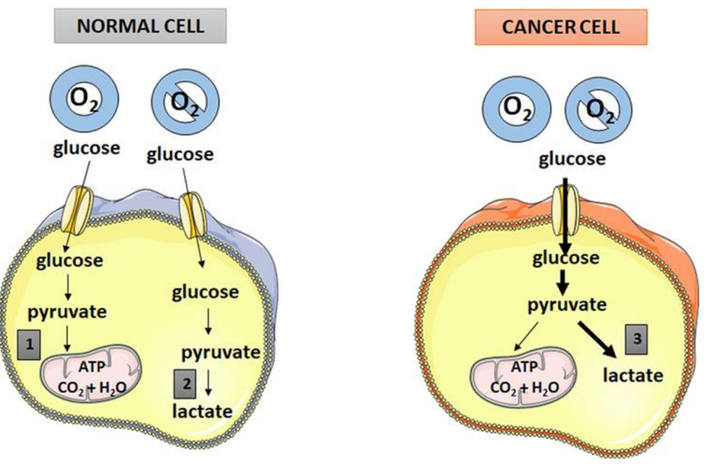
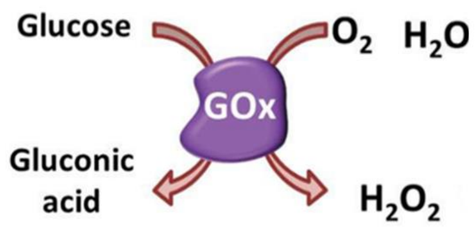
Development of nanocapillary electrochemical biosensors for glucose detection

Ekaterina Verkhovnikova, Roman Timoshenko, Aleksander Erofeev
National University of Science and Technology MISIS
maus-82@mail.ru

