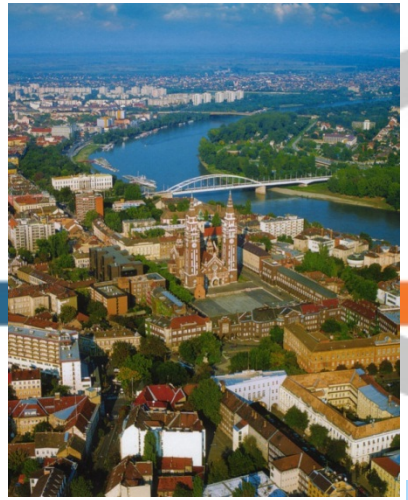


# REACTION CENTER OPTOELECTRONICS IN NANO-HYBRIDE SYSTEMS


Dr. László Nagy

Department of Medical Physics and Informatics, University of Szeged

Szeged, Hungary


**COST TD1102 2nd Plenary Workshop**

**9-11 April 2014,**

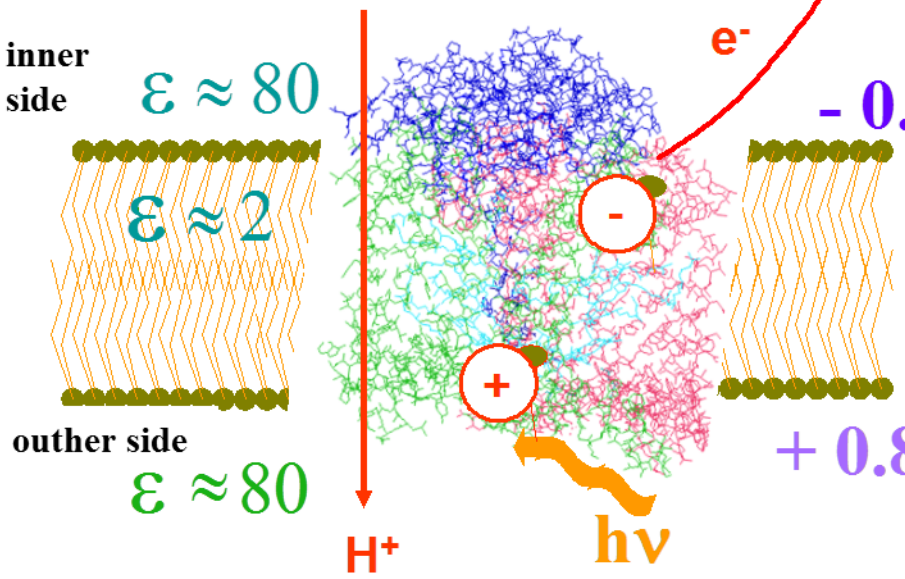
**Istanbul**


COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

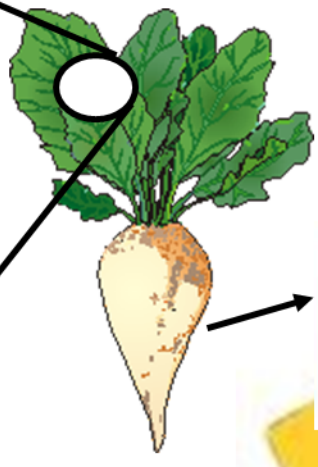
**The first steps of the photoelectric energy conversion takes place in the photosynthetic reaction center protein.**

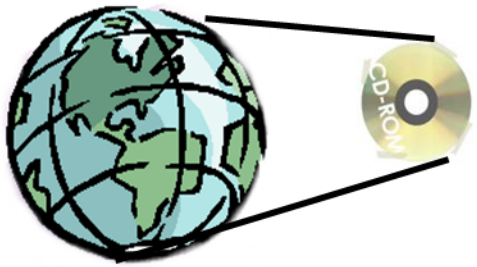
$$6\,H_2O + 6\,CO_2 = C_6H_{12}O_6 + 6\,O_2$$



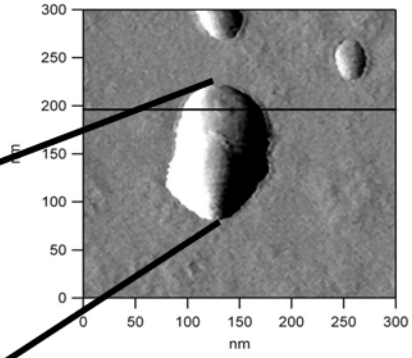

**- 0.32 V**

**+ 0.82 V**




**1 m**




**The AFM image of the RC.**

# Aim of the work is to

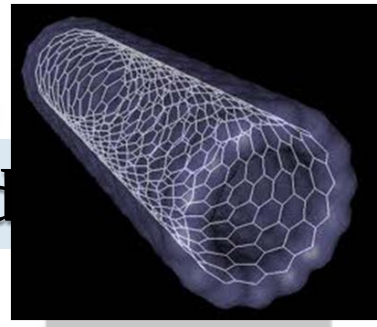
**create functional bio-nanocomposite materials from nano-structured carriers and photosynthetic reaction centers;**

**design a measuring system to investigate the basic characteristics** (optical characteristics, electric conductivity, redox properties, etc.)

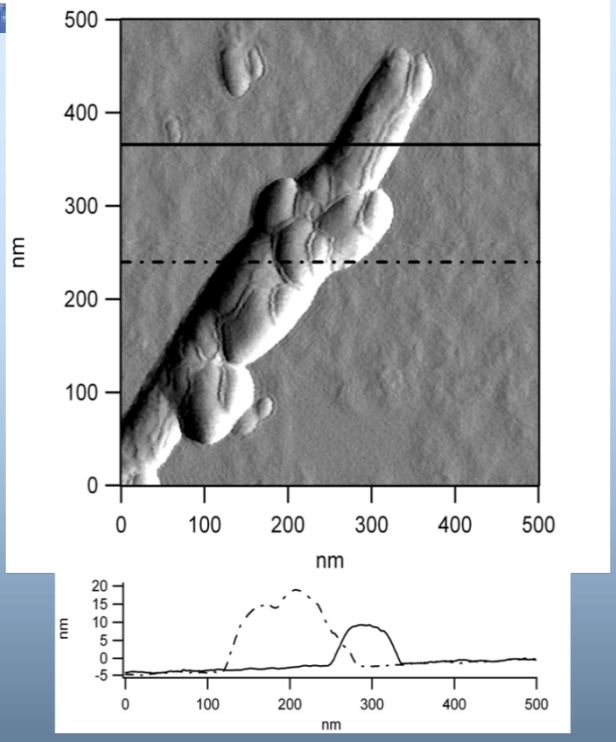
**design (model of) a device for possible future application** (integrated optical, electric conductance, photocurrent, imaging, biosensors, etc.);

**find connecting points for other projects** (other redox proteins and matrices, or auxiliary processes).

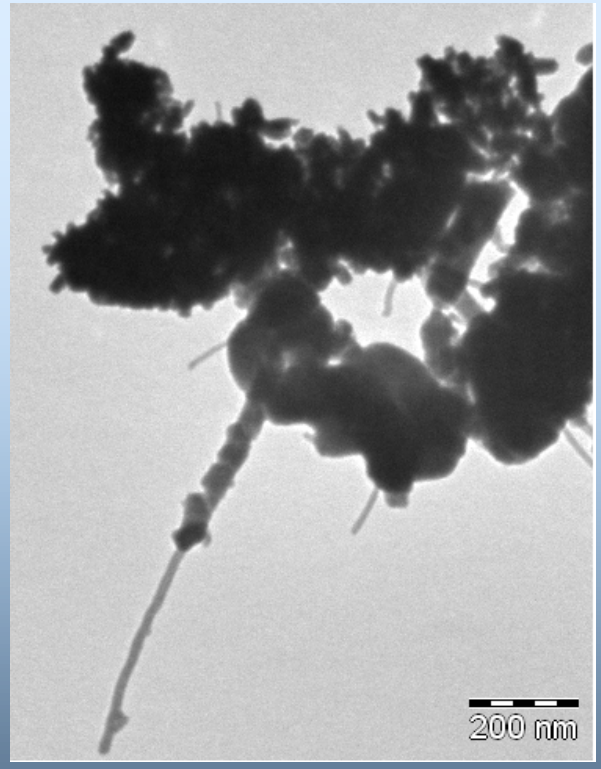
# Different carrier matrices are applied



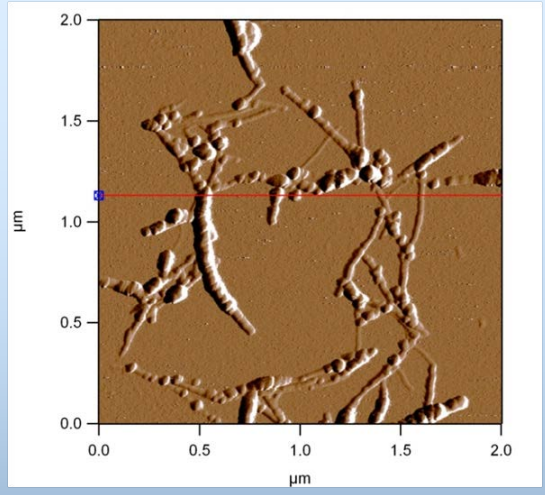
Kata Hajdu

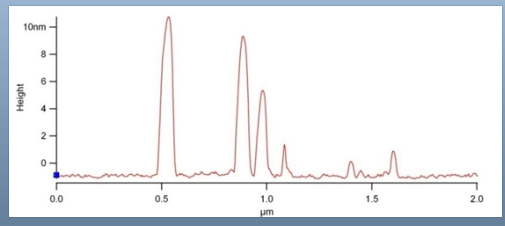



## Non-functionalized – physical binding




## $NH_2$-functionalized – peptide bonds

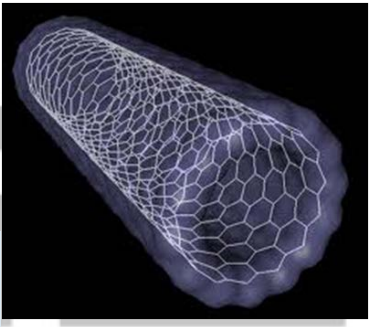



## $NH_2$-functionalized – linked through GTA

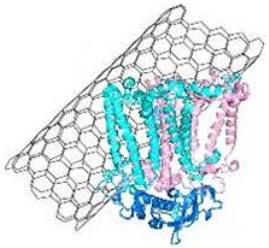
by the EU Framework Programme
FOUNDATION through a European Commission contract

