Exploring BODIPY–Dipyrromethane Hybrids as Next-Generation Molecular Platforms

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Organic dyes with tunable photophysical and electrochemical properties are crucial for modern biomedical applications, especially in fluorescence imaging, sensing, and phototherapies. Boron dipyrromethenes (BODIPYs) are notable because of their simple synthesis, modularity, strong absorption, and low toxicity, making them excellent heavy-atom-free photosensitizers (PSs) for photodynamic therapy (PDT). Traditional heavy-atom strategies to enhance intersystem crossing (ISC) face challenges such as high dark toxicity and poor biocompatibility, which has increased interest in molecular design–driven ISC. Research on dipyrrin and dipyrromethane (DPM) derivatives has highlighted their anticancer and antimicrobial potential, with reports of apoptosis induction, nanomolar antiproliferative activity, and the reversal of antibiotic resistance. These findings suggest that combining BODIPY frameworks with DPM scaffolds could produce multifunctional hybrids for imaging, cancer therapy, and antimicrobial applications. To explore this, 5-tolyl-1,3,7,9-tetramethyl BODIPY was reacted with pyrrole aldehydes under microwave conditions in DMF, yielding mono- and di-substituted products depending on the aldehyde amount. DPM reactions primarily produced mono-substituted conjugates, while pentafluorophenyl-substituted BODIPY exhibited increased reactivity, enabling both sequential condensations and nucleophilic substitutions. Remarkably, pentafluorophenyl BODIPY facilitated access to BODIPY–DPM macrocycles via double Knoevenagel condensation, establishing a versatile platform for developing next-generation hybrid scaffolds with broad biomedical potential.

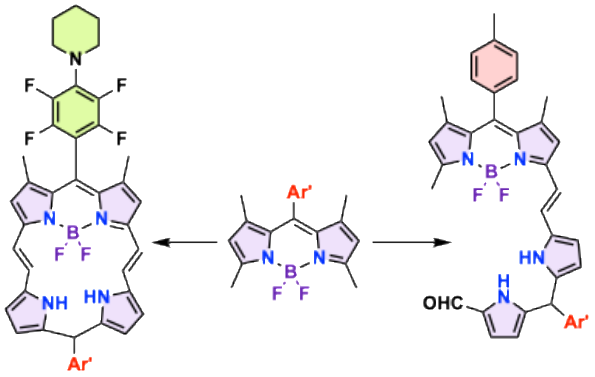

Figure 1. Synthesized BODIPY derivatives.