

Abstract (English)

The growing demand for solutions in the economy that align with the principles of sustainable development is an important driver for the advancement of biotechnology, both in the field of chemical synthesis using biological tools and in environmental bioremediation. Cyanobacteria are useful organisms in this regard, as they can be employed both as photobiocatalysts and as tools for improving environmental quality. This dissertation addresses the potential of selected cyanobacterial strains, *Synechococcus bigranulatus* CCALA 187, *Nostoc cf-muscorum* CCALA 129, *Limnospira indica* PCC 8005, *Limnospira maxima* CCALA 27, *Leptolyngbya foveolarum* CCALA 76, *Kamptonema animale* CCALA 138, and *Nodularia moravica* CCALA 114 as whole-cell biocatalysts and bioaccumulators that could serve as elements in bioremediation and resource recovery strategies.

A series of photobiocatalytic tests were conducted under controlled conditions to assess the efficiency of transforming unsaturated fatty acids, acetic acid esters, and organophosphonates such as epoxymethyl dimethylphosphonate (EMDPP). Analytical techniques including GC, HPLC, NMR, IR and ICP-MS were used for quantitative analysis of biotransformation, evaluation of stereoselectivity, and determination of rare earth element (REE) accumulation, particularly gadolinium (Gd) and europium (Eu).

The study demonstrated significant catalytic activity of the cyanobacteria. In the case of *Synechococcus bigranulatus* CCALA 187 and *Limnospira* sp. (PCC 8005 and CCALA 27), almost complete bioconversion of EMDPP was achieved within 72 and 24 hours, respectively, resulting in the formation of the product, dimethyl (1*E*)-3-hydroxyprop-1-enylphosphonate (DMHPP). Enantioselective hydrolysis of 1-phenylethyl acetate was also observed, with the use of *Leptolyngbya foveolarum* CCALA 76 yielding an enantiomeric excess exceeding 70%. Parallel bioaccumulation experiments showed that cyanobacterial biomass, especially after bioconversion, exhibits a high affinity for REEs, confirming its applicability in bioremediation and resource recovery strategies.

This work demonstrates that cyanobacterial biomass can be utilized in the design of processes aligned with the development of a circular economy, where microalgae act as photobiocatalysts enabling the synthesis of valuable products, and the recovered biomass is valorized for its bioaccumulation capabilities, which in turn enables, for example, the recovery of critical elements. It provides a foundation for future applications in synthetic biology, pharmaceutical synthesis, and environmentally sustainable REE extraction.