Noi biosenzori pe baza unui design rational al interfetei biomolecula-suport

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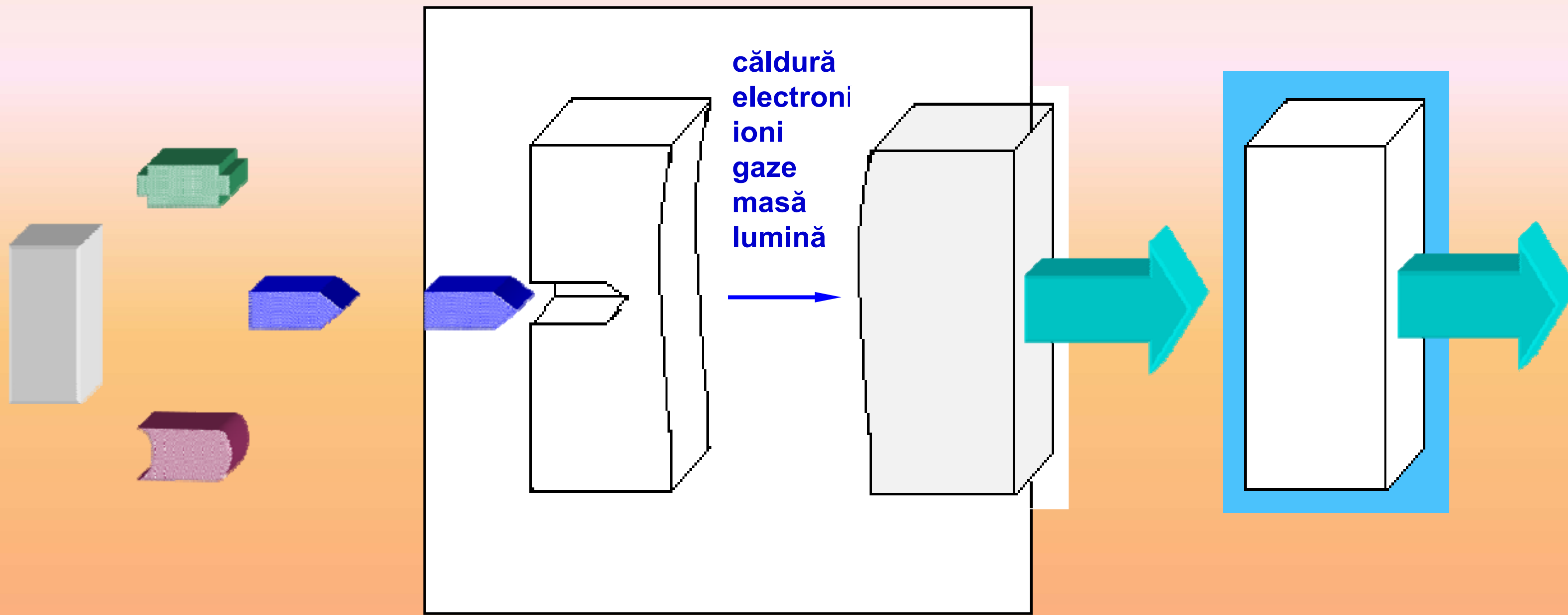
Outlines

- An introduction to biosensors
- CNT and CNF modified biosensors; food applications
- CNT-IL modified biosensors; environmental applications
- Conclusions

Biosensors



analit

situs de recunoaştere (BIOCOMPONENTA)

TRADUCTOR

parte electronică

semnal electric

• A **biosensor** is a **self-contained integrated device**, which is capable of providing specific quantitative or semi-quantitative analytical information using a **biological recognition element** (biochemical receptor) which is retained in **direct spatial contact with a physical transduction element**.

IUPAC-Technical Report ANALYTICAL CHEMISTRY DIVISION)

BIOSENSORS

BIOAFFINITY

- ANTIBODY
- BIOLOGICAL RECEPTORS
- DNA

BIOCATALYTIC

- ENZYMES
- CELLS
- TISSUES

Features and Characteristics of Biosensors

Targeted Specificity → Biosensors can be designed to detect either a single analyte with high specificity or a whole group of analytes

Electronic Processing → Data can be processed, stored, exported and displayed in many different ways

Integration into other devices allows actions to be taken automatically

Continuous Measurement

→ Immediate remedial actions are possible in fields such as medical diagnostic and industrial process control

