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Environment approachable dye sensitized solar cell using abundant natural pigment based dyes with solid polymer electrolyte

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ABSTRACT

In the present work dye sensitized solar cells were fabricated using natural pigment based dye extracted from different fruits as 'sensitizer'. The photovoltaic properties of FTO coated thin film and extracted natural dyes were studied using UV–vis-NIR spectroscope. FTO coated subtract showed complete transmittance above 350 nm wavelength that is wide-ranging visible region and above wavelength, which is the desired property for solar cells. The extracted fruits and plants dye showed absorption up to 600 nm wavelength of incident light with wide range abssorption. The TiO_2 thin films were prepared on FTO coated conducting substrate using doctor blade technique as photo anode while fruits and plants dye extracted in ethanol was used as sensitizes. The fabricated solar cells were characterized using Keithley source meter which shows that photovoltaic performance is relatively compared with popular expensive dyes i.e. N_3, black and ruthenium.

1. Introduction

Now a day's research and analysis on Dye sensitized solar cells (DSSCs) has fascinated many researchers since its development by Gratzel [1]. Compared to silicon, CdTe and CIGS solar cells DSSCs solar cells are cost effective and non-hazardous to environment. Hence DSSC is the promising solar energy harvesting technology which could reduce the word energy demand considerably without affecting environment [2,3].

In the scenario of energy age dye sensitized solar cells (DSSCs) are positioned in third generation of solar cells. DSSCs have more reimbursements over silicon solar cells such as low fabrication cost and eco-friendliness. DSSCs works on the simple principle of transferring the charge carries from dye to wide band gap material, by absorbing incident light. This process is mimic of photosynthesis taking place in plants. Researchers have fabricated DSSCs with molecular engineered porphyrin dye with maximum power conversion efficiency of 13% [4]. However, presently most growing technologies is dye replaced with natural dyes for sensitizer, this further reduces the cost of fabrication and more environmental friendly process. Natural dye can be extracted from different types of fruit, seeds, flowers and plants. Extraction of dye from natural source is very simplest process which doesn't required sophisticated instruments; also, dye can be extracted from the waste remains, this reduces environmental waste. Among natural DSSC's Wang et al. [5] have achieved 4% efficiency [5]. Kumara et al. [6] achieved efficiency of 1.55% using co-sensitization of titanium di oxide based electrode with canarium odontophyllum dye

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Fig. 1. Shows the used part of the fruits and vegetables (a) Red Beans (b) Orange Peel (c) Barley Grass.

from Kembayau fruit and Ixora flower as dye [6]. Researchers are also attempted for many other natural materials as dyes, few articles which gives vast scope of field is mentioned [7–15]. It has been detected that in nature, the flower, fruit, root, stem, bark and leaf of trees demonstrates several colours of the noticeable electromagnetic spectra from red, orange, yellow, green, blue, indigo to purple and covers numerous natural dyes these could be take out by modest technique. Consequently, it has been accentuated by many investigators to attain sensitizer dyes as light absorber for DSSC's from natural products, so that unpretentious grounding procedures, extensively available sources, and low cost [16–19]. By the all explanations, the reputation of effort finished by the writers to progress low-cost solar energy to electricity renovation components in prime is underscored. However, natural DSSCs efficiency is less compared to well established solar cells technology, which call for detailed investigation in this filed. In view of these, in the present work on dye from raspberry, pomegranate, tomato, barley grass, orange peel fruits and vegetables pigments were extracted and TiO_2 layer was sensitized [20,21] and DSSCs were fabricated using solid polymer electrolyte, which is the newest approach to make environment friendly and a new hope for humanity. We have used simple adoptable device fabrication and natural dye extractionprocedure.

2. Experimental section

2.1. Materials

Acetone was purchased from Thomas Baker, India and Titania based blocking layer solution, poly vinyl alcohol (PVA) and hexachloroplatnic acid (H_2PtCl_6) remained purchased from Sigma Aldrich, USA while acetone(C_3H_6O), acetonitrile (C_2H_3N) were bought since Thomas Baker, India. Titanium tetrachloride ($TiCl_4$), propanol, deionized water (DI), ethanol, aniline, HCl, ammonium per sulphate (APS) and ammonium hydroxide were bought since CDH (Central Drug House) while potassium iodide (KI) and iodine (I_2) were obtained from Himedia, India.

2.2. Extraction of pigments from natural dyes and preparation of dye-sensitizer solutions

The wanted solution of pigments of numerous fruits and vegetables were gained by fresh fruits and root vegetable. All spotless fresh fruits and vegetables were crumpled and additional to Ethanol and acetone. Here required, the combinations were centrifuged, and all explanations were threatened by indirect light acquaintance. Fig. 1(a) Red beans, (b) Orange peel and (c) Barley grass shows the used part of the fruit and vegetables.

2.2.1. Red beans (Anthocyanin) dye

To extract the Anthocyanin Pigment from Red beans, we arranged fresh red beans seeds, clutching the seeds and after eliminating any white part from the seeds, we put it in unsoiled mortar to crushing the seeds, we now take the red beans juice and putting it in a spotless dish [22].

2.2.2. Orange peel (β-carotene) dye

New products of Orange were gathered from the nearby market. Following wash with de-ionized water and expelling the seeds and tissue of Orange, the organic products were precisely peeled. Consequently, the peels were kept in a vacuum heater for around 10 h at 50 °C to kill the dampness. In the wake of being dried, the peels were pulverized into powder in a mortar. Around 50 g of the powdered example was put into a measuring utensil, at that point 150 ml supreme ethanol was included and the blend was kept in a shaker for 5 h. The acquired arrangement was shielded from coordinate daylight presentation and put away at around 50 °C. Afterward, utilizing channel paper, the strong build-ups were sifted through to get an unadulterated and clear characteristic pigment arrangement. Facilitate sanitization of clear arrangement was performed utilizing solid polymer electrolyte to accomplish proficient refinement. This concentrate was likewise put away at 50 °C and utilized for encourage portrayal as sensitizer in manufacture of DSSC [23].

2.2.3. Barley grass (Chlorophyll) dye

Barley grass leaves were engaged out after scrubbing the exteriors of greeneries with acetone, after that we transformed in to paste by grinding Pestle, and 10 ml acetone was added and once more grind. A Strainer paper was reserved ended the funnel of beaker and prepared solution of leaves was dispensed over the strainer paper, and then 30 ml acetone was dropped