Summary for the general public

The phenomenon of drug addiction is one of the most serious social problems and the cause of many diseases of the 21st century. Moreover, the outbreak of the COVID-19 pandemic in 2020 and the war on Ukraine in 2022, apart from causing economic stress and the financial crisis, significantly aggravated the psychological problems of humanity, including loneliness, anxiety, and depression, which are one of the key factors in reaching for various stimulants. The number of drug addicts continues to grow, and they are mostly young people. Drugs are becoming more and more ubiquitous, and the pandemic lockdown has flourished in the darknet, making it possible to buy these chemical species without leaving home. It should be also pointed out that a large group of narcotic compounds represents active substances in various types of painkillers, if taken without medical supervision, which can also lead to addiction. Moreover, we are more often informed about drivers who drive a car after taking drugs and cause serious accidents. That is the reason why, apart from sobriety control, drug tests are increasingly carried out. Currently, there are mainly two main trends in the detection of narcotic substances: colorimetric sensing and analysis conducted in dedicated forensic and analytical laboratories with the use of specialized measurement techniques. There is a significant gap between primitive colorimetric tests, which suffer from a lack of selectivity, and advanced techniques such as mass spectrometry or chromatography implemented in specialized laboratory centers, which may be filled with the solution proposed in this project.

The 3D-Dual-Sens project involves the development of a designed and 3D printed analytical device the use of which will allow generate a double analytical response - colorimetric and electrochemical, for the detection and/or determination of narcotic substances such as fentanyl, codeine, amphetamine or methamphetamine. Functional filaments, which are the building material of the device, will be developed during the project implementation. It is expected that the created material will change color upon contact with the analyte, and hence, will provide immediate information about the presence or absence of the selected chemical species. On the other hand, electrochemical techniques will enable both, the confirmation of the results of the colorimetric analysis, and also open the door to the quantitative determination of the analyte concentration in the tested sample. The small size of the device combined with the advantages of electrochemical techniques, such as portability and compatibility with a smartphone, make it possible to conduct tests on-site.

To achieve the assumed goal, it is necessary to develop the following aspects:

1. The production of innovative filaments that will change their color in contact with the selected analyte and insightful characterization of the developed thermoplastic material.

2. Design and printing of a device that will be able to generate an electrochemical response. Both the device case and the electrode system used in the electrochemical analysis will be 3D printed.

3. Fabrication device that will combine the above aspects and generate a dual analytical response - colorimetric and electrochemical.

4. Testing the usefulness of the developed device in the analysis of narcotic substances and optimization of measurement conditions.

5. Modification of the active surface of the working electrode based on thin films of mesoporous silica and its subsequent functionalization towards molecular sieving depending on the size and charge of the analyte and selective recognition using aptamers.

6. Optimizing the developed analytical platform for the detection of narcotics from real samples. Testing the efficiency of the proposed solution and assessing its usefulness.

We hope that the research described in this project in conjunction with the growing problem of drug addiction will find applications in forensic analysis and will contribute to the development of this field of science.