Selected measurement in complex samples

→ Sample may not need preparation prior analysis

→ Direct measurements in blood, foods, waste water, etc. are possible

Fast measurement

Waiting times for test results acceptably short

High sample through-put can be achieved in automated analysers

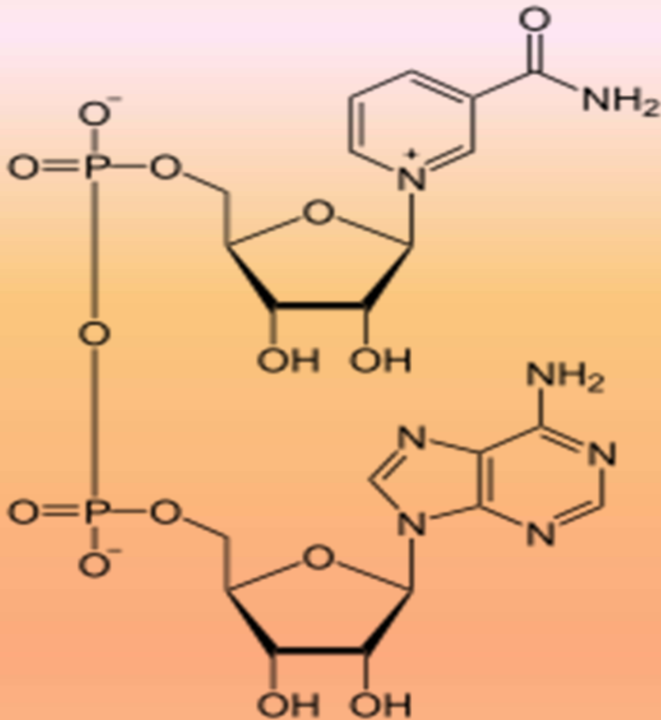
Small size

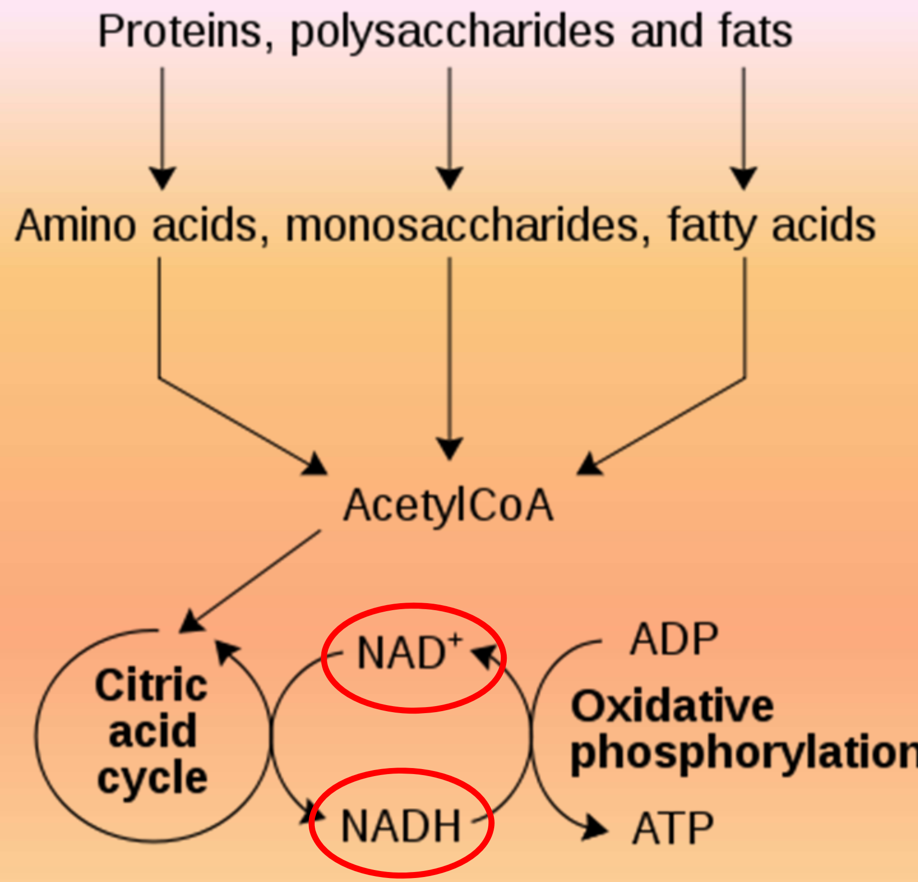
Compact designs for “field use” are possible