Melinda Magyar

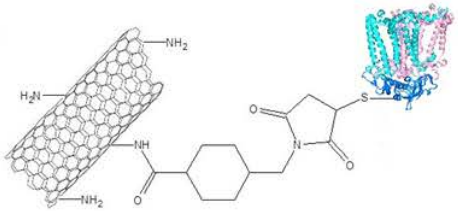


# Different binding methods are applied

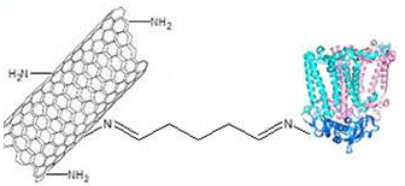
## Physisorption:



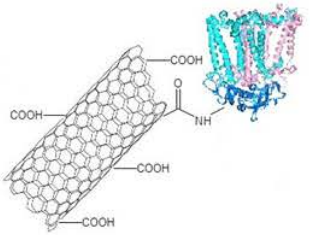
## Chemisorption:



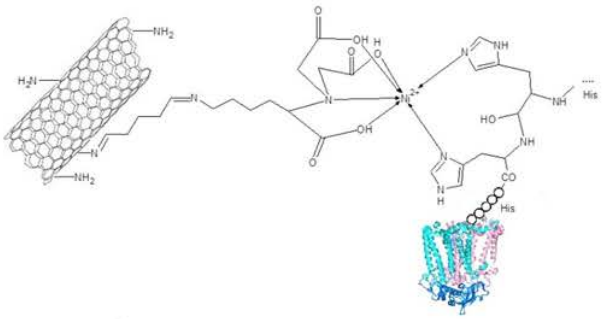
Sulfo-SMCC activation



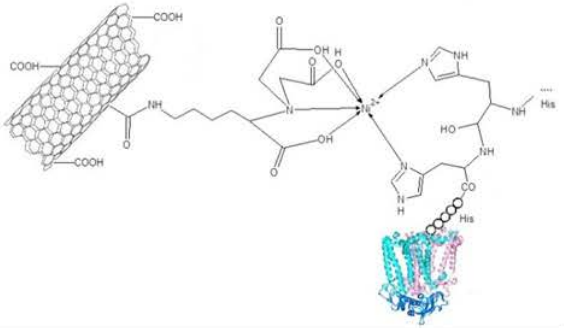
Glutaraldehyde activation



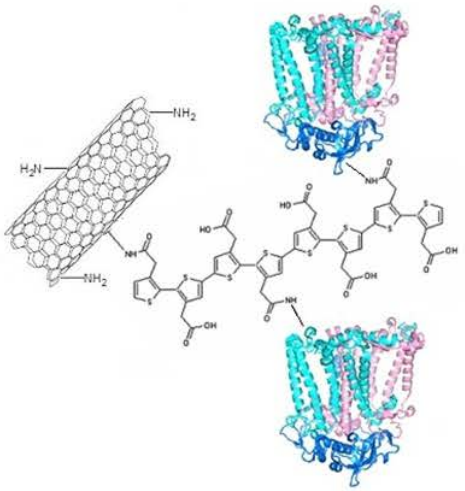
Carbodiimide activation



Nickel-complex with glutaraldehyde activation

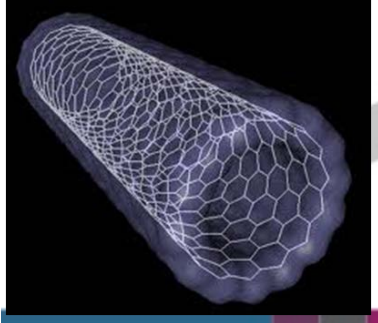


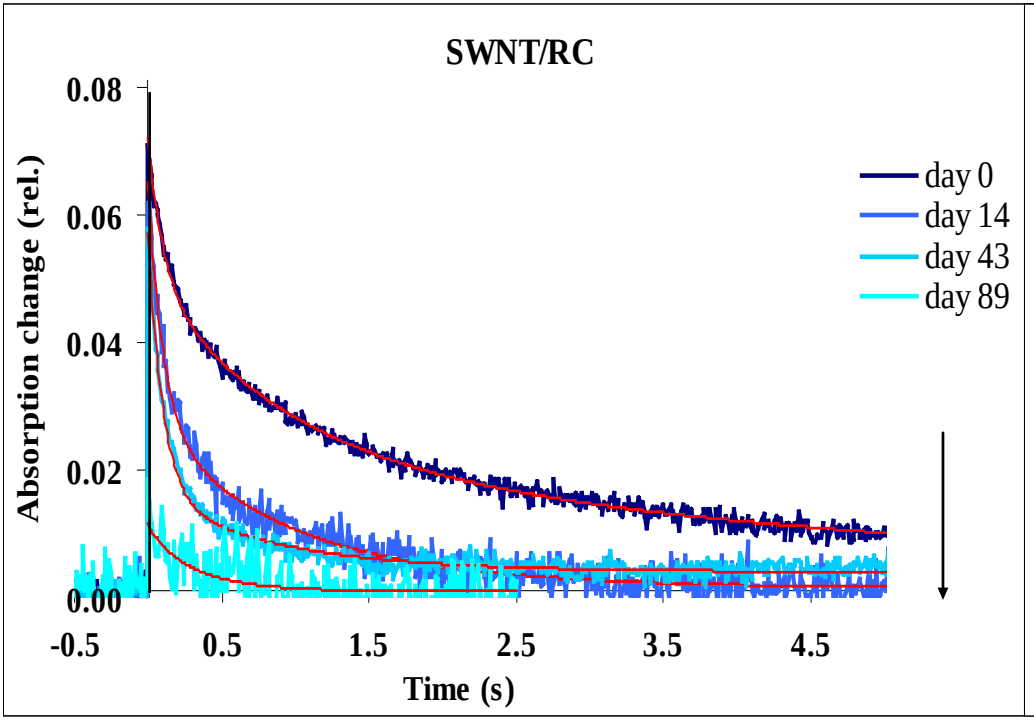
Nickel-complex with carbodiimide activation