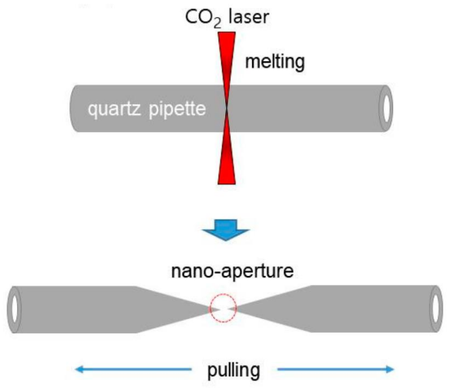
INTRODUCTION & AIM

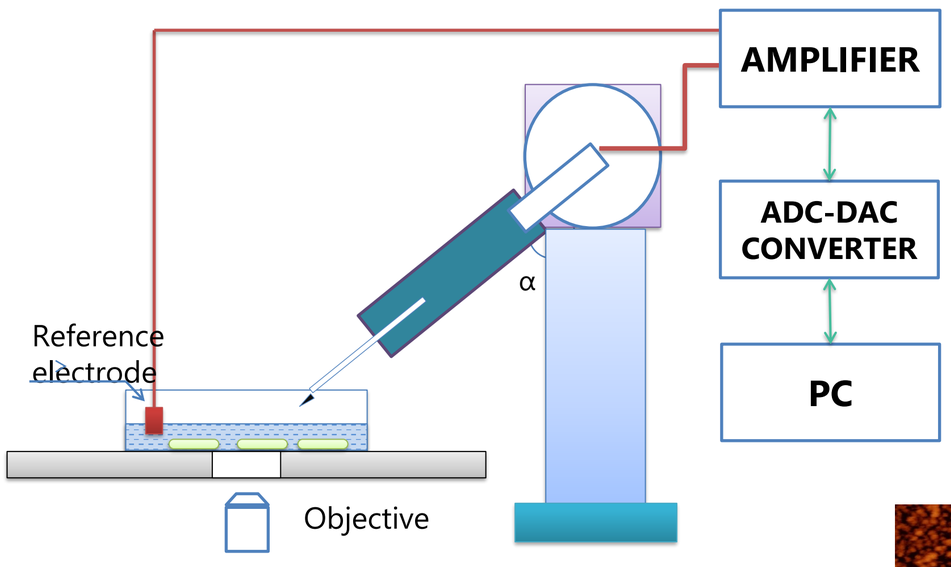




Glucose plays a key role in providing energy to cells. It is an important source of energy for cellular metabolism and is required for various vital processes such as ATP synthesis. Cancer cells have an abnormal metabolism that involves the utilization of glucose for aerobic glycolysis. In this process, glucose is broken down to pyruvate even in the presence of sufficient oxygen to carry out a more efficient process, oxidative phosphorylation. This metabolic pathway provides protection against apoptosis, prolongs survival, increases proliferation, and enhances resistance to chemotherapeutic drugs. Because the transition from oxidative phosphorylation to anaerobic glycolytic metabolism occurs at the single cell level and is a hallmark of cancer progression, it is important for diagnosis to identify individual living cancer cells by their unique metabolic signatures. Research into glucose metabolism in cancer cells and the development of methods to accurately detect glucose levels in them may lead to the development of new approaches to cancer diagnosis and treatment. This may include the use of biosensors and other technologies to monitor metabolic processes in cancer cells and individualize treatment based on their metabolic profile.
Glass nanocapillaries represent a unique and promising platform for the development of biosensors capable of detecting various analytes, and they are easy to fabricate, highly sensitive, selective and small in size.

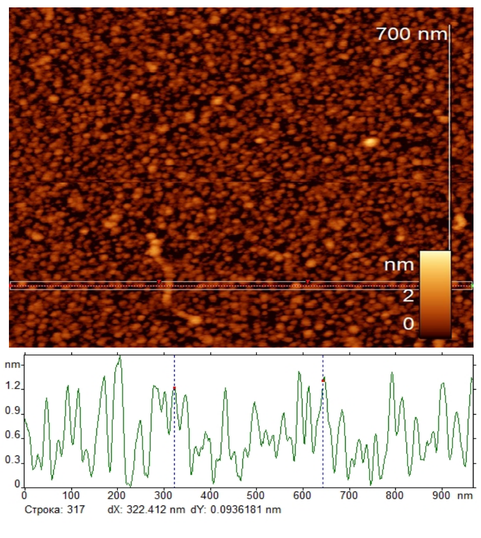
METHOD





Before the fabrication of the nanocapillary sensor, the technique of enzyme immobilization on the mica surface was reproduced. Freshly pierced mica sheets were silanized with 0.33% APS diluted in water and ethanol. The silanized mica was washed in distilled water and immersed for 12 h in 2.5% GA solution in PBS, then washed with distilled water and dried under an Ar atmosphere. The mica samples were then immersed in GOx in PBS solution (2 mg/mL) overnight at room temperature. At each modification step, the surface topography was examined via AFM. Evaluation of the surface topography showed that irregularities in the topography appear during the enzyme immobilization process, which change as the mica surface is modified. This technique was reproduced to functionalize the inner surface of the nanopipette.