Use in confined places such as needlesand catheters *in vivo* is possible

Can measure mulitple analytes in a small sample

Nicotinamide Adenine Dinucleotide

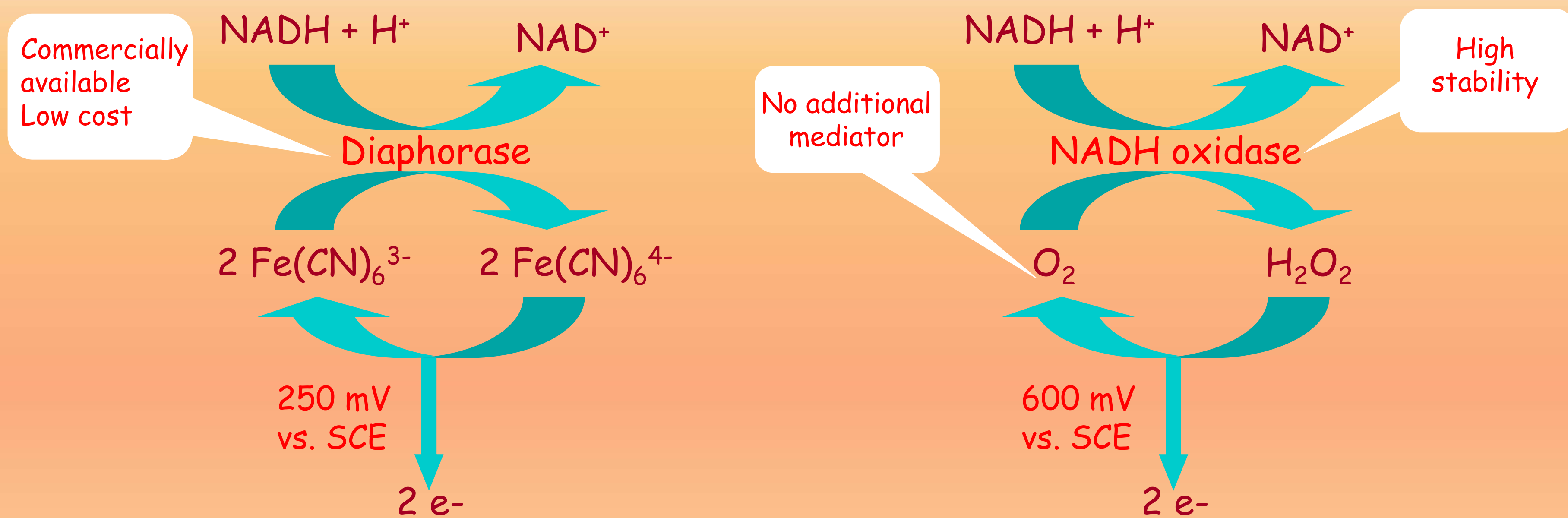




Redox metabolism

- **coenzyme found in all living cells.**
- **natural carriers of electrons;**
- **participate to redox processes in cells;**
- **act as coenzymes for ~500 oxidoreductases**

