

**Ph.D. Thesis Title: Design, Synthesis and Characterization of Borondipyrrromethane (BODIPY) Based Conjugates to Access Organic Dye Laser, NIR Absorption and Sensory Applications**

**Name: Apurba Maity**

**Roll: 13CY91F03**

**Abstract**

The family of 4,4-difluoro-4-bora-3a,4a-diaza-s-indacene (BODIPY or dipyrromethane) has gained recognition as one of the most versatile fluorophores owing to its wide applications in chemo sensing, organic light-emitting diodes (OLEDs), fluorescent labeling of biomaterials, artificial light-harvesting systems and photosensitizers for photodynamic therapy. Prompted by the current research trend on tunable organic dye lasers, a series of judiciously designed 2,6-diacetylenyl- and 2,6-bis(arylacetylenyl)-functionalized pentamethyl BODIPY derivatives have been successfully synthesized following the strategy of extended  $\pi$ -conjugation. Under transverse pumping condition at 532 nm, these dyes exhibit maximum lasing efficiency of 41%. BODIPY dyes with perfluoroalkyl appendage on boron centre have been successfully developed to investigate their random lasing action in a polydimethyl siloxane (PDMS) based microfluid device (MFD). On the other hand, the study of the triplet excited state of organometallic BODIPYs is an emerging field of research. In this regard, a series of mononuclear and binuclear Ru(II)-BODIPY organometallic dyads have been designed and synthesized by varying the position of the acetylenyl linker between the BODIPY and Ru(II) center to access triplet photosensitizers for singlet oxygen ( $^1\text{O}_2$ ) generation. The electrochemical and NIR absorption studies indicate the electronic interplay between metal to metal or metal to redox active BODIPY chromophore. In addition, acetylide bridged hetero-bimetallic complex,  $[\text{BODIPY-C}\equiv\text{C}-(\text{tpy})(\text{PPh}_3)_2\text{Ru-C}\equiv\text{C-Fc}]^+$  (*tpy* = terpyridyl based ligands; Fc = ferrocenyl) was also synthesized to access electronic communication between the two hetero metal termini (Ru(II) and Fe(II)) and consequent NIR absorption due to intravalence charge transfer. Fascinated by the highly luminescent properties of BODIPY dyes, reusable *turn-on* fluorescent probes comprising of BODIPY fluorophore and N,N-bis(2-(pyridin-2-ylmethoxy)ethyl)aniline or dicarboxylate pseudo-crown ether  $[\text{NO}_4]$  as receptor have been explored successfully for the selective detection of environmentally concerned toxic metal ions like  $\text{Hg}^{2+}$  or  $\text{Cd}^{2+}$  up to submicromolar level in semi-aqueous or aqueous medium respectively. Moreover, long alkyl chains appended luminescent BODIPY and fluorene based alternating  $\pi$ -conjugated copolymers have been developed for the trace detection of nitroaromatics (NACs) both in solution and vapor phase. The molecular design and the synthetic strategies demonstrated in this doctoral thesis will certainly help in evolving BODIPY based new smart materials in optoelectronics, photophysics and sensing applications.

**Keywords:** BODIPY, Dye laser, Microfluid device, Random lasing, Triplet photosensitizers, Ruthenium, Bimetallic complexes, Organometallics complexes, Singlet oxygen, Cyclic voltammetry, Electronic communication, Inter valence charge transfer (IVCT), NIR absorption, Fluorescent probes, Toxic metal ion detection, Aqueous medium, Reusable, NACs detection,  $\pi$ -Conjugated polymer, Triazole, Trace detection.