Investigating Visible-Light-Induced Photoredox Catalysis for Functional Group Interconversion and Phototherapeutic Applications in Living Systems

Our main focus is to develop new synthetic photoredox methodologies for functional group interconversion from easily accessible feedstocks. Additionally, we aim to design new Ir(III)-photocatalysts by incorporating the PCET process to enhance catalytic efficiency and explore PCET-integrated Ir-photosystems for selective and efficient cancer treatment.

The thesis entitled ***Investigating Visible-Light-Induced Photoredox Catalysis for Functional Group Interconversion and Phototherapeutic Applications in Living Systems*** consists of five chapters. **Chapter 1** deals with the overview of photoredox catalysis for synthetic transformations, design of new bioinspired photocatalysts and applications in biological systems. **Chapter 2** discusses the mild and metal-free organophotoredox assisted cyanation of bromoarenes via photogenerated silyl-radical-mediated bromine atom abstraction (via XAT to provide an aryl radical). **Chapter 3** describes a common organophotocatalytic route for the selective oxidation of (hetero)aromatic or aliphatic alcohols, alkylarenes, and terminal alkenes to access the corresponding carbonyl functionalities or tertiary alcohols. The photocatalytic generation of azide radical participated in different modes of reaction mechanism (catalytic HAT and reversible addition/elimination strategies). **Chapter 4** illustrates the design, synthesis, photophysical, and photochemical studies of bioinspired ESIPT/PCET-based mononuclear Ir(III)-complexes; moreover, investigating organelle-targeted phototherapeutics via a redox-catalysis under hypoxia to evoke synergistic ferroptosis/apoptosis, established by *in vitro* and *in vivo* studies. **Chapter 5** deals with the design, synthesis, photophysical, and photochemical studies of newly designed excited-state intramolecular proton-coupled electron transfer (PCET) in dinuclear Ir(III)-complex via covalently tagged hydroquinone. This complex was applied as a light-driven therapeutic, predominantly localizing in mitochondria and inducing programmed cell death (PCD) through apoptosis via futile redox cycling.