Summary of the Doctoral Dissertation by MSc Eng. Magda Kozak titled: "Bactericidal and Photocatalytic Properties of Copper and Silver Modified Nanotubes"

ABSTRACT

The biocidal properties of copper and silver provide the potential to develop nanomaterials with dual capabilities: exhibiting photocatalytic properties and maintaining bioactivity even in the absence of light. One of the nanomaterials demonstrating high photocatalytic activity is TiO_2 nanotubes. Additionally, copper and silver-modified nanotubes can be synthesized through a one-step anodic oxidation process of titanium alloys containing copper and/or silver. This approach could enable the future industrial production of such materials. The bactericidal properties of copper and silver-modified nanotubes make them suitable for medical applications, such as producing antibacterial and biocidal coatings on medical device surfaces. Meanwhile, the photocatalytic properties of these nanotubes open possibilities for their use in environmental remediation processes, such as removing contaminants from aqueous phases.

This doctoral dissertation aimed to develop a method for obtaining photocatalytically active nanotubes using thin foils composed of Ti, Cu, Ag, Pt, and Au metals as substrates in the anodic oxidation reaction and to investigate the photoactivity of the obtained nanostructures in a model reaction of phenol degradation and the removal of microorganisms from the aqueous phase. The dissertation consists of two main parts. The first part contains a theoretical introduction concerning the basic principles of heterogeneous photocatalysis, limitations in using wide-bandgap semiconductors, techniques for modifying these semiconductors, and certain materials' antibacterial and biocidal properties. The second part comprises three original articles, preceded by a description of the methods for producing photocatalysts and the techniques used to evaluate their physicochemical properties, a description of the methodology of the conducted photocatalytic experiments, and a brief discussion of the studies contained in each article.

The research yielded two series of photocatalytic systems: (i) active TiO_2/Cu_xO_y nanostructures obtained electrochemically from binary alloys, and (ii) active $TiO_2/Ag_2O/Cu_2O$, $TiO_2/Ag_2O/Au^0$, $TiO_2/Ag_2O/PtO_x$, $TiO_2/Cu_2O/Au^0$, and $TiO_2/Cu_2O/PtO_x$ nanostructures in the form of nanotubes, which were formed in the anodic oxidation process using ternary titanium alloys. The photocatalytic activity of the obtained materials was studied under UV-Vis and visible radiation in the process of phenol degradation in the aqueous phase for the first series of

photocatalysts and in the reaction of microorganism removal from the aqueous phase in the presence of visible light for both series. The conducted photocatalytic experiments and comprehensive characterization of the properties of the new photocatalytic systems allowed for a detailed understanding of the mechanisms involved and the assessment of the stability of the photoactive materials.

The results of the first series of photocatalysts (described in publication A1) formed the basis for designing and constructing a prototype thin-film photoreactor equipped with a photocatalytic layer in the form of oriented nanotubes made from a mixture of oxides. The results concerning the efficiency of the thin-film photoreactor in the process of phenol degradation and microorganism inactivation using radiation of different wavelengths are briefly presented in this paper. The proposed solution has been protected under patent numbers P.439488, P.439489, and P.439490.