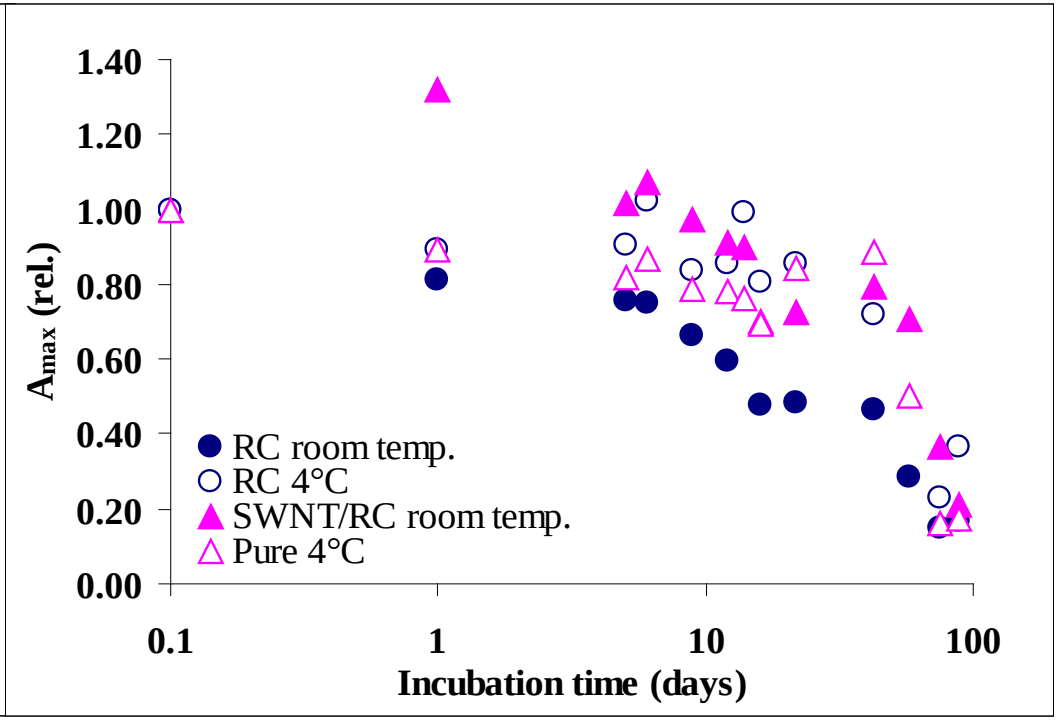


PTAA polymer

COST i
by the E
ice
ssion contract





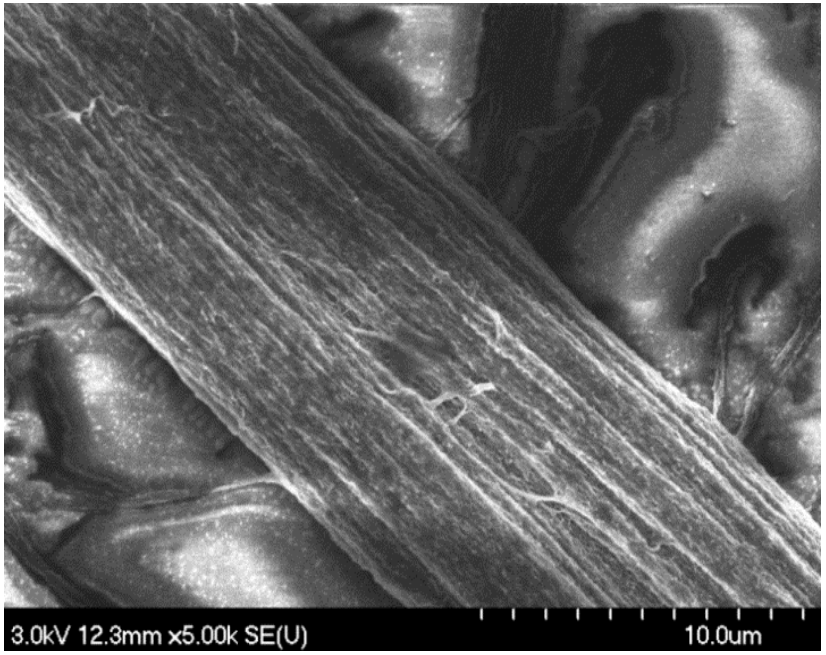




COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

Szabolcs Torma

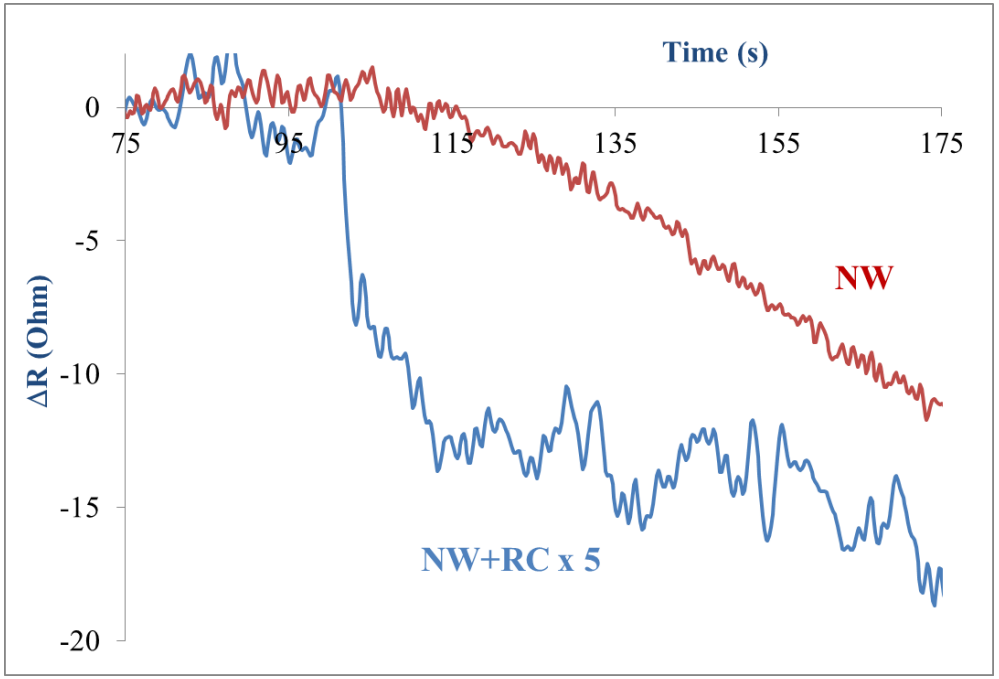
# MWCNT bundles

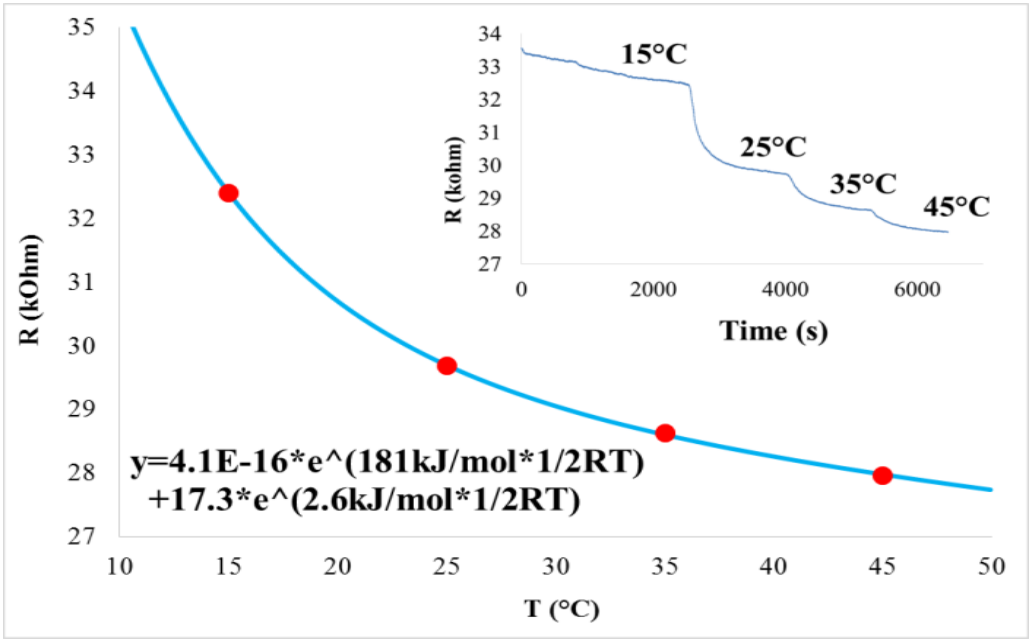




COST is supported by the EU Framework Programme

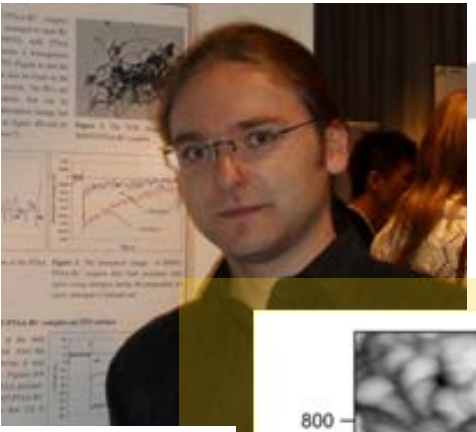
ESF provides the COST Office through a European Commission contract



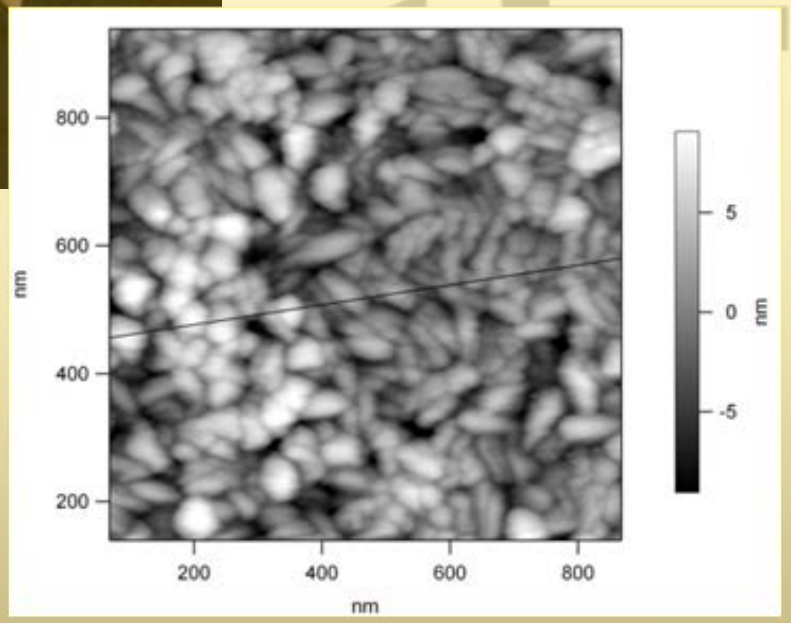



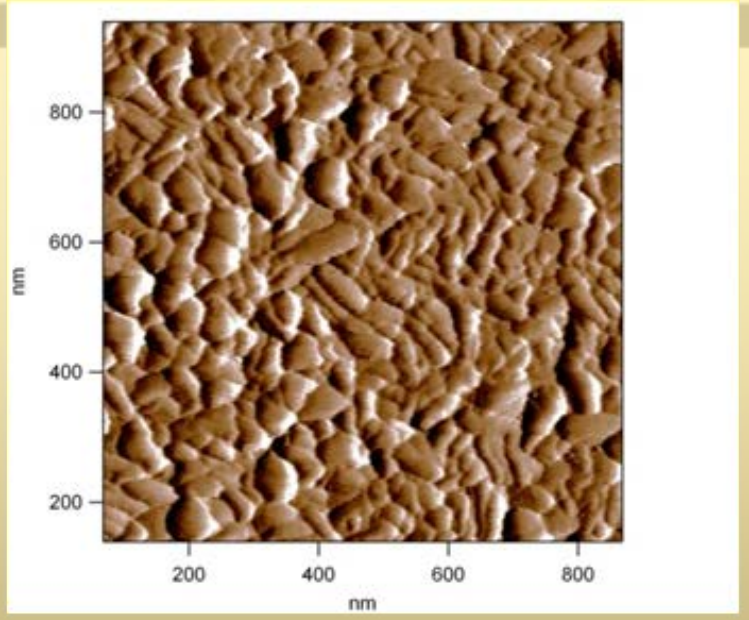

COST is supported by the EU Framework Programme

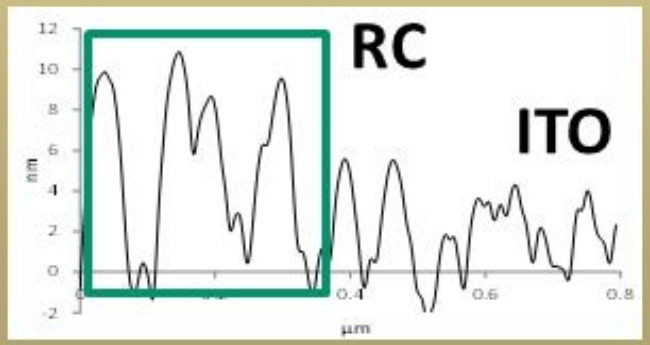
ESF provides the COST Office through a European Commission contract



