Advanced oxidation processes (AOP) are of increasing interest to researchers focused on environmental and natural resource conservation issues. In particular, this is due to the growing need for **effective (photo)catalysts** that allow the chemical degradation of harmful pollutants found in the aquatic environment. In these processes, the role of oxidants is played by **reactive oxygen species** (ROS) such as hydroxyl **radicals** ($^{\bullet}OH$), superoxide **anion radicals** ($O_2^{-\bullet}$), or singlet oxygen ($^1O_2$). These are extremely important from the point of view of catalytic chemistry, environmental chemistry, and biochemistry entities containing oxygen atoms at atypical oxidation states or dioxygen in the excited state. ROS are formed by the **famous Fenton reaction** using **hydrogen peroxide** (H_2O_2), another reactive form of oxygen, and photocatalytic processes. Yet, another reactive form is **ozone**, O_3, an allotrope of oxygen. Using such **green oxidants** and considering their high activity in oxidizing organic pollutants make advanced oxidation processes an alternative to the commonly used, chemically assisted, biological-mechanical treatment methods. AOP can be used as the last stage of the **water purification (treatment) process** when contaminant concentrations are at a shallow level. This aspect is advantageous because the efficiency of AOP processes can be controlled by selecting a suitable **catalyst** that allows the formation of significant amounts of highly oxidizing radicals.

The proposed research project is concerned with **determining the factors affecting the ability of the obtained catalysts based on transition-metal compounds to form reactive oxygen species through H_2O_2 decomposition, photocatalytic processes, interaction with ozone, or hybrid reactions that combine the mentioned processes**. The project's key goal is to determine the factors controlling the formation of ROS and their selective launching. The selection of the studied systems will provide insight into processes analogous to the Fenton mechanism, electroprotic processes, electron transfer, and interfacial radical processes. During the realization of the project, the following materials will be obtained: **composite catalysts** made of metallic nanoparticles or metal oxides with redox properties deposited on non-redox amorphous oxides, oxide **heterojunctions** made of two semiconductors, and Schottky-type systems. The first group of materials will exhibit a combination of two types of H_2O_2 decomposition mechanisms: nanoparticles and metal oxides will play the role of Fenton's reagent, while the amorphous reactive support will enable ROS formation according to the electroprotic mechanism (coupled electron-proton transfer reactions). The second group will allow the generation of photoactivity in the desired ranges of the electromagnetic radiation spectrum and pH of solutions. The objectives will be achieved through (1) characterization of the materials obtained, (2) spectroscopic identification of the ROS formed and determination of the effect of catalyst type on the speciation of reactive oxygen species, (3) determination of the effect of catalyst composition and structure on its activity in degradation reactions of model organic pollutants such as dyes, herbicides, and pharmaceuticals (model water detoxication processes). To this end, measurements will be carried out using several complementary research methods. These will include structural and textural characterization of the resulting oxides, surface charge measurements in the presence of reactants, redox properties, and spectroscopic identification of ROS. Catalyst activity will be studied in selected oxidation reactions using ROS as oxidants. The progress of the reaction will be traced using colorimetric measurements and analyzing the composition of the reaction mixture. Combined use of photocatalytic and hybrid processes will make it possible to increase the catalytic activity of designed materials and thus increase the efficiency of water purification processes.