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Synthesis and DSSC application of triazole bridged dendrimers with benzoheterazole surface groups

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ABSTRACT

Triazole bridged dendrimers with benzoheterazole surface groups were successfully synthesized in high yields by click chemistry via convergent approach. The photophysical properties of the dendrimers reveal that as the generation increases the light absorption ability also increases. The fluorescence intensity gradually decreases as the dendritic generation increases because of fluorescence quenching due to steric crowding of the dendritic arms. On increasing the number of benzoheterazole unit at periphery, the anodic peak was shifted to higher positive potential in cyclic voltammetry. When the synthesized triazole dendrimers are utilized as an additive in the redox couple of a DSSC, the lower generation dendrimers showed better current generating capacity with higher power conversion efficiency than the higher generation dendrimers.

1. Introduction

Dye-sensitized solar cells (DSSCs) have emerged as one of the promising technologies for renewable energy in recent years due to the rapidly increasing demand for eco-friendly conversion of energy by solar cells which have attracted a growing interest in environmentally benign alternative energy sources. The first report on dye sensitized solar cells by O'regan and Grätzel in 1991 has emerged as one of the most promising low cost alternative for renewable generation of electricity by solar cells (O'Regan and Gratzel, 1991). It is a great challenge to the scientific research to utilize renewable energy source of power supplies in the emerging area of flexible optoelectronics. With the aim of increasing and improving renewable energy sources, recently a large number of functional π-conjugated polymers (Burroughes et al., 1990), oligomers (Kwon et al., 2012) and dendrimers (Jiang et al., 2009) have been synthesized and used in DSSCs and as organic light emitting diodes. From more recent developments, dendrimers are used to increase the power conversion efficiency of light harvesting antenna in optoelectronics. Dendrimers are highly branched well defined globular, synthetic macromolecules with characteristics that make them useful in nanoscience. Dendrimers find ever-increasing applications in sensing, catalysis, molecular electronics, photonics, and nanomedicine (Somani and Dufes, 2014). Dendrimers are attractive sources of nanomaterials with predictable size, shape and function because they can be synthesized in a controlled fashion. Dendrimers are also used in fluorescent sensors (Olley et al., 2011), liquid crystalline (Guerra et al., 2016), light harvesting (Li and Liu, 2009), organic light emitting diode (Nantalaksakul et al., 2006) and drug delivery (Caminade and Turrin, 2014) systems as well as in other applications. Novel structural materials can be synthesized rapidly and reliably using click chemistry. Copper-catalysed azide alkyne cycloaddition is a robust coupling reaction that forms 1,2,3-triazole ring system which is used in various research areas (Meldal and Tornoe, 2008). Click reactions are a relatively facile method to couple dendrimer components to reach high yielding product (Damaramadugu et al., 2013). The mild reactions conditions and tolerance of different functionalities and lack of by-products make click reaction an attractive synthetic method to build dendrimers and dendritic polymeric materials (Wang et al., 2014). They have potential applications for the synthesis of materials that can be used as chemosensors, charge transfer agents (Woller et al., 2003), lectin adsorption (Wang et al., 2011) and liquid crystalline materials also.

Synthesis of benzene annulated heterocyclic compounds such as thiazole (Sun et al., 2017), oxazole (Losada et al., 2017) play conformational behaviour due to π-π interaction and charge delocalization over two or more sites. The benzoxazole and benzothiazole have the capability of producing a range of colours with good electron transport ability and also used as photophysical and electron transport materials in OLEDs (Sunil et al., 2016). The heterocyclic system such as oxazole and thiazole as strong electron acceptor unit usually employed to modulate the HOMO-LUMO energy levels for low band gap features in optoelectronic and enhanced photovoltaic cells (Rajavelu et al., 2016).