**Tibor Szabó**



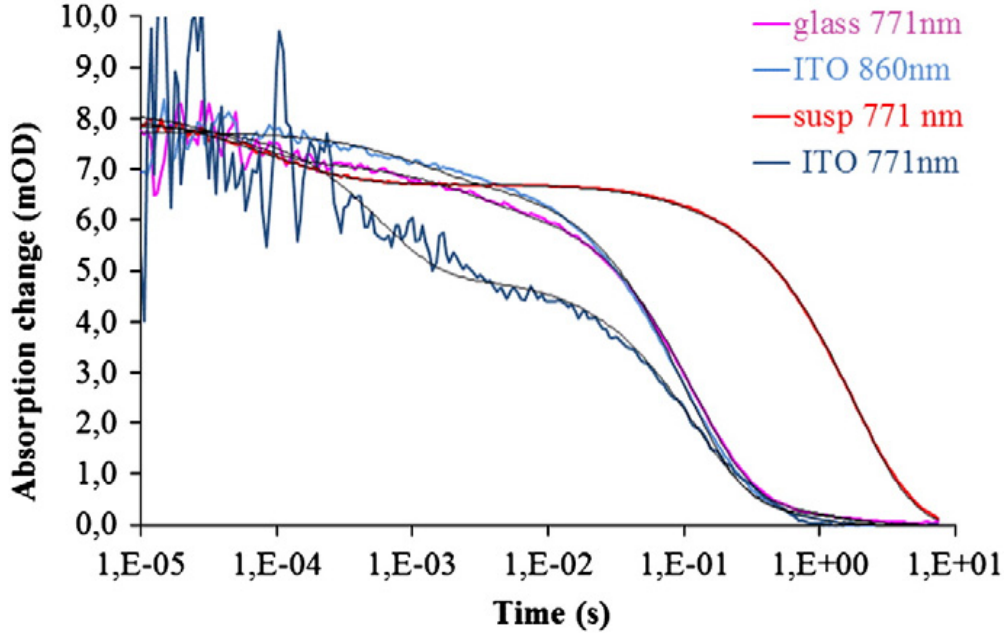



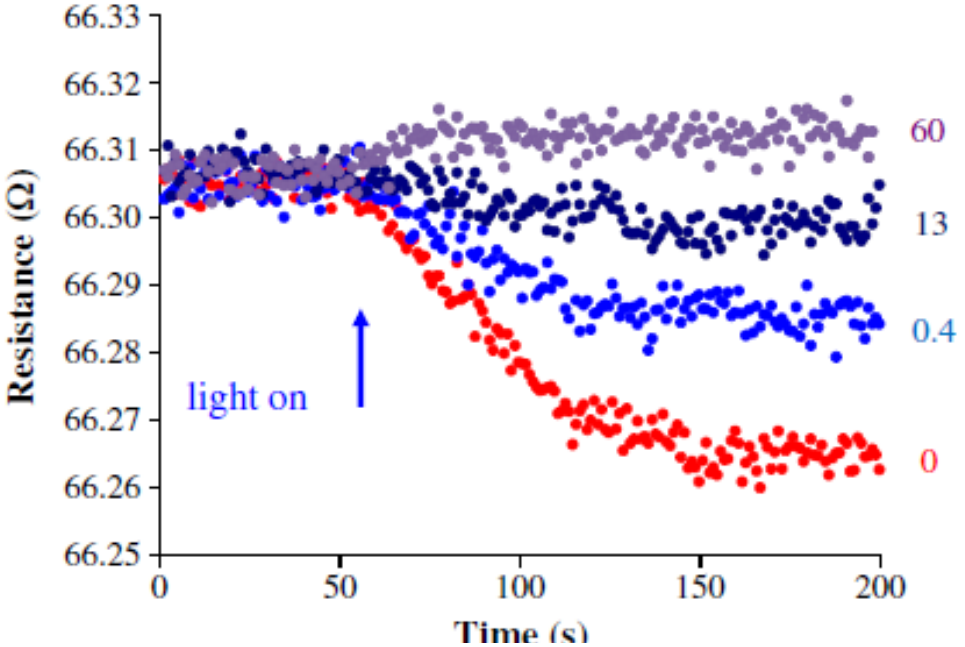



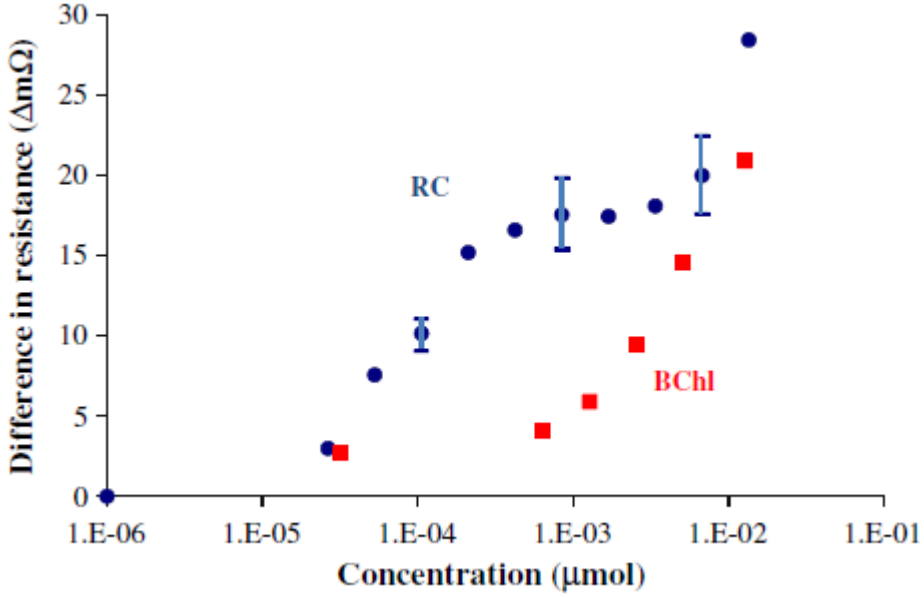

**ITO**

COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

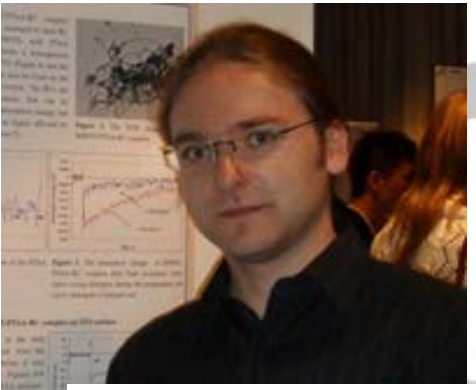


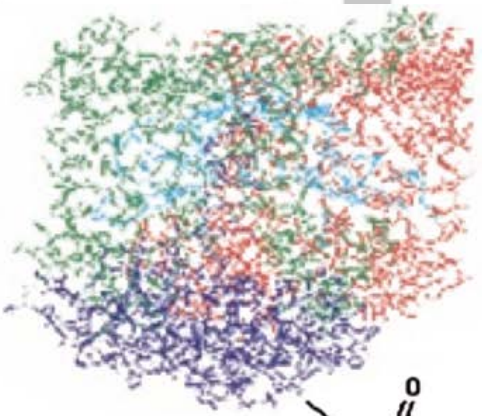



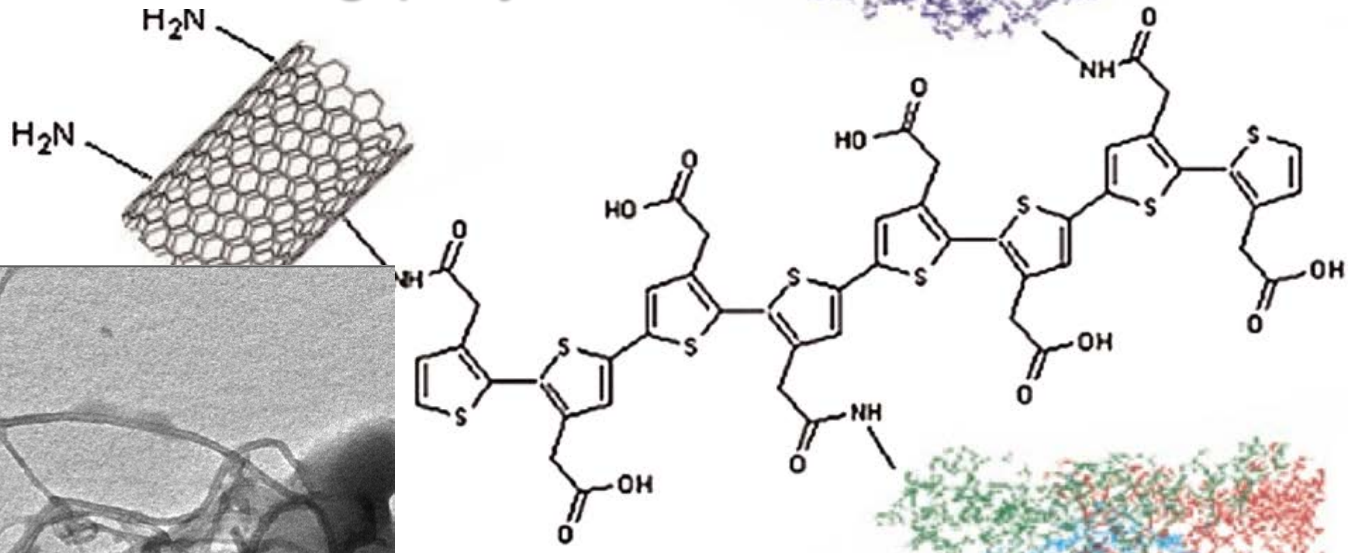

COST is supported by the EU Framework Programme

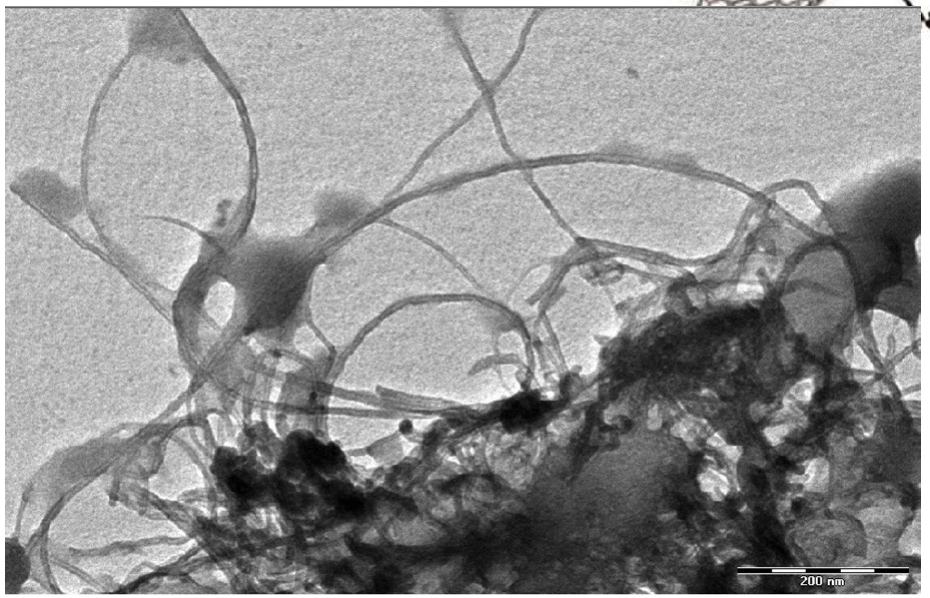
ESF provides the COST Office through a European Commission contract

