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Research Article

Incorporation of Kojic Acid-Azo Dyes on TiO_2 Thin Films for Dye Sensitized Solar Cells Applications

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Sensitization of heavy metal free organic dyes onto TiO_2 thin films has gained much attention in dye sensitized solar cells (DSSCs). A series of new kojic acid based organic dyes **KA1–4** were synthesized *via* nucleophilic substitution of azobenzene bearing different vinyl chains **A1–4** with kojyl chloride **4**. Azo dyes **KA1–4** were characterized for photophysical properties employing absorption spectrometry and photovoltaic characteristic in TiO_2 thin film. The presence of vinyl chain in **A1–4** improved the photovoltaic performance from 0.20 to 0.60%. The introduction of kojic acid obtained from sago waste further increases the efficiency to 0.82–1.54%. Based on photovoltaic performance, **KA4** achieved the highest solar to electrical energy conversion efficiency (η = 1.54%) in the series.

1. Introduction

Dye sensitized solar cells (DSSCs), a third-generation solar cell discovered in early 1990s, have gained intensive attention and been considered as promising alternative for fossil fuel energy [1, 2]. DSSCs offer advantages over the conventional silicon based solar cell due to cost effectiveness, flexibility in shape, easy accessibility of dye resources, and noteworthy performance [3, 4]. DSSCs convert sunlight into electrical energy mimicking the photosynthesis process employing synthetic or natural dye as light harvesting pigments [5]. Sensitizer in the cell absorbs photons and induces excitation of electron to the wide bandgap semiconductor, dyes, and electrolyte [6]. Ruthenium complex is one of the most effective light harvesting sensitizers reported in DSSCs; however, the drawbacks of these ruthenium sensitizers are complicated procedure, limited source, and being expensive, environmentally unsafe, and carcinogenic [7–9].

Over the years, tremendous efforts have been made to explore natural and organic dye as DSSCs sensitizer due to being nontoxic and environmentally friendly, low cost, and easy modification for functionalization. Extracted natural dye, however, has low yields of extract and scarce resources [10]. Organic dye such as azobenzene has outstanding chromophores with strong absorption in visible region and intrinsic advantages of good photo and thermal stability [11, 12]. Azobenzene is a reactive precursor for functional group conversion and attachment such as vinyl and alkoxy chain with enhanced optical properties [13, 14].

Development of natural and organic dyes as sensitizer on TiO_2 thin film for DSSC performance has been widely reported [15–17]. Anthocyanin in natural dye which has carbonyl and hydroxyl groups has been reported for its anchoring ability to TiO_2 surface in DSSC applications [18–20]. Binding of C=O and OH groups to the TiO_2 surface promotes better electron transfer mechanism to the conduction band of TiO_2. Kojic acid [21, 22], a natural pyrone which carries one C=O and two OH groups, is envisaged to have similar properties of natural anthocyanins dyes for its ability to bind with TiO_2. Kojic acid is a nonhazardous and biodegradable natural product, which was earlier reported for tyrosinase inhibition and colorimetric determination [23–26]. To the best of our knowledge, no studies reported on the applications of kojic acid derivatives as DSSCs sensitizer.