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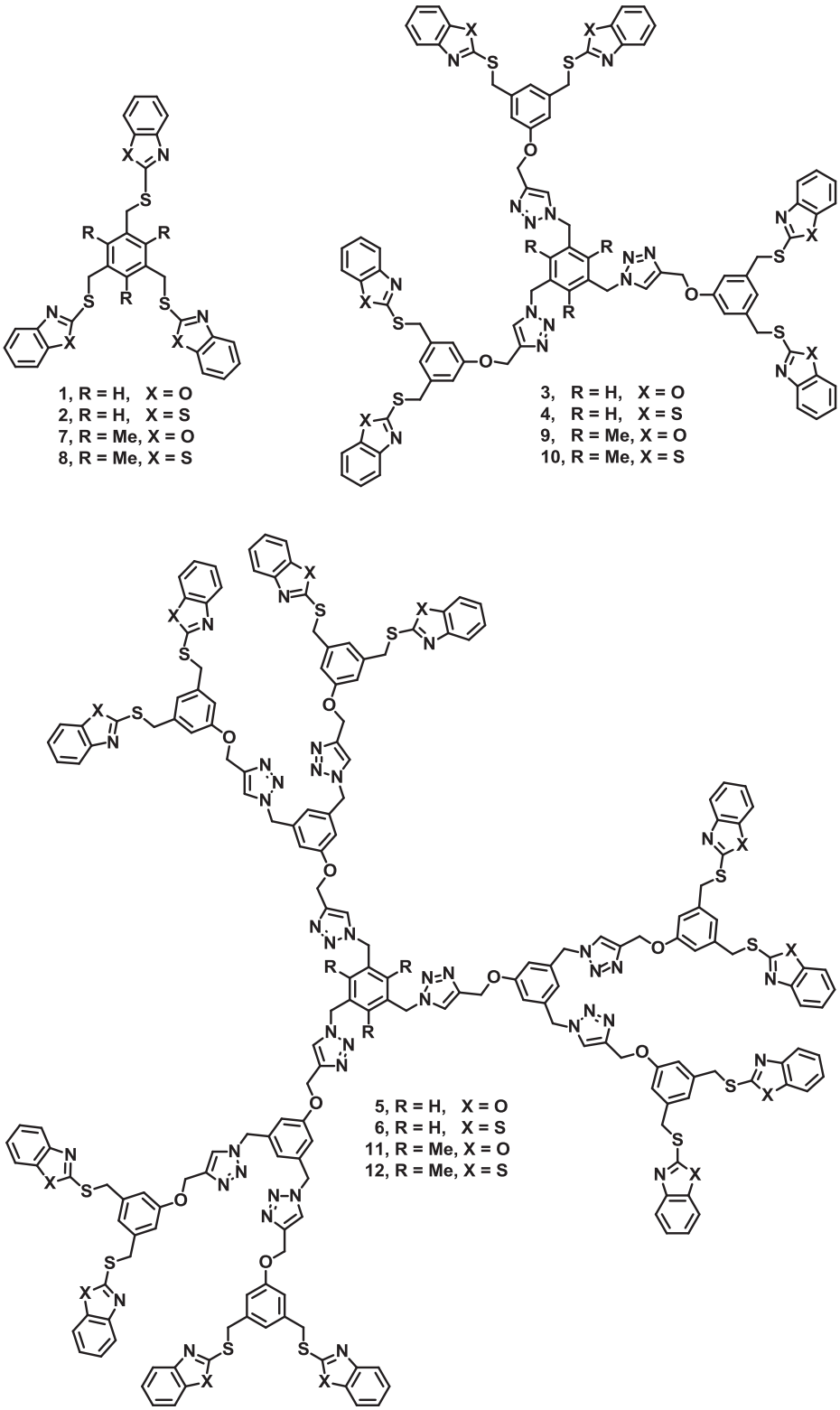

Fig. 1. Molecular structure of the benzoheterazole dendrimers with triazole bridging unit.

Over the past two decades scientific research efforts to increase the power conversion efficiency in DSSC by using nitrogen containing heterocycles such as pyrazole, imidazole, triazole, pyridine, pyrimidine and pyrazine as additives that have led to increase the open circuit voltage and improve the efficiency of DSSC (Rajakumar et al., 2013). In our laboratory dendrimers with benzothiazole (Rajakumar et al., 2011), triphenylamine chalcone (Anandkumar et al., 2017) and phenothiazine (Ravivarma et al., 2017) as the surface group have been used as additives in DSSCs. We report herein the low cost effective synthesis of benzoheterazole dendrimers **1–12** (Fig. 1) by click chemistry using a convergent synthetic approach along with their photophysical properties.