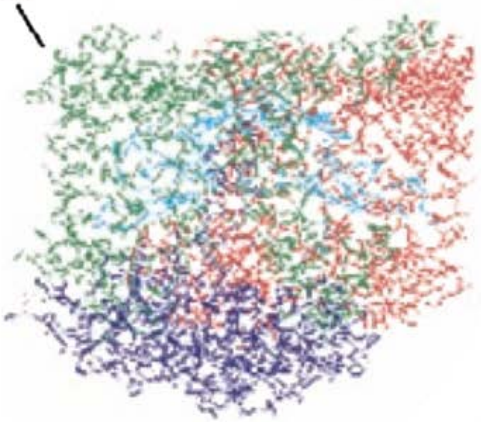


# RC/MWCNT/ITO/conducting polymer



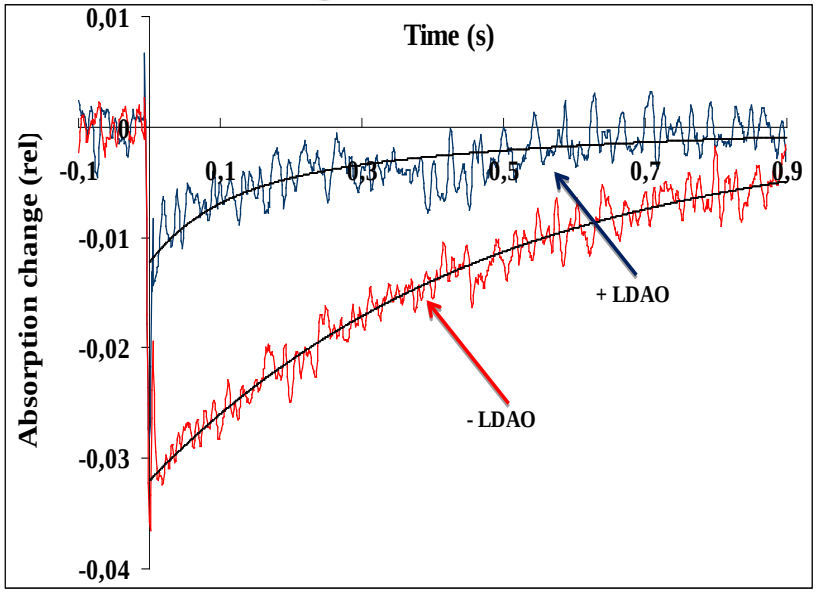


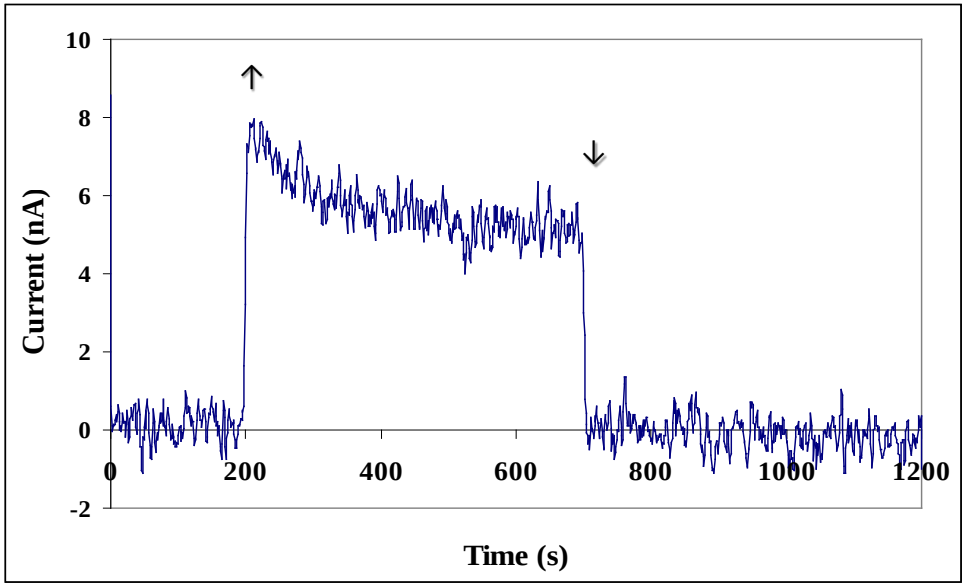



COST is supported
by the EU Framework Programme

ESF provides the COST Office
through a European Commission contract



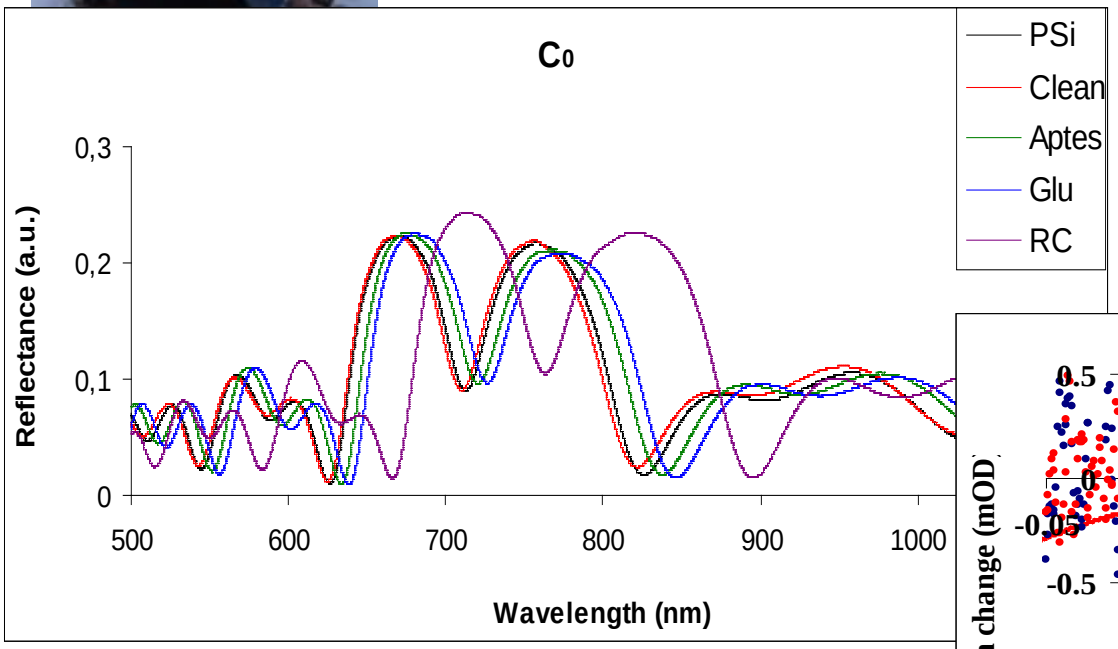



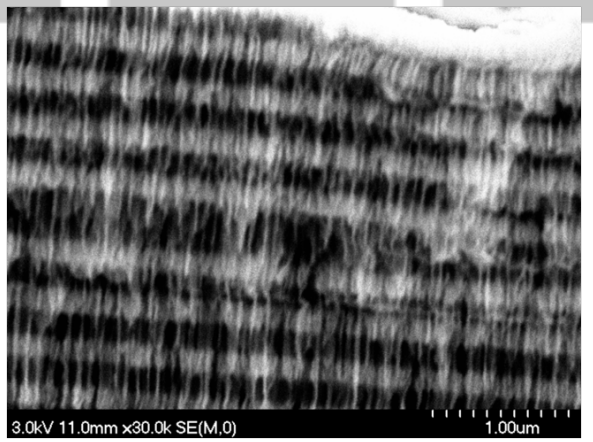

| | $A_1$(%) | $\tau_1$ (ms) | $A_2$(%) | $\tau_2$ (ms) |
|---|---|---|---|---|
| +LDAO | 72 | 90 | 28 | 476 |
| -LDAO | - | - | 100 | 480 |

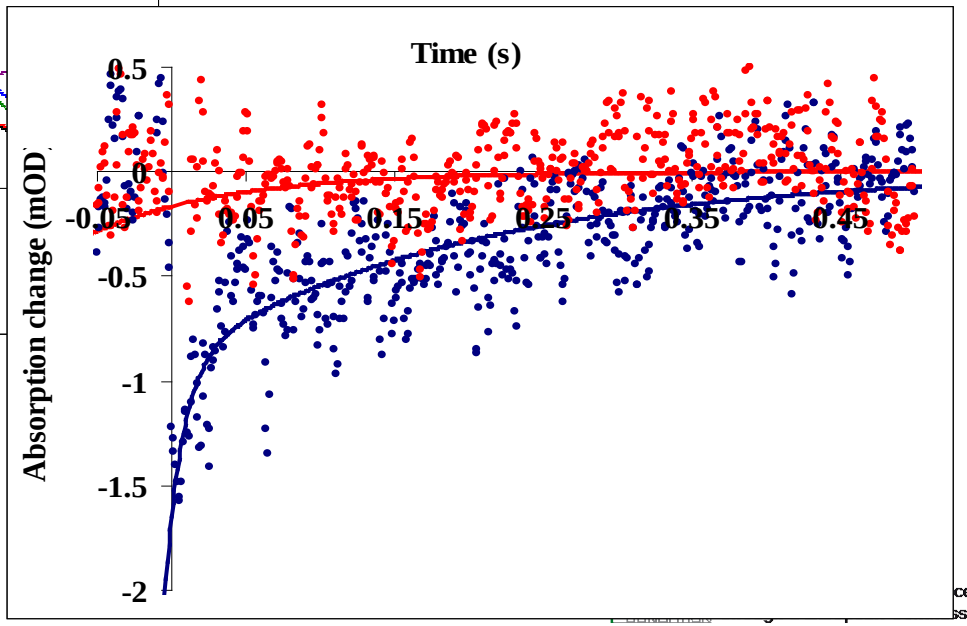
COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

