Synthesis of a Dipyrinone Derived BODIPY-Xanthoglow Hybrid Fluorescent Dye

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Introduction

BODIPYs (Boron-dipyrromethene) and xanthoglow are two classes of fluorophores that can be derived from dipyrroles/dipyrinones. Dipyrinones are nonfluorescent molecules that readily undergo E/Z isomerization (Figure 1) via 390-430 nm light. Mechanically restricting the E/Z isomerization process results in fluorescent molecules such as xanthoglow (Figure 2). When excited with UV/blue light it reaches a polar state, then relaxes via fluorescence.⁽¹⁾ Fluorophores are commonly used in fluorescent dyes as probes and sensors for environmental and biological detection.⁽²⁾ Fluorescent dyes are capable of emitting photons after light absorption. The emitted light is of longer wavelength and the difference between the two is called stoke shift. Higher values of stoke shift correspond to superior fluorophores. Because BODIPY's and xanthoglow can be conjugated to certain molecules, and possess large Stokes shifts, these molecule classes show promise as molecular probes in industry. These dyes are commonly used for the identification of analytes such as metals, lipids, and pesticides inside of living systems.⁽³⁾ The BODIPY series of fluorophores particularly possesses promising characteristics as this class generally has a higher water solubility and a narrower wavelength spectrum than currently used commercial dyes, such as Nile Red.⁽⁴⁾ Known xanthoglow have high Stokes shifts, high quantum yields, but do not possess a formal charge as thus display potentially novel applications to BODIPY such as enhance cell solubility.⁽⁵⁾ Notably, both xanthoglow and BODIPY have a range of characteristic that make suitable for a numerous applications. We hypothesize that combining characteristics of these two fluorophores into a "hybrid" type molecule has the potential to create a more dynamic dye that shares characteristics of BODIPY's and xanthoglow. This hybrid class of molecules, which are highly likely to be fluorescent, have never been synthesized or studied. In addition, we are interested in additional N,N-bridging groups that potentially could replace the carbonyl-bridge of the xanthoglow unit. This poster describes our effort to accomplish these goals.

Figure 1. Interconversion of Z to E isomers

Results

Table 1. Scheme of target molecules.

Rxn	Electrophile	Protectant group	Rxn Time ^{a,b}	Bridged Product
1	BF ₃ OEt ₂	-	17 h	No ^c
2	BCl ₃	-	17 h	No ^c
3	SOCl ₂	-	4 h	No ^d
4	BF ₃ OEt ₂	TMSOTf	17 h	No ^c
5	DCDMS	-	17 h	No ^c
6	Imidazole / Oxalyl Chloride	-	17 h	Yes ^e

^a Reactions all ran using CH₂Cl₂ as a solvent at reflux.

^b Diisopropylethylamine used as a base for all reactions.

^c Bright fluorescence and degrades over time.

^d Weak fluorescence and degrades over time

^e Bright fluorescence and stable over time

In this research, a synthetic route for a novel BODIPY-Xanthoglow hybrid was explored from a dipyrinone derivative. Our target molecules display a covalent bond to bridge the ring closed, but we hypothesize our fluorescence may be due to, instead, hydrogen bonding between the lactam and pyrrole nitrogen atoms. This mechanical restriction of the E to Z isomerization process allowed our molecule to display fluorescence.

Figure 3. Hypothesized Molecule

Results cont.

Conclusion/Future Work

Overall, our molecules did show fluorescence, but generally did not show much stability after the addition of acetic acid. However, entry 6 did remain fluorescent after the addition of acetic acid and was tested for up to 24 hours with thin layer chromatography showing stable fluorescence. Further research should explore the duration of stability entry 6 is capable of. Also, extended analysis should be done on exploring different electrophiles to better understand the wavelength shift influence each can possess while forming this hybrid. Potentially, the instability of our fluorescent molecules can be used as an advantage while designing radiometric pH probes in acidic aqueous environments.

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