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Review

# Triphenylamine based dyes for dye sensitized solar cells: A review

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**Abstract**

In recent years a lot of work has been done in the field of dye-sensitized solar cells (DSSC). Dye-sensitized solar cell being a low-cost way for light-energy conversion is an emerging field of research. Triphenylamine based organic dyes (with D–π–A structure) as sensitizer for dye-sensitized solar cells (DSSCs) attain considerable attention because of their structural versatility, low cost and high molar absorption coefficient. In this review discussion is focused on application of TPA based dyes in dye-sensitized solar cells. Special consideration has been paid to study the relationship between molecular structure and DSSC performance. This field seen exciting progress and light to power conversion efficiencies exceed to 11%. Photovoltaic performance of DSSCs sensitized by TPA based dyes is compared and comprehensive overview is provided.


*Keywords:* Dye-sensitized solar cells; Triphenylamine; Efficiency; Organic dyes

**Contents**



## 1. Introduction

Massive consumption of Fossil fuels has reduced the earth's reserves of Fossil fuels and cause the environmental

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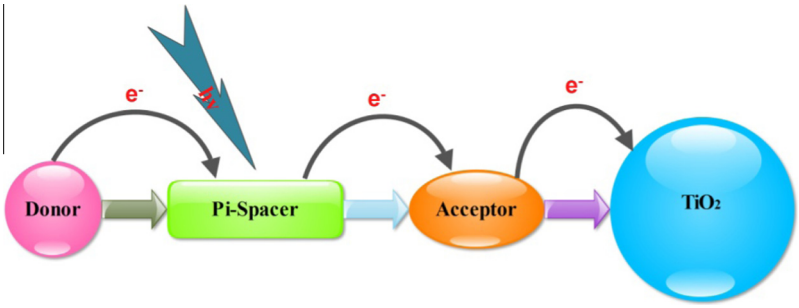


Fig. 1. Schematic of the D–π–A structure of an organic dye.

contamination and greenhouse effect. Recently, commercialization of various renewable energy sources is increased as solution to these problems. Solar energy is most popular among all the renewable energy forms. Solar cell is one of the most favorable ways to convert solar energy into electricity and have received considerable attention.

Traditional costly and less efficient silicon-based solar cells have been replaced by dye-sensitized solar cells (DSCs). These high efficient and low cost solar cells was first reported by O'Regan and Gratzel (1991).

Metal complexes, porphyrins, phthalocyanines and metal-free organic dyes have been used as photosensitizers in dye-sensitized solar cells (DSSCs). Ruthenium base dye N719 $(Bu_4N)_2[Ru(dcbpyH)_2(NCS)_2]$ showed a superior photovoltaic performance to other metal complexes (Hagfeldt et al., 2010). But large scale utilization of ruthenium-based dyes in DSSC applications limited because of high manufacturing cost and toxicity. As a solution to this problem, a large number of metal-free organic dyes have been tested for efficient dye-sensitizer solar cells (Abdullah et al., 2013a,b).

Metal free dyes can be synthesized easily and economically. They show high molar extinction coefficients due to intermolecular $\pi$–$\pi^*$ transitions. Generally organic dyes (use as sensitizer) contain D–π–A structure, where D is donor, π is linker and A is acceptor. When dye absorbs light, charge transfer occurs within the molecular due to this push-pull structure (Fig. 1). Charge transfer is important for light harvesting. Moreover, it is easy to tune the absorption spectra as well as the HOMO and LUMO levels of the dyes by variation of the D, π and A moieties. Among the metal-free organic dyes, the tripheylamine dyes, holding the record for validated efficiency of over 10.3%, are promising candidates for highly efficient DSCs (Zeng et al., 2010).

Better elucidation of structure-efficiency relation-ship would facilitate the better utilization of these dyes in DSSCs. DSSC technology undoubtedly have an exciting future and there are still vast opportunities to ameliorate performance. Therefore, the development of a conceptually new design for constructing metal-free dyes is an important and urgent challenge.

The main purpose of this review on TPA base dyes was to provide the science and engineering community with a broad overview of this field and to identify promising design principles for the future development of new dyes. Although remarkable advances have been made with triphenylamine dyes as sensitizers in DSSCs, there is still a need to optimize their chemical and physical properties to further improve the solar cells. Triphenylamine dyes offer infinite possibilities for improving a wide range of properties such as molecular structure and function, efficient light-harvesting ability in different parts of the solar spectrum, control over the molecular energy levels, charge generation and separation, and molecule-to-molecule interactions.

This review gives the current state-of-the-art in the field of triphenylamine dyes for DSSCs and describes structure–property relationships. Future challenges and perspectives are also discussed.

## 2. Parts of dye-sensitized solar cell

Dye-sensitized solar cell (DSSC) directly converts the solar radiation into electric current. The system consists of the following parts (Fig. 2):

(i) a transparent anode made up of a glass sheet treated with a transparent conductive oxide layer; (ii) a mesoporous oxide layer (typically, $TiO_2$) deposited on the anode to activate electronic conduction; (iii) a monolayer charge transfer dye covalently bonded to the surface of the

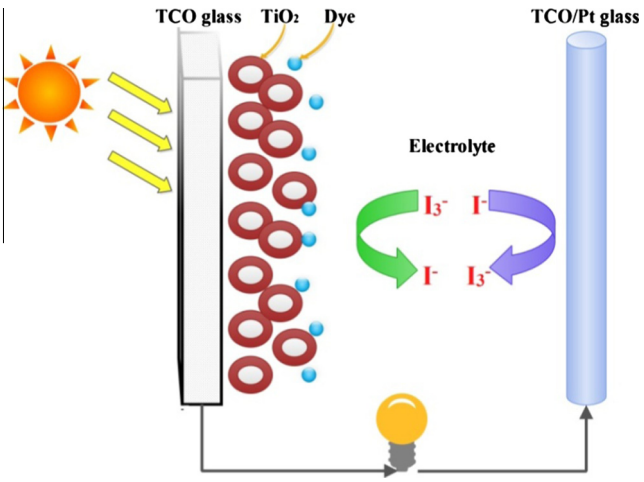


Fig. 2. Schematic diagram of the dye-sensitized solar cell.