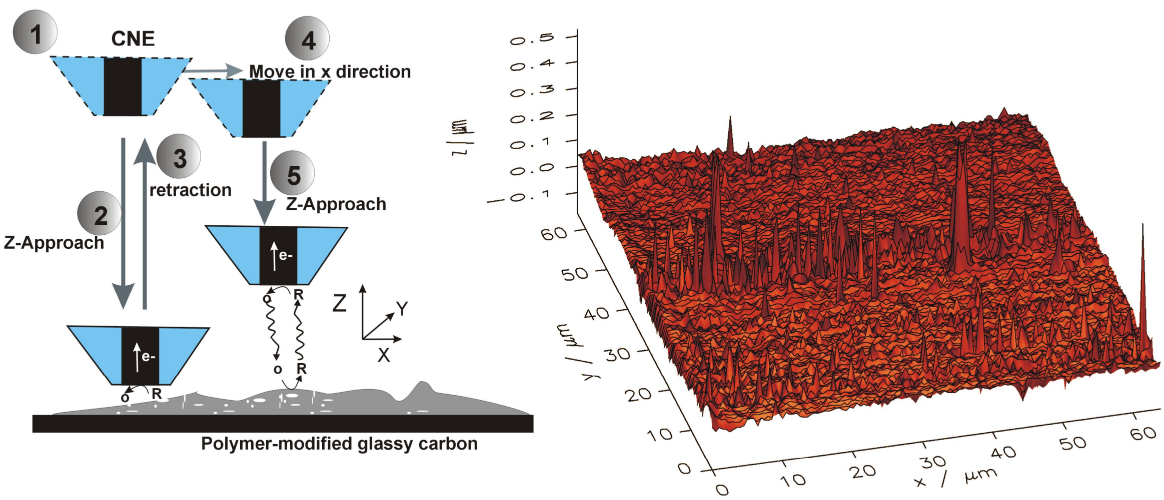


Fig.3: 4D SECM principle and topography of the quinone film where the z direction represents the last point before the retraction of CNE (170 nm of diameter)

Personal Experience

During this visit I improved my technical knowledge concerning CNE; preparation, handling and characterization of CNE were learned. The concept regarding recessed electrode and FCV were also studied. I got a good comprehension of SEM imaging during this intensive work.

Conclusions

These preliminary results show an overview of different applications of CNE. Use of the CNE for a better understanding of the chemistry of quinone films is now set. The results showed how the diffusion of redox mediators is affected by the quinone films. It will be untimely to give a realistic conclusion at this stage of the work. An intensive experiment need to be planned to get more relevant results.

Outlook

- o Poster is planned to present these results.
- o There are different possibilities of exchange with other research topics. It can be used as a film for a good biocompatible interface (in biosensor or biofuel cell for example) and also as a source of specific reactive oxygen species.

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