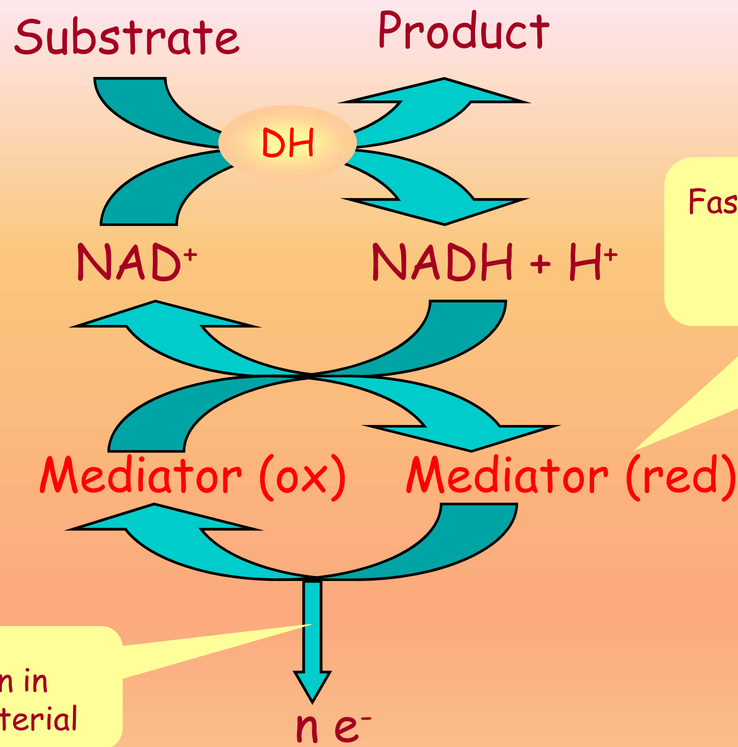
DH-BASED BIOSENSORS



Low stability of diaphorase
Necessary addition of ferricyanide in the medium

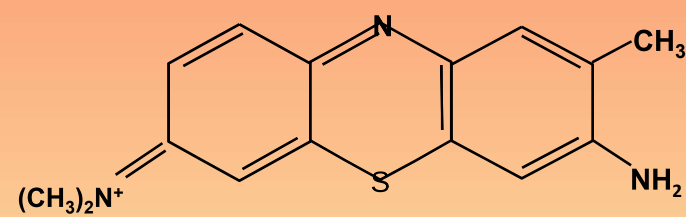
High overvoltage for H_2O_2 oxidation

DH-BASED BIOSENSORS

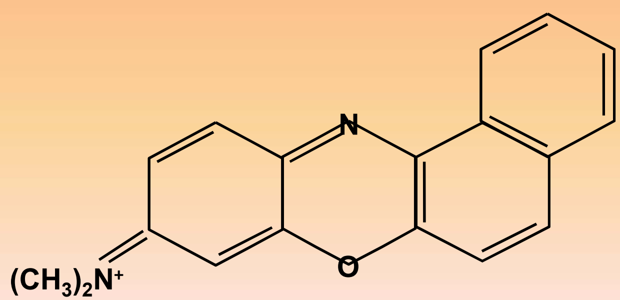


Fast electron transfer rate with NADH

lLow incorporation in the electrode material



Toluidine Blue

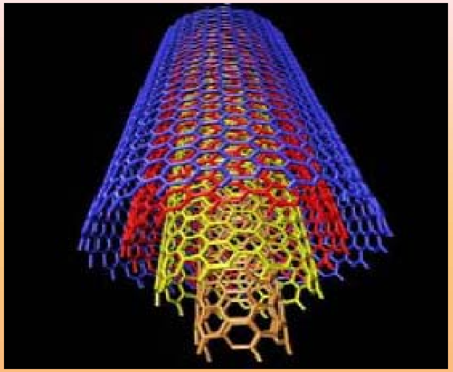


Meldola Blue

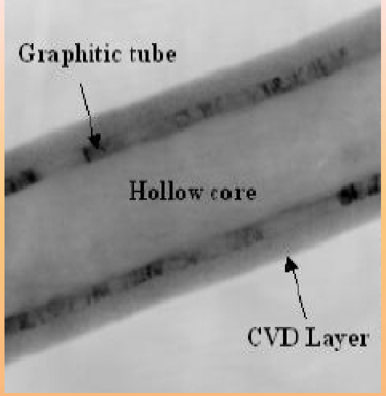
Carbon Nanotubes (CNT)

SWCNT

MWCNT



CNF

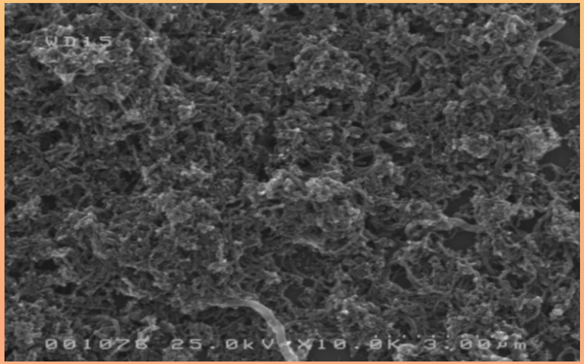


- High surface area
- High electrical conductivity (six orders of magnitude higher than copper)
- Good chemical stability
- Can be easily functionalized through the attachment of other chemical groups (the functionalization takes place at ends cap and defects existing on the wall)
- Can be easily assembled in different composite matrices or pastes

Science and Applications, M. Meyyappan, CRC Press, 2004

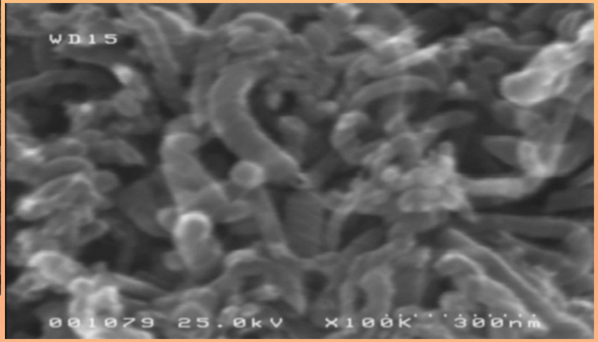
NADH oxidation using carbon nanofibers and nanotubes based sensors

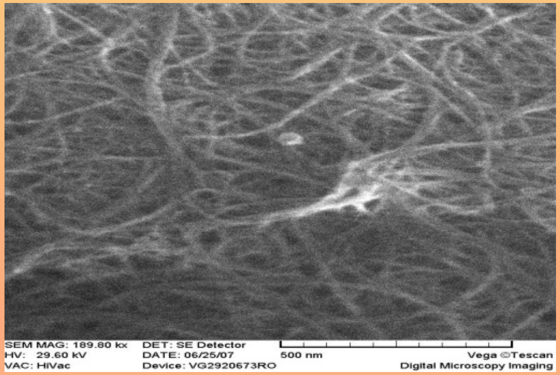
- **Morfologic characterization of carbon nanofibers/nanotubes layer**



(CNF)

(CNF)

