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# Donor-Acceptor Conjugated System: A Neutral Hydrophobic Fluorescence Probe

**Abstract**

Fluorescence probe with intramolecular charge transfer behavior has received a great deal of attention in recent years. Such molecule is highly sensitive to its local environment and plays critical role in many industrial and biological applications. Donor-acceptor conjugated systems based on diphenylpolyene are one of such example. The presence of conjugated chain length and the donor-acceptor substituent's at the appropriate position allows the molecule to cover a wide range of absorption and fluorescence wavelength and hence, the optical property of the molecule is attenuated easily. Thus, diphenylpolyenes are suitable candidate for various fluorescence probe applications. The above mentioned aspects have been discussed and summarized in this paper.

**Keywords:** Absorption; Fluorescence; Fluorescence probe; Charge transfer; Diphenylpolyene

Mini Review

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**Abbreviations:** LE: Locally Excited; ICT: Intramolecular Charge Transfer

## Introduction

A fluorescence probe is a molecule that plays important role in sensing various biological [1-5] and chemical processes [6-10]. This includes cell imaging applications [1,2,5], studying the bio-molecular interaction (e.g. protein-lipid, protein-protein, small molecule-protein interaction) [6-10], characterization of microenvironment of organized assemblies [9,10], etc. The development of two photon absorbing fluorophore near-infrared wavelength region is one of the such example, that is used for cell imaging application because of its less photo-damaging activity towards live cells [5]. Upon absorption of light, such fluorescence probe is excited to its higher energy level and returned back to ground state by emitting light at higher wavelength. This process is highly dependent upon the nature of surrounding environment and the structure of the molecule. A good fluorescence probe is characterized by its maximum absorption and emission wavelength, extinction coefficient, quantum yield of emission and large Stokes' shift value [11]. A fluorescence probe is mainly classified into two categories: small organic molecules and biomolecule (e.g. protein, antibody and peptides). The protein such as Green fluorescent protein is based on fluorescent biomolecule that can anchored into a non-fluorescent biomolecule for probing the biological process [1,2]. On the other hand, few extrinsic fluorescence probes based on small organic molecule were developed for tracking such biological process [3-10,12-24]. Fluorescence probe can be attached to a biomolecule like protein, through amino or carboxyl or thiol groups and the biological events can be monitored using fluorescence techniques. The existing extrinsic fluorescence probes, however, have their own issues and limitation for such biological application. Some of the extrinsic probes have shorter absorption and emission wavelength, which makes them limited to use in medicinal application. Some of them have individual charge that rise the question of possible probe-biomolecular interaction and may interfere with the biological process. Some fluorophores are toxic, lesser solubility and therefore, not suitable for such purpose. Probing studies with fluorescence probe bearing neutral charge, greater sensitivity, higher absorption and fluorescence maximum are ideal, but are limited, e.g. prodan, diphenyl polyene, etc (Figure 1). Donor-acceptor based conjugated diphenyl polyene is one such fluorophore that play important role not only for the characterization of the structure, function of retinal-bound photoreceptors [25,26], but also act as a membrane probe [27]. Extensive studies and review on the spectral properties of donor-acceptor conjugated systems are available in the literature [28-35].

## Diphenyl Polyene as a Fluorescence Probe for Future Application

In general, donor-acceptor substituted diphenyl ethenes and dienes show solvent dependent absorption and fluorescence properties. Some of the molecules exhibit dual fluorescence emission, which is highly dependent upon the local environment and substituent present on the molecule [36-41]. For example, diarylethenes bearing donor group, methoxy and amine or acceptor group, cyano and nitro show fluorescence emission from their locally excited state (LE), whereas, in presence of both donor and acceptor substituents, cyano or nitro and methoxy and amine shows solvent polarity-dependent dual fluorescence emission due to LE and intra molecular charge transfer (ICT) states. The synthesis of conjugated diphenyl polyenes are simple and easy through various condensation reaction including Wittig-Wadsworth-Emmons reaction [42]. The presence of conjugated chain length and the donor-acceptor substituents at the appropriate position allows the molecule to cover a wide range of absorption and fluorescence wavelength as well as solubility. Hence, the optical properties of the molecule is attenuated easily. Some of these molecules with ICT phenomena are highly sensitive to their local environment and thus, diphenyl polyene systems are suitable for various fluorescence probe application.

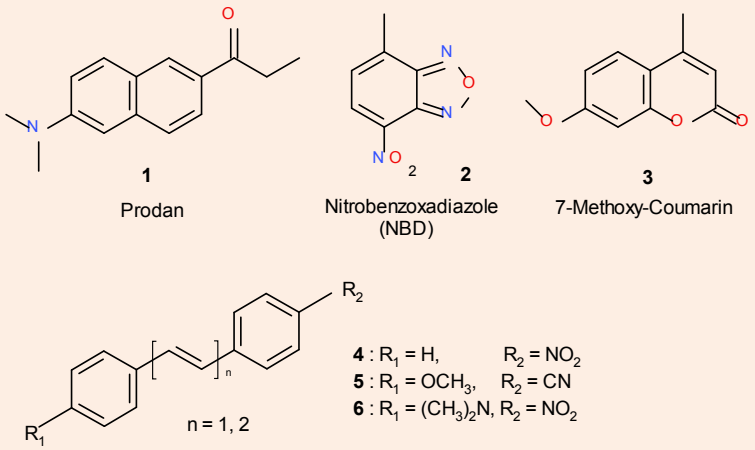


**Figure 1:** Structure of some of the neutral fluorescent probe that are used in tracking various chemical and biological processes.

Recently, several groups have shown that donor-acceptor based ethenes [6-10] promised and serve as excellent neutral fluorescence probe for studying organized assemblies, membrane and protein systems. It is shown that the fluorescence intensity of some of these molecule is increased linearly with increasing protein concentration and act as a probe for protein quantification [7]. Some of these donor-acceptor based diphenylpolyenes act as a probe for organized assemblies [9,10], lipid, vesicle and protein interaction study [6-8,10,18,27]. In general, these probes have restricted motion in the vesicles and fluoresce from LE state, whereas fluoresce from ICT state in micelles. Recently such type of donor-acceptor conjugated systems are also used as a sensor for detection of ions for various other applications [43-45].

## Conclusion

It is clear from the foregoing discussion that diphenyl polyene based fluorescent probes with charge transfer character is useful for several biological, industrial, and medical applications. In general, donor-acceptor diphenylpolyenes are neutral and better fluorescent at ambient temperature and relatively easy to prepare. Diphenylpolyenes substituted with appropriate donor-acceptor groups with charge transfer phenomena are highly sensitive to their local environment. Thus, development of novel fluorophore based on diphenylpolyene is definitely useful for probing various chemical and biological processes as discussed above.

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