# Porous silicon/RC complexes

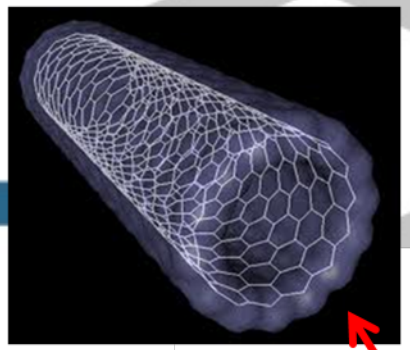



COST is supported
by the EU Framework Programme

# Formation of singlet oxygen



Anikó Kinka

≈

≈ $^1\Sigma_g^-$

$k_{t,BChl}$

$k_{t,P}$

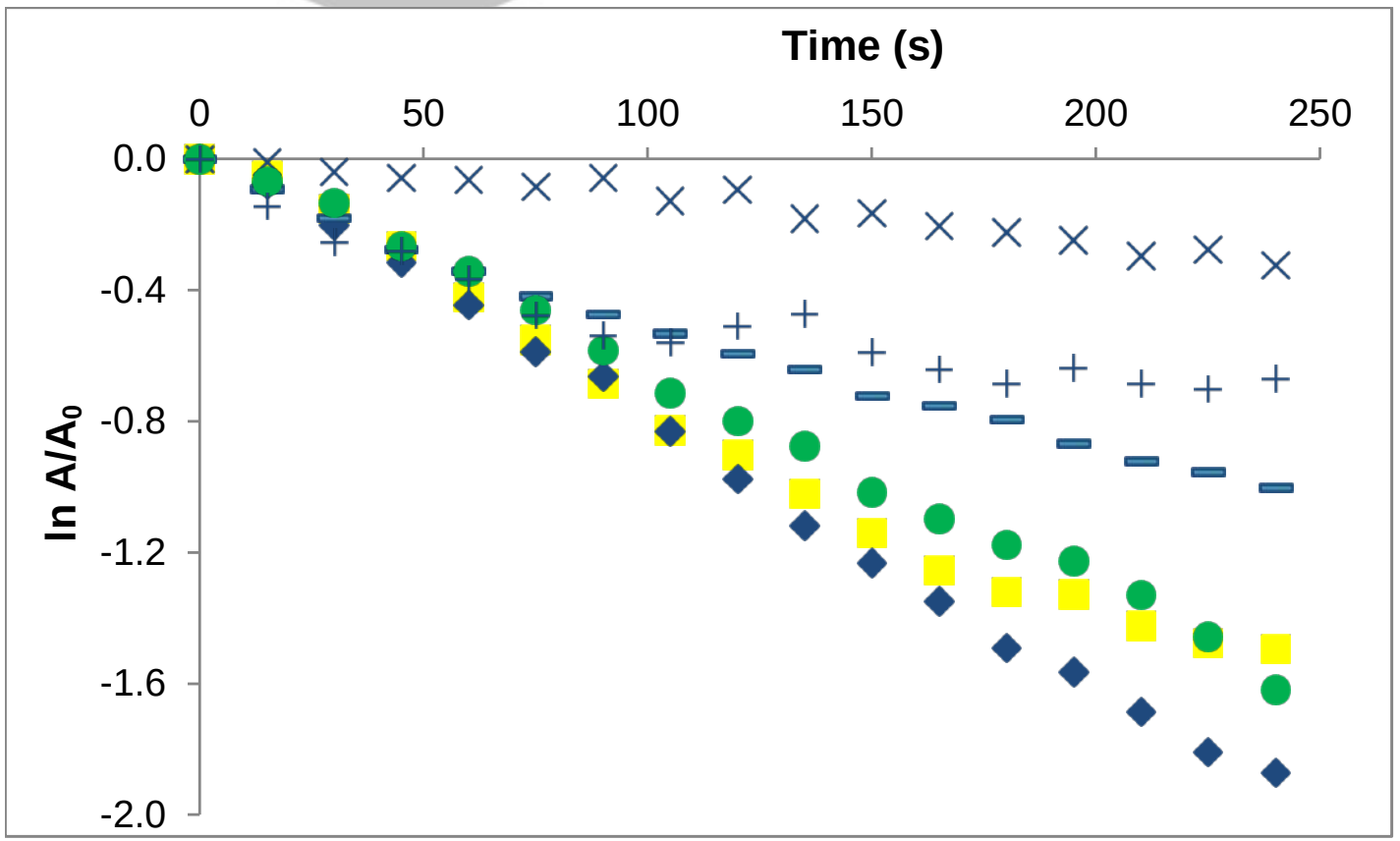
$^3\Sigma_g^-$

BChl

P

≈ energy transfer

→ chemical reaction




## Samples:

(x) RC-R-26 – physical binding, no detergent

(+) RC-R-26 – physical binding with detergent

(–) RC-R26 and DPBF

(●) SWCNT-$NH_2$-RC

(■) MWCNT-$NH_2$-RC

(♦) MWCNT-COOH-RC

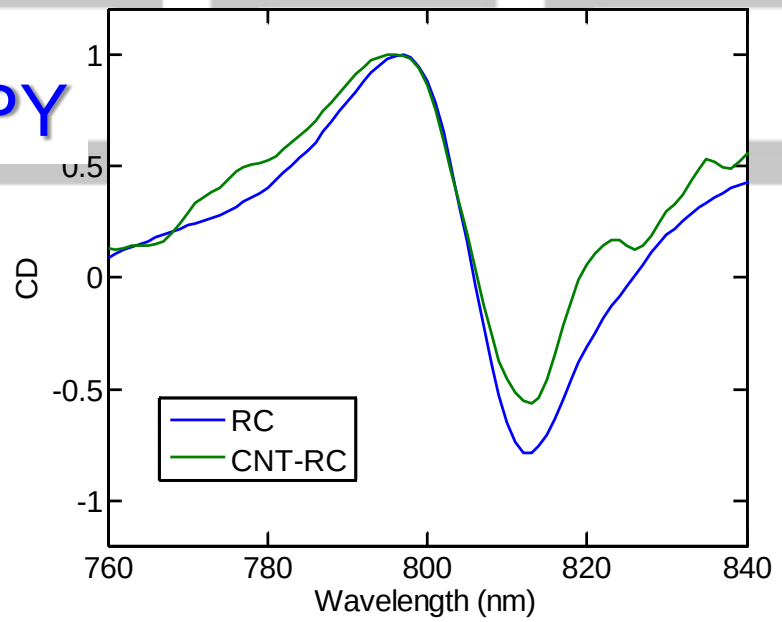
COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