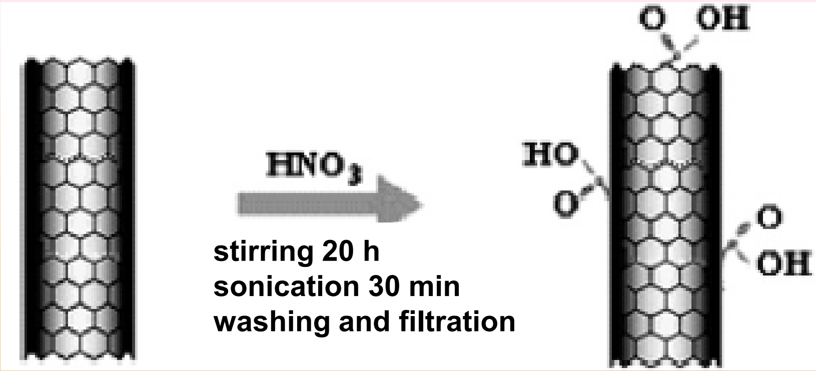




(SWNT)

Improving the sensitivity and selectivity

- **Modification of CNT by oxidation**



✓ **Oxidation peak of NADH shifts to lower value for oxidized SWNT (from 300 mV to 220 mV)**

✓ **Specific sensitivity: 67.46 mA/M×cm^2**

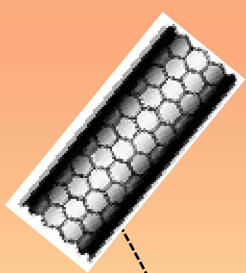
➢ **Linear range: 0.015 - 2.5 mM**

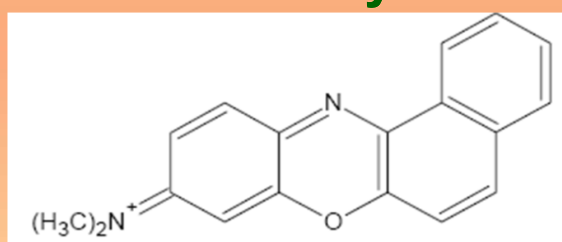
➢ **Limit of detection: 12 μM (S/N=3)**

inferior to those of GC electrode modified with untreated SWNT

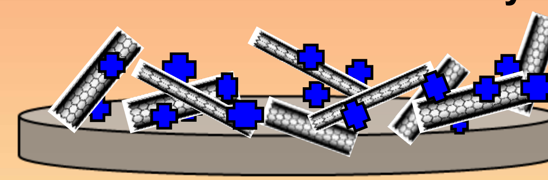
➡ **The decrease of oxidation potential by only 80 mV is not sufficient to eliminate the interference of easily oxidable compounds**

- **Modification of CNT by redox mediator**

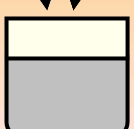




Electrode surface modified by SWNT-MB



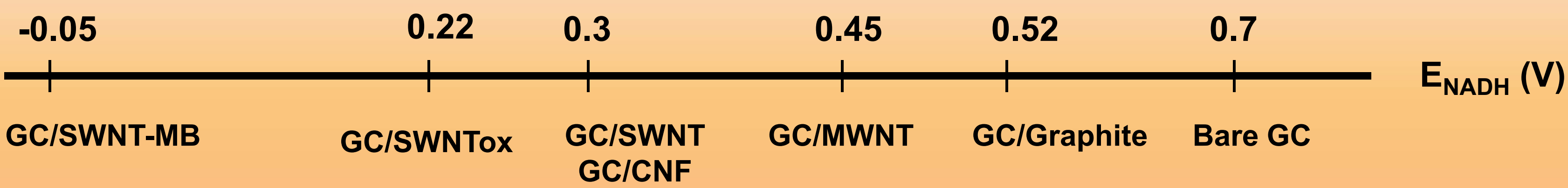
SWNT **Meldola blue**



H_2O → **Stirring 2 h, Sonication 5 min** → **Filtration, Washing, Drying** → **Suspension in DMF (2mg/mL)** → **2.5 μL** ↑

