We live in a world with continuously increasing the electrical, chemical and thermal energy demand. There are still more and more drawbacks regarding the use of conventional-fossil fuels-based sources of energy. Their resources are limited, and their use, despite the latest technologies of the purification of combustion products, produces substances toxic for the environment. In turn, alternative energy sources do not meet as yet the growing demand. These are the reasons why technologies that use solar energy and converting it into forms in which it can be easily stored - the energy of chemical bonds are currently thriving. One of the promising branches of solar energy conversion is the photo-electrochemistry of semiconductor oxide electrodes. Properly applied oxides of: titanium, tungsten(VI) or iron (III) work well as photo-anode materials. These materials have adequate gaps between the conduction band and the valence band, which makes them capable of absorbing light from the solar spectrum (visible and ultraviolet light). Following illumination of such metal oxide electrodes in the solution, the absorbed light induces the formation of holes and free electrons, which can then react with the components of the solution, allowing the storage of energy in the form of chemical bonds. During photo-electrolysis of aqueous electrolytes s hydrogen is formed on the cathode. The hydrogen can then be used as fuel - in fuel cells or even in combustion engines-with water being the only product. To ensure a sufficiently high process efficiency, the materials must have appropriate nanostructure, obtained in sophisticated synthesis and thermal processing of the tested oxides. Traceability is possible thanks to sensitive techniques such as X-ray photoelectron spectrometry (XPS), X-ray diffraction (XRD), and scanning electron microscopy (SEM). The properties of semiconductors can be additionally tested by special spectroscopic techniques, such as transient absorption spectroscopy (TAS) or intensity modulated photocurrent spectroscopy (IMPS). In addition to the design of new photoactive nanomaterials, the second part of the project is an attempt to study the pathways and kinetics of the decomposition reactions of large organic molecules, e.g. antibiotics. The radicals formed on the surface of the electrodes are very reactive, as previously demonstrated, by breaking down phenol molecules and dyes into simple inorganic compounds. Nevertheless, it is a relatively superficially known field and a promising research object, in the context of the growing use of synthetic chemical compounds and water contamination with them. The influence of electrode structure, doping, or even pH (various oxides have different isoelectric points, thus different surface charges depending on the reaction of the environment) are very important and will be carefully tested. We will investigate decomposition of a few model organic compounds containing aromatic rings, aliphatic fragments and heteroatoms (fluorine, nitrogen, oxygen, chlorine, sulfur). By combining the two main goals of the project, we hope to obtain materials that allow for the most effective solar energy capture and that will be able, at the same time, to convert efficiently the pollutants in innocuous compounds.