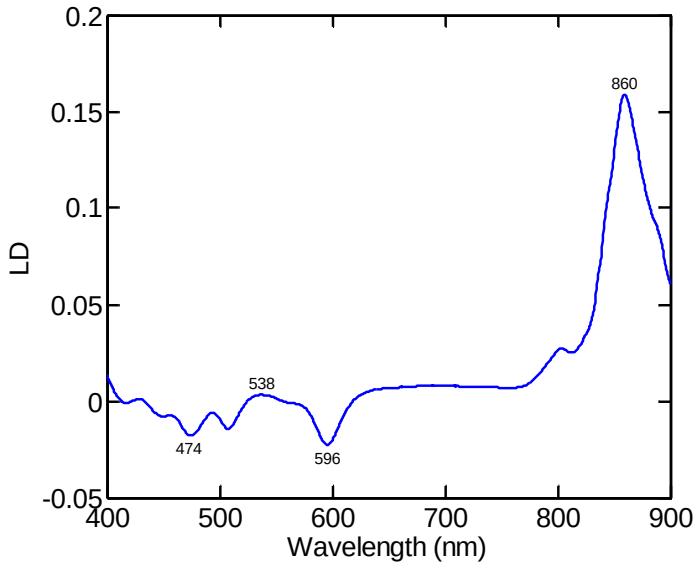
Gy. Garab, M. Dorogi, P. Lambrev

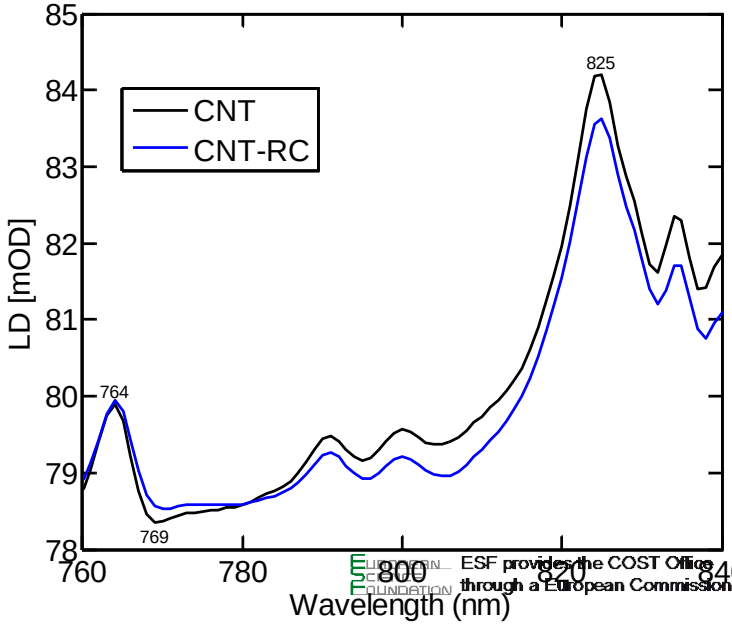
# POLARISATION SPECTROSCOPY

## RC/CNT




## RCs in liposomes



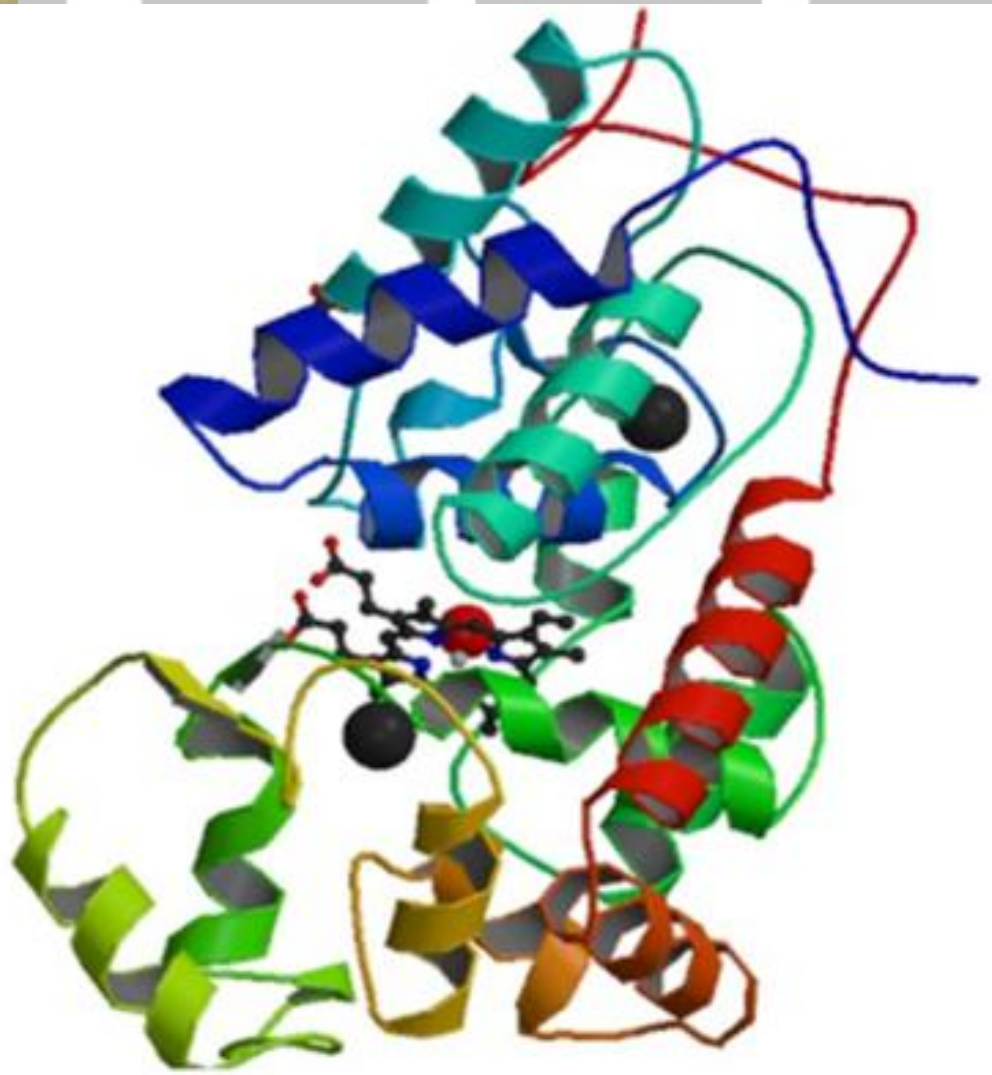




COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

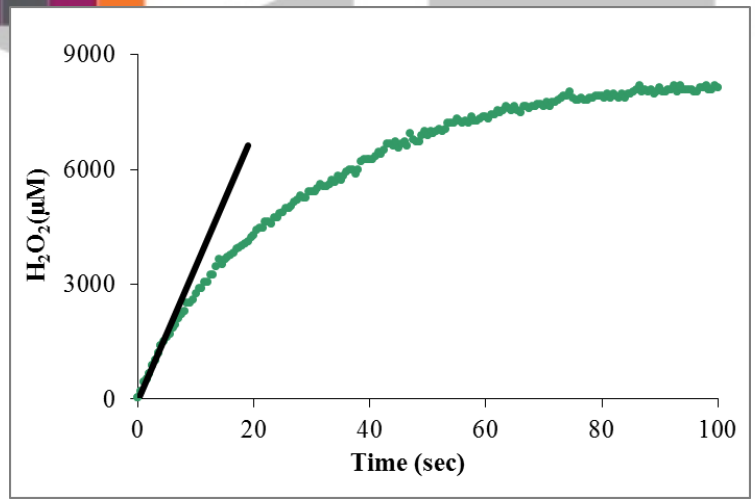
Viktor Gombos

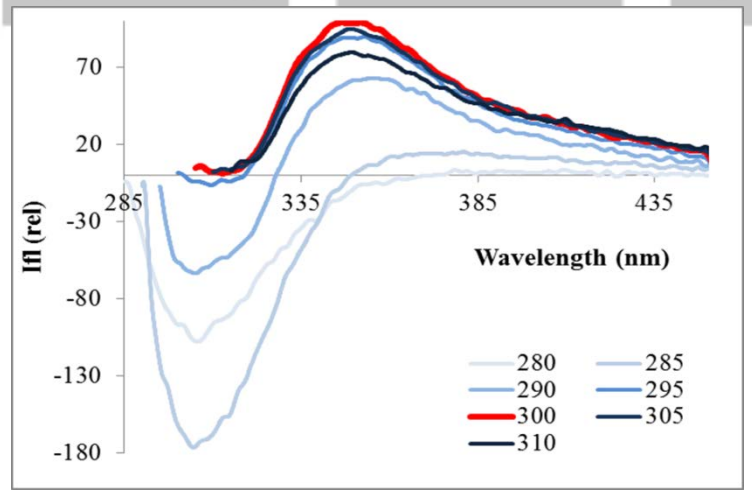
# Other redox proteins – peroxidase enzyme

