CHAPTER V. CONCLUSION

5.1 Conclusion

Based on the research conducted, the following conclusions can be drawn

1. The synthesis of a fluorescent tertiary phosphine compound based on BODIPY was successfully developed through a structured stepwise approach. The process began with the formation of the F_2-BODIPY core **3** via a condensation reaction between a pyrrole derivative and 4-bromobenzaldehyde, followed by oxidation and complexation with $BF_3{\cdot}OEt_2$ to yield a stable BODIPY framework. Subsequent transformations included a cross-coupling reaction with diethyl phosphite to introduce a phosphonate group, forming compound **4**. The next stage involved methylation of the boron group to produce compound **5**, which was then reduced using $LiAlH_4$ and TMSCl to yield the primary phosphine 6. Finally, this compound was converted into the tertiary phosphine through an intermediate dichlorophosphine and reaction with an aromatic Grignard reagent. All synthetic stages were supported by consistent NMR spectroscopic characterization data, confirming the successful formation of the target compound.
2. A fluorescent phosphonium compound was successfully synthesized via a reaction between the previously designed tertiary phosphine and α,α′-dibromo-p-xylene, yielding a charged product with high potential as a precursor for macrocyclic conjugates. The success of this transformation was evidenced by the $^{31}P\{^1H\}$ NMR spectrum, which exhibited a characteristic shift for phosphonium species, as well as the ^1H NMR spectrum, which confirmed the presence of aromatic and methylene groups consistent with the expected structure. Although minor impurities that were difficult to separate remained, the main compound was obtained with sufficiently high purity. The bright color and stability of the compound demonstrate superior optical properties, making it an ideal candidate as a dual-modal fluorescent probe for bioimaging applications, both at the cellular (in vitro) and whole-organism (in vivo) levels.

5.2 Suggestions

Based on the results of this study, it is recommended that the synthetic process be further optimized to improve yield, particularly during the initial formation of F_2-BODIPY, which remains relatively low. The development of purification methods such as hot extraction has proven effective; however, additional approaches that are more efficient and environmentally friendly should be considered. Furthermore, it is essential to continue in-depth photophysical

characterization and to evaluate the biocompatibility and imaging capability of the compound in biological systems, in order to ensure its practical potential as an effective dual-modal fluorescent probe for both in vitro and in vivo imaging applications.