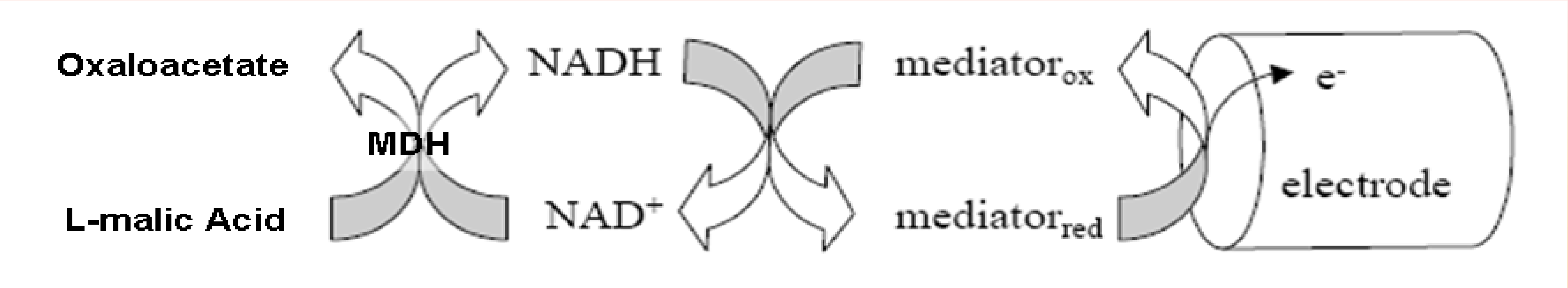
Benefits

- By modifying the glassy carbon electrode with CNF and CNT (treated or untreated) is possible to obtain a porous surface, able to oxidize the NADH cofactor at lower potential values

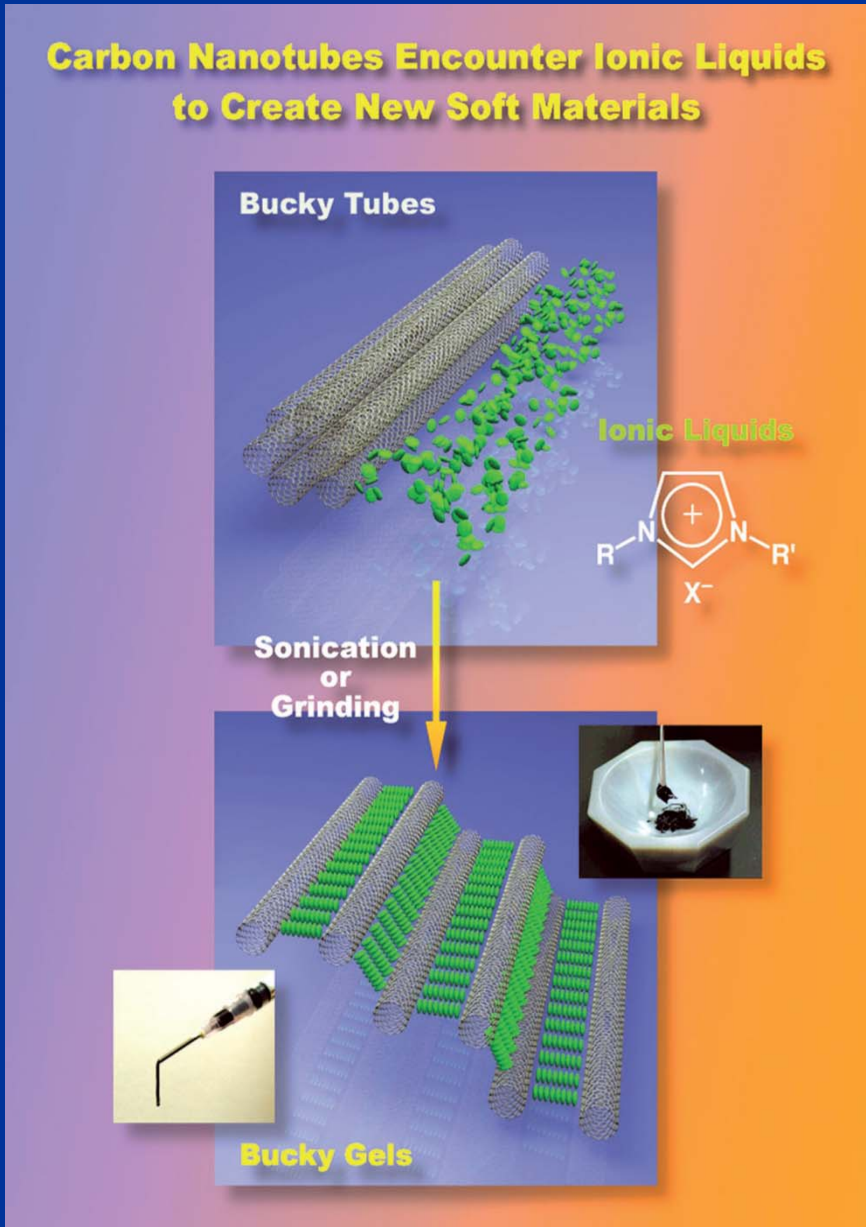


- Increased sensitivity
- Shorter response time
- Smaller limits of detection
- Good stability
- Functionalization of SWNT with redox mediator totally eliminates the interferences
- Improved detection of NADH could offer a great possibility to assemble low-potential biosensors based on dehydrogenases for important substrates detection.

