Three Novel Derivatives of 3-Phenylselanyl and 3-Phenyltellanyl BODIPY Derivatives as Candidates of Triplet Sensitizer

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Abstract

Three novel monosubstituted 3-phenylselanyl and 3-phenyltellanyl BODIPY derivatives were synthesized and their steady-state and transient absorption spectroscopic properties were used to evaluate the extent of intersystem crossing related to the heavy-atom effect of the Se and Te atoms. Compared to those of iodine and chlorine-atom containing analogues as well as an unsubstituted BODIPY derivative, their fluorescence quantum yields were found to decrease, whereas the intersystem crossing quantum yields (Φ_{ISC}), increased in the order of the H→Cl→Se/I→Te substitution. The maximum Φ_{ISC}, found for the 3-phenyltellanyl derivative, was 59%. As the photostability of the selenium atom-containing derivatives was found relatively high, they could be considered as triplet sensitizers in various applications.

Introduction

BODIPY, in addition to coumarin, fluorescein, rhodamine, and cyanine dyes,[1] is one of the most promising and extensively used fluorophores, used in various application as described in the Introduction.[2-9] This interest is connected to the remarkable physico-chemical properties of BODIPY, such as high extinction coefficients, high fluorescence quantum yields, distinct absorption and emission spectra, and a relatively high photostability and chemical stability.[10-12]

An unsubstituted BODIPY chromophore exhibit a strong fluorescence and very low intersystem crossing rate constants. In order to reach and study the excited triplet state of this chromophore due to the heavy atom effect, 2,6-diiodo BODIPY derivatives were prepared and studied by Nagano and coworkers.[13] Later, several heavy-atom-containing analogues of the BODIPY derivatives have been prepared[14-17] and used as triplet photosensitizers[18] and reactive species sensors.[19-21] As alternatives of BODIPY molecule bearing an ISC promoter, Se- or Te-substituted BODIPY derivatives, have also been reported.[22,23] However, the effect of the heavy atoms on their ISC quantum yields has not yet been evaluated. In most of the literature, only the quantum yields (QY) of singlet oxygen ($^1O_2$) generation was used as a tool to determine the ISC efficiency in BODIPY derivatives.[14,15] In this work, we present the synthesis and spectroscopic characterization of several novel 3-phenylselanyl and 3-phenyltellanyl BODIPY derivatives. Transient absorption spectroscopy was used to determine the triplet lifetimes and ISC quantum yields to evaluate the effect of chalcogen substituents as heavy atoms. The spectroscopic results are compared to those obtained with some other reference BODIPY derivatives.