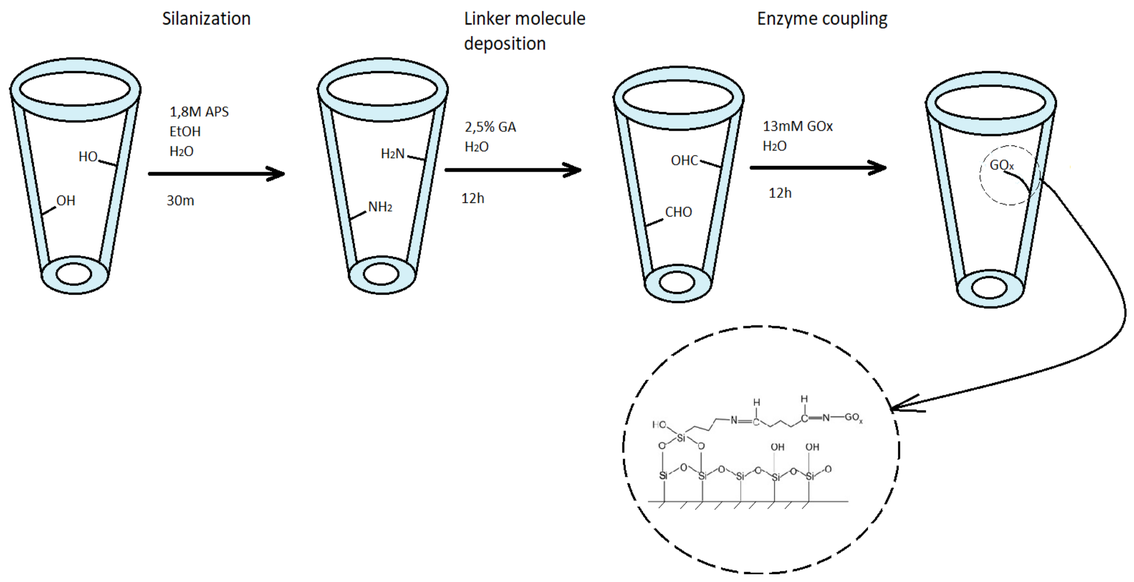
A model experiment on mica



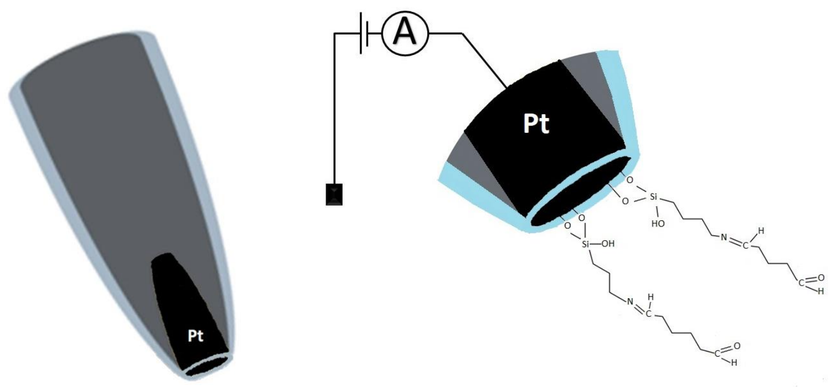
Assessment of the surface topography by the AFM method

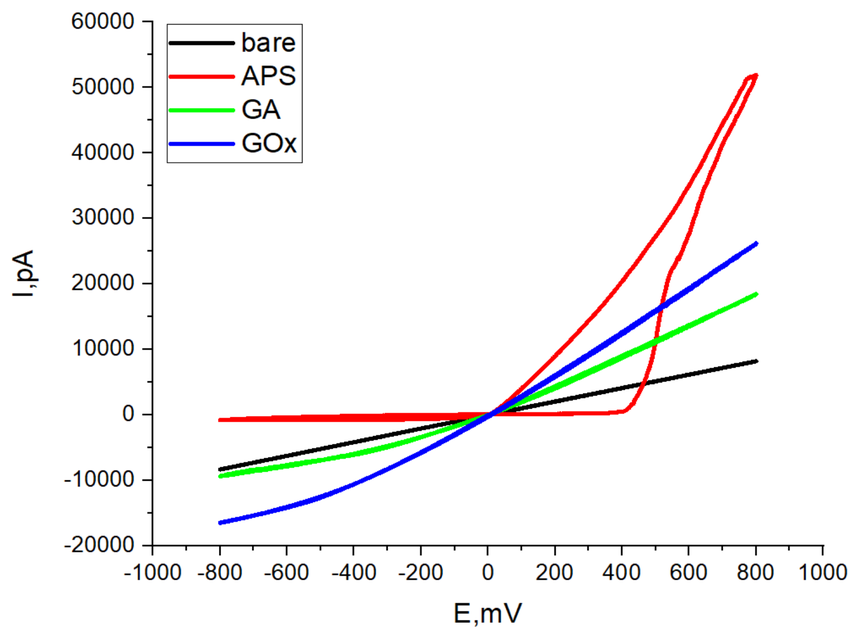
RESULTS & DISCUSSION

1. Immobilization of glucose oxidase on the inner surface of the nanocapillary



2. Immobilization of glucose oxidase on a platinum nanocapillary





CV of the modified nanocapillary (in HBSS from -800 to 800 mV, 400 mV/s relative to Ag/AgCl)

CONCLUSION

The possibility of immobilization of glucose oxidase on the inner surface of the nanocapillary was shown. This technique was replicated on an H2O2 sensitive electrode for the subsequent quantitative determination of glucose.

REFERENCES

1. Luda S. Shlyakhtenko, Alexander A. Gall, Alexander Filonov, Zoran Cerovac, Alexander Lushnikov, Yuri L. Lyubchenko Silatrane-based surface chemistry for immobilization of DNA, protein-DNA complexes and other biological materials // Ultramicroscopy. - 2003. - С. 279-287.

2. Sebania Libertino, Filippo Giannazzo, Venera Aiello, Antonino Scandurra, Fulvia Sinatra, Marcella Renis and Manuela Fichera XPS and AFM Characterization of the Enzyme Glucose Oxidase Immobilized on SiO2 Surfaces // Langmuir. - 2008. - №24. - С. 1965-1972.