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Poly (3-Dodecylthiophene)/Natural Dye Bulk Heterojunction Organic Solar Cell: An Electrical Conductivity, and Hall Effect Study

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Abstract

Today, world is facing the increasing energy demand, security of energy supply and reduction of emissions. Energy consumption which accounts for 60% global greenhouse gas emissions has mainly contributed to climate change. Renewable energy is an appropriate way to satisfy energy consumption without environmental degradation. Solar energy is one of the most promising renewable energy sources today. In recent years, organic solar cells (OSCs) which are a promising alternative to conventional inorganic devices have received much attention. In this research, OSCs are developed from organic material; Pulasan (*Nephelium mutabile Labill*), Kemunting (*Rhodomyrtus tomentosa*) and Poly (3- Dodecylthiophene) (P3DT). These OSCs are facbricated accordingly bulk heterojunction of ITO/P3DT+natural dye/Au via electrochemical method at room temperature. The OSCs was deposited onto heated substrate from 50˚C to 200 ˚C. From four point probes (FPP) data revealed that electrical conductivity increases by the increment of light intensity and temperature of substrate. Then, the samples were examined using Hall Effect measurement to obtain the type of sample, Hall mobility, and highest charge carrier in the sample of OSCs. Both samples detected was N-type of charge carrier from Hall effect measurement.

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Keywords: Natural Dyes; Electrical Properties; and Organic Solar Cell.

1. Introduction

The search for clean and renewable energy sources has become one of the greatest challenges for our society, due to the rapid depletion of fossil fuels and increasing demand on energy supply. One of the most promising alternative

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energy sources is solar energy which is clean, renewable, safe and abundant [1,2]. Solar cell is an electrical device that converts the sunlight directly into electricity by the photovoltaic effect.

In recent years, organic solar cells (OSCs) which are a promising alternative to the conventional inorganic devices have received much attention. It is due to their high performance, potential applications, including low cost materials, ease of production, and lack of harmful emissions [3].

The biological ingredients could be utilized almost anything from plants, minerals, and even some insects which can be extracted by simple procedure. Most natural dye colours are found in the roots, bark, leaves, flowers, skins, and shells of plants. The advantage of natural are that they are cost effective, renewable, eco-friendly i.e., they do not create any environmental problems at the stage of production or use, maintains ecological balance and has no allergic reaction on skin [4-5], their abundance in supply, easy accessibility and high absorption in the visible region make them all good candidates as alternative photosensitizer [6]. It has been emphasized by many researches to obtain useful dyes as photosensitizers for solar cell from natural products [7-13].

In this study, OSCs were formed to find their electrical conductivity, and Hall Effect measurement. The substrates indium tin oxide (ITO) glass, polymer Poly (3-Dodecylthiophene) (P3DT) and natural dye Pulasan (*Nephelium mutabile Labill)* and Kemunting (*Rhodomyrtus tomentosa)* fruit were used to form OSCs. The OSCs were deposited using electrochemical method.

Nomenclature

OSCs	Organic Solar Cells
ITO	Indium Tin oxide
P3DT	Poly (3-Dodecylthiophene)
FPP	Four Point Probes
HEM	Hall Effect Measurement

2. Experimental

2.1 Sample collection and preparation

Pulasan *(Nephelium mutabile Labill)* and Kemunting *(Rhodomyrtus tomentosa)* was hand-picked from three separate plants in Dungun, Terengganu. The fruit were carefully collected and packed into plastic boxes to avoid physical damage, and then transported to the laboratory within 2 h. Upon arrival, the fruit were selected based on their color (dark purple). This color, which is a maturity indicator. In the laboratory, fruits were washed under tapwater and then rinsed in distilled water three times to remove the contamination of fruits.

The 2 cm x 2 cm ITO glass were used as a substrate. The cleaning process of substrates was done using ultrasonic vibrator (JEIOTECH model). The tank in ultrasonic vibrator was rinsed using distilled water to make sure it is cleaned [14]. 50ml beaker filled with distilled water and ITO substrates was put into the ultrasonic vibrator. Then, ITO substrates were thoroughly cleaned by distilled water, the detergent. It was followed by acetone in order to remove any contaminations that might have been formed on the substrates [15] and distilled water. The time was set for 20 minutes, 30°C and mode vibration was set as medium for each cleaning. Lastly, the ITO substrates were dried using the dryer before kept into a Petri dish. P3DT was prepared through polymerization of the Dodecylthiphene.

2.2 Extraction of dye

The 20 g of kemunting (Figure 1) were immersed in 200 mL of distilled water for 10 minutes. Then, it was crunched into small size and immersed with ethanol for 2 days. After that, it was vibrated using ultrasonic bath for 1