ELECTROCHEMISTRY WITH ULTRASOUND

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*Academy of Sciences of the Czech Republic: J. Heyrovsky Institute of Physical Chemistry. Czech Republic
OBJECTIVES AND EXPECTED ACHIEVEMENTS

**Electroanalysis**
Development of enhanced electroanalytical procedures that are effective in real media, leading to improved sensors and biosensors.

Sensitive electroanalyses for metal ions and other deleterious electroactive species in the environment.

**New systems**
Novel electrosynthesis reactions with applications in organic and biochemistry.

Novel functional materials and their practical applications, including nanoparticles and conducting polymers.

Development of new electrode materials and the understanding of surface processes in these processes.
OBJECTIVES AND EXPECTED ACHIEVEMENTS

Environmental applications
Improved strategies for waste minimisation:
  obviation of environmentall-unfriendly systems in synthesis
  sonoelectrochemical reactor design
Degradation of pollutants and enhanced environmental clean-up using
sonoelectrochemistry

Technological applications
Improved methods for electrodeposition, electrodissolution, including effects on
morphology, hardness, microstructure...
Scale-up form micro-scale to pilot-plant scale
WORK PROGRAMME FOR THE FIRST YEAR

Events

Kick off COST D-32 Meeting, held in Alicante, July 2004.

Kick off Working Group Meeting, held in Alicante, December 2004.

Tasks

General task: Finding and development of common research interests by means of:
   Research interactions
   Short term scientific missions

Specific tasks:
   Sonoelectrochemical reactor design
   Degradation of pollutants using sonoelectrochemistry
   Development of new electrode materials
   Sensitive electroanalyses for metal ions
ACTIVITIES DURING THE FIRST YEAR

Events

Kick off COST D-32 Meeting, held in Alicante, July 2004.

Kick off Working Group Meeting, held in Alicante, December 2004.

Research interactions

Short term scientific mission (financed by COST)
Verónica Sáez (University of Alicante) in Coventry University

Short term scientific mission (financed by COST)
Jiri Klima (J. Heyrovsky Institute of Physical Chemistry) in University of Alicante

One-year visit (financed by Ministerio Educación y Ciencia (Spain)) in progress
José González-García (University of Alicante) in University of Oxford

Further actions

Annual Working Group Meeting, to be held in Prague, November 2005.
Kick off Working Group Meeting

Kick off Working Group Meeting, held in Alicante, 3rd-4th December 2004.

Participants and talks

University of Alicante
Welcome J. González-García
“Sonochemistry: fundamental and applied studies” V. Sáez
“Optimization of Hydrodynamics in Electrochemical Reactors: Use of numerical and experimental methods” A. J. Frías-Ferrer

University of Oxford
“Sonoelectroanalysis” R. G. Compton
“A hand held probe for the sonoelectroanalysis of arsenic”. A. Simm
“Materials for the sonoelectrolysis of hydrogen peroxide” C. Banks

University of Bath (Invited speaker)
“Microwave Effects and Applications in Electrochemistry” F. Marken
Participants and talks (II)

University of Coventry
“Electrooxidation and Photooxidation of Thiphene-s-Oxides” D. Walton

University of Franche-Comté
“Electrochemistry under ultrasound at the interface” J.-Y. Hihn
“Design of sonoreactors and application in surface treatment” M. L. Doche

J. Heyrovsky Institute of Physical Chemistry. Czech Republic
"Intensity of ultrasound in sonochemical and sonoelectrochemical measurements“
J. Klima
“Electrochemical reduction and dimerization of halogenated benzothiophenes and benzothiophene-2-oxazolines. Use of sonication” J. Ludvik

Université de Paris
“Ultrafast sonoelectrochemistry” E. Masionhaute
Visit to the pilot plant. The existence of this facility is an important aspect of the Operation at Alicante, which is not available at other laboratories in the network.

**Achievements and objectives**

*Talks reviewed the active research in the working group labs*

- Alicante: Electrodeposition, pollutant degradation assisted by ultrasound
- Design and Characterization of (sono)electrochemical reactors

- Oxford: Sonoelectroanalysis in real practical applications
  Sonoelectrosynthesis, in particular hydrogen peroxide from oxygen

- Coventry: Electroorganic and photoelectroorganic synthesis focused on the oxidation of thiophene-S-oxides
Kick off Working Group Meeting (IV)

Objectives and achievements (II)

Prague: Physical background in sonochemistry and sonoelectrochemistry

Besançon: Better modelling of sonoelectrochemical systems
   Electroplating assisted by ultrasound
   Open to new emerging fields: Room temperature Ionic liquids
   polymer synthesis under US

Paris: Cavitation analysis with nanosecond time base equipment
   Fundamental approach to the cavitation event

*Relevant points which can fit WG objectives
   Definition of reproducibility and characterization of operating conditions
   Identification of problems in applications or phenomena needing theoretical understanding
   Sonoelectrochemical reactor design
**Objectives and achievements (III)**

*As a first step, development of STSMs in order to establish bilateral collaborations for:

- Mutual exchange of expertise
- Mutual training
- Finding specific collaborating targets
- Definition of the tasks and contributions in a future research project

*After, applications for the 7th European Framework will be considered looking at:

- Complementarity among laboratories
- Possibility to open the applicant list to other COST laboratories
Short Term Scientific Mission: V. Sáez (Alicante) in Coventry

Objectives
Study of the degradation of a chlorinated organic compound using sonochemical, electrochemical and finally the exploitation of the combination of both methodologies at 850 kHz (equipment not available in UA)

Degradation of perchloroethylene as a model molecule in aqueous solution.

Perchloroethylene

Publications
“Sonoelectrochemical degradation of perchloroethylene at 850 kHz”
V. Sáez, J. Iniesta, A. Frías-Ferrer, J. González-García and D. J. Walton
Electrochem 2005, Newcastle, UK
Short Term Scientific Mission: J. Klima (Prague) in Alicante

Objectives
Knowledge of local distribution of ultrasonic intensity is necessary for measurement of intensity:

\[ I = W_c = \frac{1}{2} \rho c \omega^2 A^2 = \frac{P_0^2}{2 \rho c} \]

\[ I = \frac{P_{US}}{S} \]

only for progressive wave

Publications
“Physical aspects of Sono(electro)chemistry: Distribution of intensity of ultrasound”
J. Klíma, A. Frias-Ferrer, J. González-García, J. Ludvík, V. Sáez, J. Iniesta
COST WG 2 Workshop 9-10 June 2005, Oxford, UK
One-year visit: J. González-García (Alicante) in Oxford

Objectives

Identification of practical electrocatalysts capable of acting as electrode materials in a sonoelectrochemical reactor for the reduction of oxygen (air) to hydrogen peroxide

The determination of the stability of the electrocatalysts in respect of insonation to identify the optimal sonoelectrocatalysts for hydrogen peroxide formation

Design, development and optimisation of a reliable and efficient laboratory bench scale sonoelectrochemical reactor
Interactions between Working Groups
Short Term Scientific Mission: D. Bogdal WG10 in Coventry

Objectives
Carbazole electropolymerization in acetonitrile/ammonium system. Influence of the ultrasound and a magnetic field

Results
Polycarbazole films on indium-tin oxide coated (ITO) glass

Further work
Characterization of the luminiscent properties in Politechnika Krakowska
COST D-32 –Action. Results presented in Modena