Abstract

Research on the development of optical quality bioresorbable materials has been gaining interest in recent years. A well-known material among them is Calcium Phosphate Glass (CPG), that has been widely investigated for several biomedical applications in the past decades. Previous research in our lab has focused on creating low-loss CPG-based optical fibers, including comprehensive characterization and biocompatibility studies. Building on this foundation, this thesis advances methods to prepare and evaluate CPG fibers in preclinical applications, with a particular focus on their potential use in interstitial cancer therapy.

The thesis starts with a literature review on the progressive advancements in the biomedical applications of calcium phosphate glass-based devices over the past 50 years. Their move from a passive implant material to an active degradable material is outlined. Recent developments in optical quality CPG glass and fibers are then highlighted. Through this exploration, the chapter identifies gaps, challenges, and further potential of exploring and testing CPG based optical fibers in advanced biophotonic applications.

Subsequent chapters detail the proof-of-concept validation of CPG optical fibers for diffuse correlation spectroscopy (DCS) and diffuse fluorescence tomography (DFT). The former technique is used to retrieve rapid changes in microvascular blood flow while the latter is used to retrieve the spatial distribution of the photosensitizing drug in tumor. Monitoring of both of these parameters can provide significant insights into the therapeutic outcomes in interstitial Photodynamic therapy (PDT) and to optimize the procedure for improved outcomes. Customized CPG fibers were in-house realized for both applications, matching the optical properties of silica fibers clinically used in DCS and PDT devices. Notably, this thesis reports the first ever CPG single mode (SM) fiber at the DCS wavelength of 785 nm. The last part of the thesis mainly includes the trials conducted to investigate the dissolution behavior of CPG fibers, introducing a novel microfluidic protocol to assess dissolution kinetics under dynamic conditions. This approach provides a deeper understanding of the fibers' durability in physiological environments.

The final chapter reflects the conclusions of this research journey, highlighting the progression from fabrication and characterization of CPG fibers to demonstrating the potential of preparing and validating them for advanced biophotonic applications. The thesis concludes with a call for continued research, as the foundation laid in this work could inspire new pathways, envisioning a single resorbable photonic platform in the future that can bring immense potential in retrieving continuous complementary physiological information which can be collectively used for planning, optimizing and in predicting or monitoring the outcomes, for example in interstitial photodynamic therapy.