Low-potential detection of malic acid with SWNT-MB

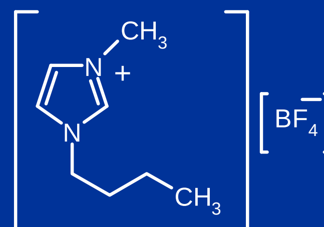


L-malic acid - predominant acid in many fruits
- serves as principal indicator of fruit maturity

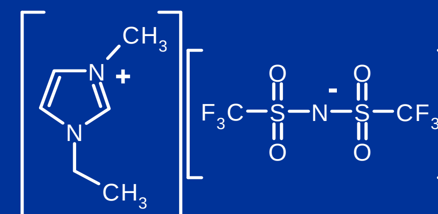


Imidazolium-ion-based Ionic Liquids

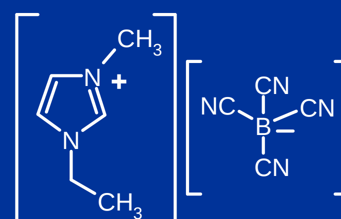
- **electrical conductivity**
- **electrochemical stability**
- **dispersants for CNTs**



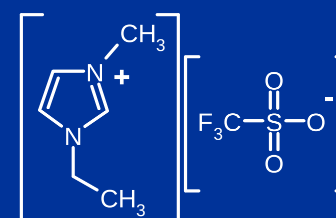
[BMIM][BF_4]



[EMIM][NTF_2]



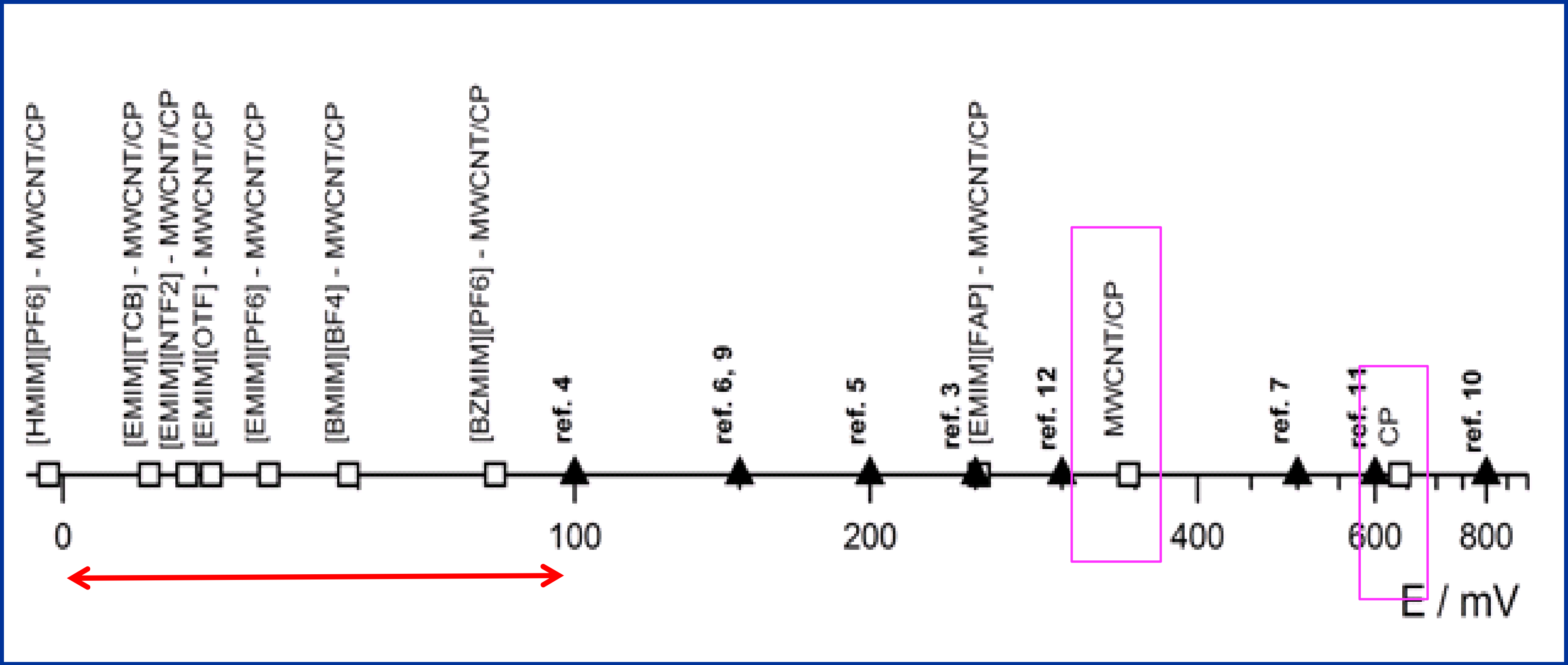
[EMIM][TCB]



[EMIM][OTF]

