Laboratory of Bionanostructures

HEAD:

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RESEARCH PROFILE:

Bioelectrochemistry, Bioinorganic Chemistry, Supramolecular Chemistry, Nanoparticles, Langmuir-Blodgett and self-assembled molecular films at solid-liquid and air-water interfaces.

CURRENT RESEARCH ACTIVITIES:

Lipidic cubic phase nanoparticles, gold and carbonaceous nanoparticles and macrocyclic compounds (e.g. cyclodextrins) as drug delivery systems, Interactions of drugs and drug carriers with model biomimetic membranes and cell membranes. Electron transfer mechanisms of redox enzymes and ion transport through integral proteins – ion pumps and channels immobilized in biomimetic molecular films.
We are searching for new drug carriers decreasing the toxic side effects of drugs by eliminating formation of reactive oxygen species responsible for cardiotoxicity of anthracycline drugs and by providing selective release of the drug in the pathological cells. We found that appropriately designed drug delivery systems e.g. modified lipid cubic mesophase nanoparticles and β-cyclodextrins (see figure above) containing an addressing unit and a pH-sensitive moiety allow to address the carrier to the cancer cell and release the drug through receptor endocytosis. We use liquid crystalline lipid cubic mesophase films also as the biomimetic matrices for the reconstitution of membrane proteins e.g. Na-K-ATPase or chloride channels and studies of their functions.

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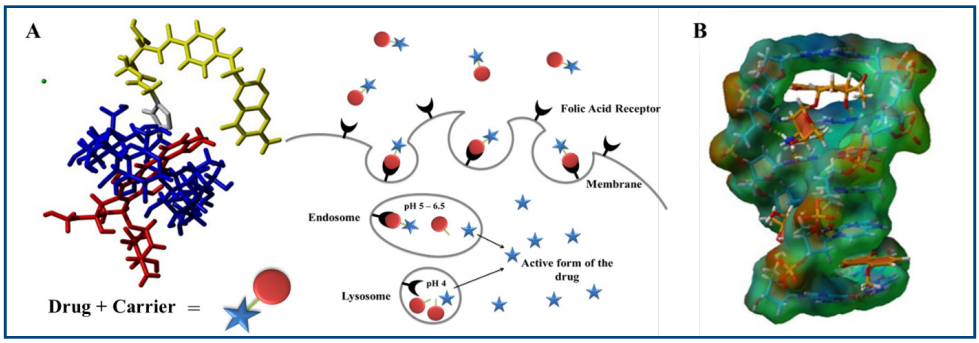

Fig. 1. Scheme showing the function of drug carrier.

We develop new methods of synthesis of metal nanoparticles, especially gold nanoparticles with sizes ranging from one to several hundred nanometers, stabilized physically or chemically by adsorbed compounds. These surface groups determine the properties of the nanoparticles leading to their various applications: in catalysis, sensors, electrode materials, and carriers.

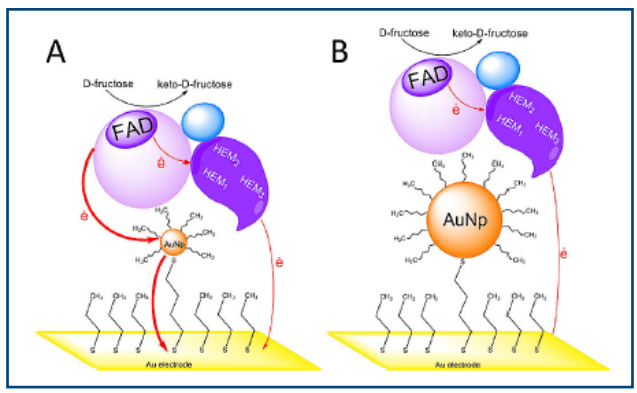

Fig.2. Scheme showing different electron transfer pathways between the electrode and the enzyme active sites in the presence of gold clusters (A) and gold nanoparticles (B).

Enzymes immobilized on the surface of metallic clusters retain their catalytic bioactivity in contrast to similar systems prepared on the metallic electrodes. In these systems, gold nanoparticles act not only as a matrix for immobilization of enzymes, but also provide electron transfer between the enzyme and the electrode, which means, that they may function as mediators, and the systems often do not require any external mediator.

Another topic explored in our group is supramolecular electrochemistry – e.g. electrochemical behaviour of intertwined structures as rotaxanes (see Figure 3) or catenanes. Electrochemical methods allow to trigger movement of one part of molecule versus the second one.

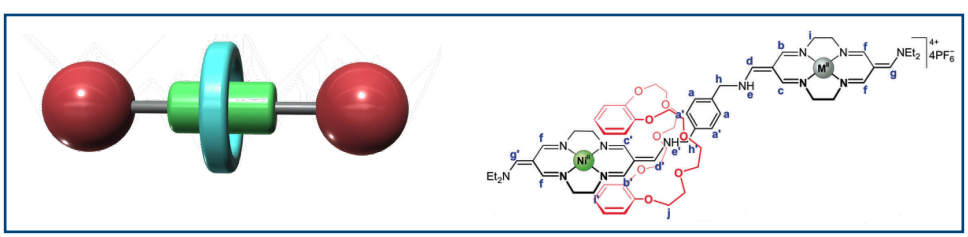

Fig.3. Scheme of rotaxane and chemical structure of exemplary rotaxane

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9. K. Stolarczyk, D. Lyp, K. Żelechowska, J.F. Biernat, J. Rogalski, R. Bilewicz, Arylated Carbon Nanotubes for Biobatteries and Biofuel Cells, Electrochim Acta. 79 (2012) 74-81.
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