Project 2.4 Photoelectrochemical conversion of biomass – development of transformations based on oxidation

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Background:

In the face of the climate crisis, it is crucial to develop new methods of producing valuable chemical compounds that maximize energy efficiency, atom economy, eliminate toxic waste and reduce the carbon footprint (through the use of renewable sources). Biomass is a renewable resource that can be converted into high-value-added products, including pharmaceutical or cosmetic compounds. Unfortunately, many biomass conversion technologies are not economical in terms of atom economy or energy. The use of photoelectrochemistry is a solution to these problems, as this approach can achieve mild conditions while dramatically reducing the applied current. In interfacial heterogeneous photoelectrochemistry (iPEC), the reaction occurs on the surface of a semiconductor photoelectrode, which, upon activation with visible light, generates an electron-hole pair that is used to drive the redox reaction. While the utility of this approach for solar energy conversion is well known (e.g. for hydrogen production), its benefits for biomass conversion are poorly or unexplored. Therefore, the main goal of this project is to design and apply interfacial, heterogeneous photoelectrochemistry systems for biomass conversion. During our research, we will first examine the possibilities of photoelectrochemical conversion of model compounds (derived from biomass), then we will apply the developed approach to the conversion of plant biomass (lignin and cellulose). The finally developed methodology will be used directly to create more economical syntheses (from the atomic and energetic points of view) syntheses of compounds for industrial use. This will allow obtaining valuable semifinished products for the chemical, pharmaceutical, and cosmetics industries from sources independent of crude oil, while minimising electricity consumption.

Aim:

In particular, the main tasks will involve:

- development of transformations based on the use of photocathodes and photoanodes – model oxidation and reduction reactions;
- testing the compatibility between the activity of photoelectrodes and the conditions of organic reactions;
- development of photoelectrochemical systems for biomass conversion;
- examination of the scope and limitations of the developed methods.

Requirements:

- a Master's degree in chemistry;
- experience in organic or related;
- other skills include analysis and interpretation of experimental data (NMR, MS, UV/Vis);
- demonstrated experience in research work will be an asset;
- effective written and oral communication in English.