T. Fukushima, T. Aida, Chem. Eur. J. 2007, 13, 5048 – 5058

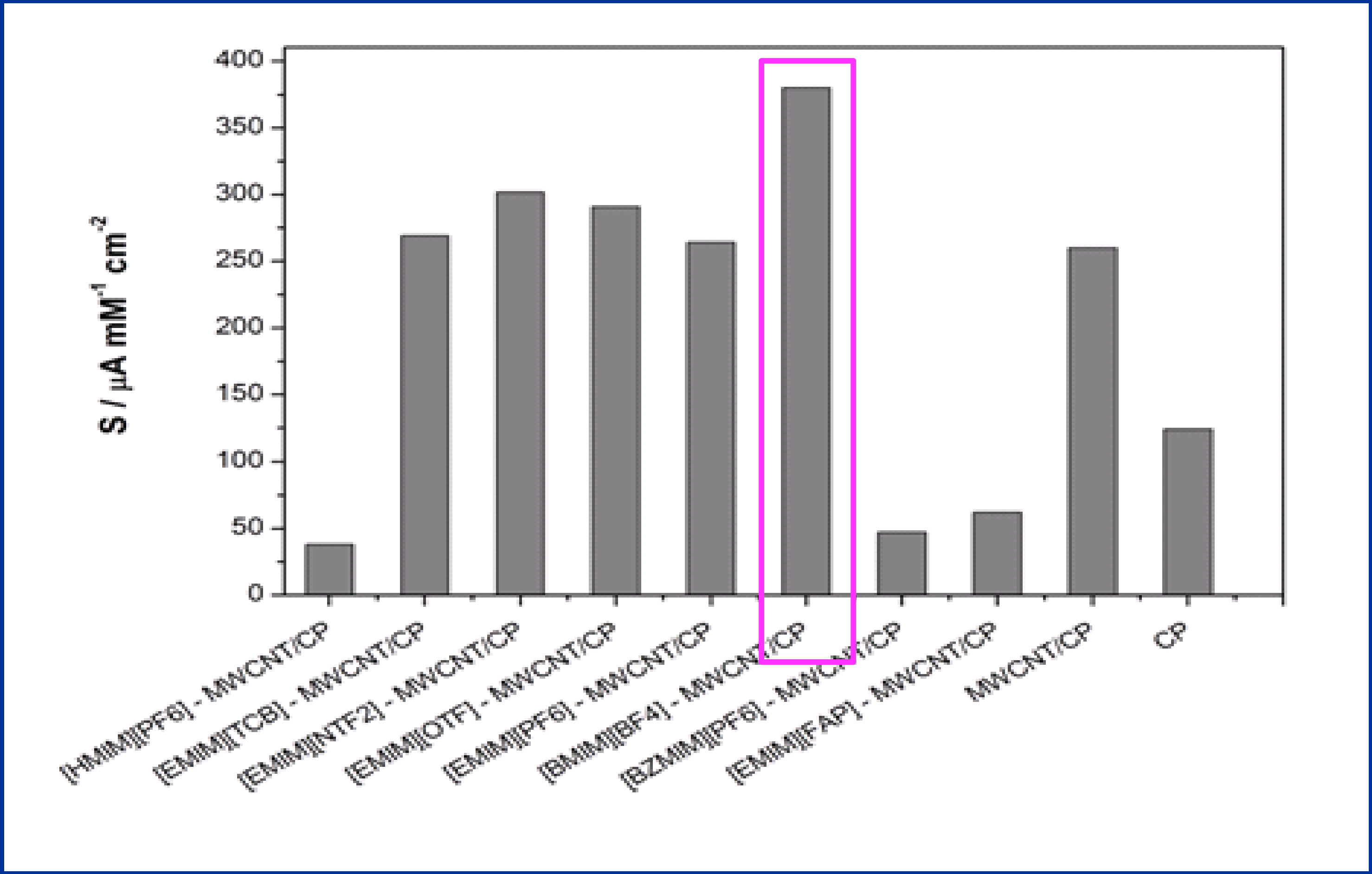
Main characteristics of thiocholine sensors



(A) Thiocholine oxidation potential for IL-MWCNT based sensors and other reported sensors;

Rotariu L., L.G. Zamfir, Bala C, Sensors and Actuators B, **2010**, 150, 73-80,

Main characteristics of thiocholine sensors



B) Sensitivity of the thiocholine sensors

Four gel modified electrodes present better sensitivity compared with MWCNT/CP electrode, the highest being obtained with [BMIM][BF_4]-MWCNT gel

Conclusions

- Analytical parameters of biosensors (limit of detection, linear range, stability) were improved through optimization of the immobilization matrix of enzyme.
- The functionalization of SWNT with redox mediator results in significant improvement for analytical characteristics of developed biosensor.
- Amperometric biosensors developed were used for simple and fast determination of some analyts.
- Sensitivity can increase due to better conduction properties, the limits of detection can be lower, very small quantities of samples can be analysed, direct detection is possible without using labels, and some reagents can be eliminated.