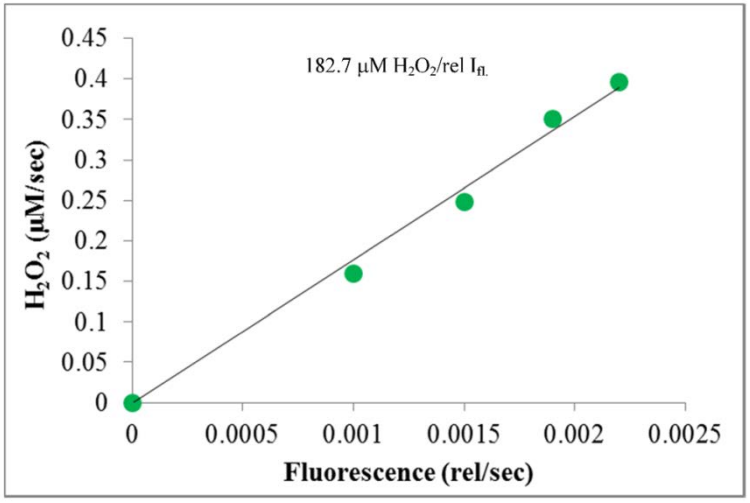


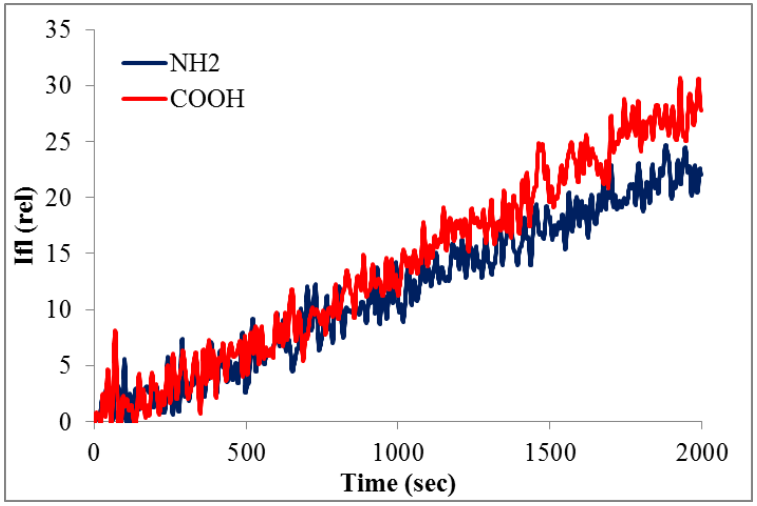
COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract




COST is supported
by the EU Framework Programme

ESF provides the COST Office
through a European Commission contract

# Conclusions:

- **We managed to bind RCs to different inorganic carriers in nano-systems** (CNTs, ITO, PSi, conductive polymers, liposomes**);**
- **Different binding methods can be used;**
- **The binding is proved by structural investigations** (SEM, TEM, AFM);
- **The RC remains active after the binding** (for couple of months)**;**
- **The whole nano-hybrid system shows functional activity** (light induced absorption change, conductivity change)
- **Specific orientation can be achieved** (CD, LD**);**
- **Auxiliary systems/processes**

COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

# Future challenges:

- Other matrices (graphene)
- Measuring processes connected to charge separation
- Oriented binding (creating and measuring)
- Stability
- Quantum efficiency
- Photocurrent
- RC-biosensors
- Auxiliary systems/processes

COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

# Collaborations:

## University of Szeged, Hungary

Department of Medical Physics and Informatics **(L. Nagy, K. Hajdu, M. Magyar, T. Szabo, G. Kozak, P. Boldog, A. Horvath)**

Department of Applied and Environmental Chemistry **(K. Hernadi, Z. Nemeth)**

Department of Physical Chemistry and Materials Science **(G. Bencsik, B. Endrődi, Cs. Visy)**

Institute of Material Sciences and Engineering **(A. Dombi)**

Department of Optics and Quantumelectronics **(K. Osvay, A. Börzsönyi)**

## Biological Research Center, Szeged, Hungary

Institute of Biophysics **(Gy. Varo, K. Nagy, Zs. Szegletes)**

Institute of Biophysics **(L. Zimanyi)**

Institute of Plant Biology **(Gy. Garab, M. Dorogi, P. Lambrev)**

## Semmelweis University, Budapest, Hungary

Department of Biophysics and Radiation Biology **(M. Kellermayer, R. Pires)**

C
b Programme

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

the COST Office
opean Commission contract

## Ecole Polytechnique Fédérale de Lausanne, Switzerland

Institute of Physics of Complex Matter **(L. Forro, A. Magrez, E. Horvath)**

## Université Montpellier

Département Semiconducteurs, Matériaux et Capteurs **(Cs. Gergely)**

## Universidad Autónoma de San Luis Potosí, Mexico

Centro de Investigación y estudios de Posgrado (CIEP) **(A.G.P. Escobeldo)**

## Universidad Autonoma del Estado de Morelos, Mexico

Centro de Investigacion en Ingenieria y Ciencias Aplicadas **(V. Agarwal)**

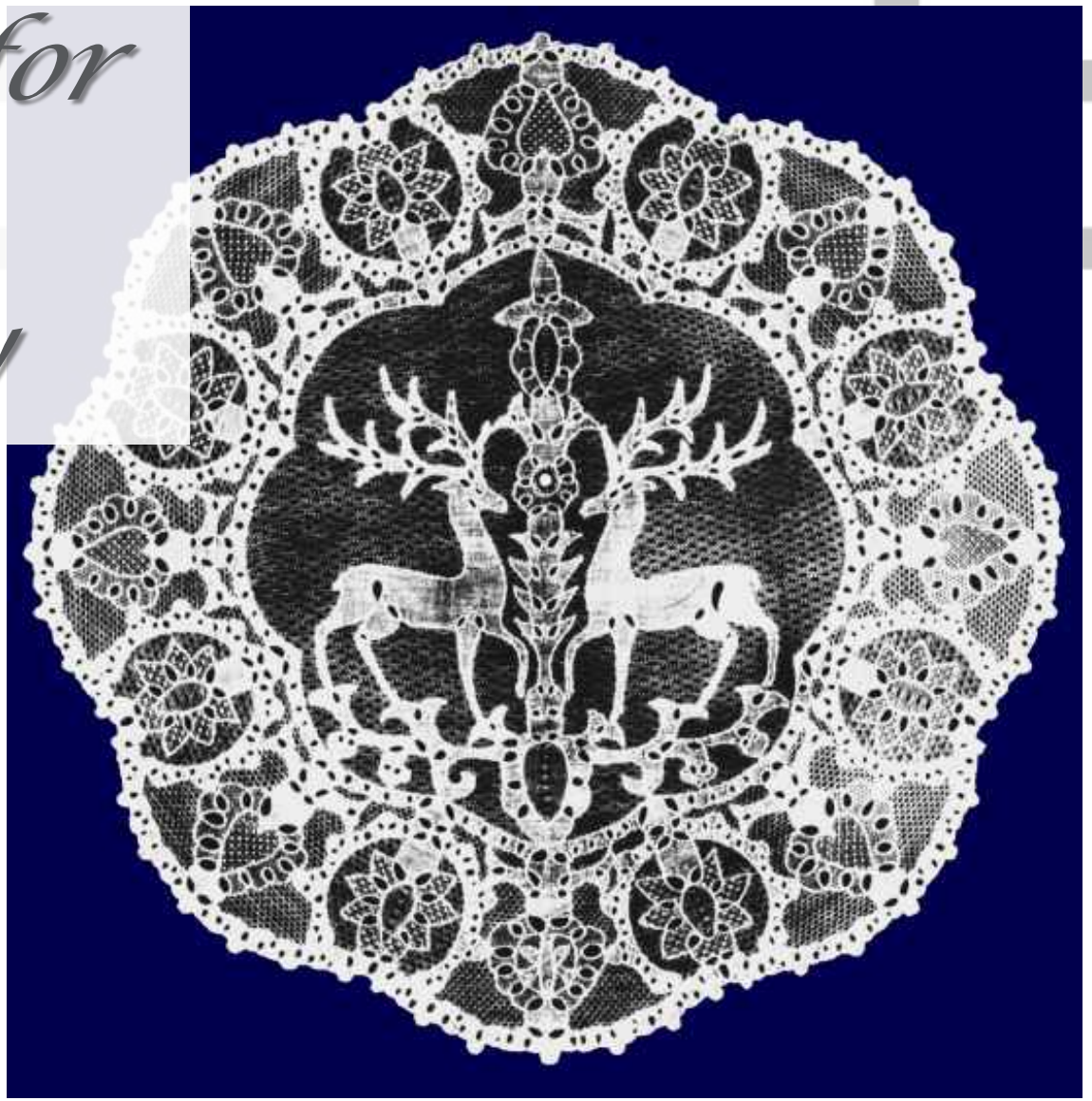
## IPCF CNR, Bari, Italy, (F. Milano)

## University of Salento, Lecce, Italy

Department of Material Sciences **(L. Giotta)**

rted
ework
he COST Office
pean Commission contract

# *Thank you for your attention!*



cost TD1102
PHOTOTECH: BIOSENSORS & BIOCHIPS

Nemzeti
Fejlesztési Ügynökség

FNSNF
SWISS NATIONAL SCIENCE FOUNDATION

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Contribution

**OTKA (Hungarian Science Foundation)**
**MTA (Hungarian Academy of Science)**
**CONACYT (Mexico)**

ESF provides the COST Office through a European Commission contract