Analysis of Elemental Concentrations and Optical Characterization of Ye-Yo (*Morinda Angustifolia Roxb*.) Leaves

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Abstract

Green pigments are used in many industrial branches including food, drinks, soap and cosmetics. Chlorophyll can be substituted for synthetic dyes which may affect health. Natural dyes (chlorophyll-based) were extracted from Ye-Yo (Morinda Angustifolia Roxb.) leaves, combined with different solvents. Different dye solutions were extracted by using ethanol, methanol and ethanol: methanol (V/V). The absorption and transmission spectra of dye solutions were analyzed by using UV-Vis spectroscopy. The optical energy band gaps for three dye solutions were observed by using absorption and transmission spectra. The elemental concentration of the leaves was examined by using EDXRF analysis. According to EDXRF results, it was observed to be Ca>K>Cl> Si>Fe>Mn> S>Zn>Br>Cu.

Keywords: Ye-Yo leaves, dye, chlorophyll, UV-Vis, EDXRF

INTRODUCTION

Many types of natural organic dyes extracted from leaves, fruits, and flowers of various species of plants have been actively studied and tested as low cost alternative materials to replace rare and expensive ruthenium dyes. Natural plant dyes can be extracted through simple procedures. These dyes have been a subject of various studies because of their cost efficiency, environment-friendliness, non-toxicity, availability, and full biodegradation potential. Commonly studied natural dyes include chlorophyll and anthocyanins, carotenoids, betalains, flavonoids, cyanine and tannins (Mahmoud A. M et al, 2017).

Chlorophyll is a green photosynthetic pigment which helps plants to get energy from light. The plants use the energy to combine carbon dioxide and water into carbohydrate to sustain their life process. There may be many factors that affect the photosynthesis; the main factors are light intensity, carbon dioxide concentration, and temperature [Muhammad A. H. S et al, 2013]. The most popular example of natural biocomplex is chlorophyll - a green chlorine pigment found in plants, algae, and cyanobacteria, responsible for the absorption of energy from light in the process of photosynthesis (Magdalena M. B., & Agnieszka A. K., 2014).

Chlorophyll is the well-known and dominant natural pigment in terms of absorbing specific wavelengths of the visible light, converting sunlight to chemical energy. The common types of chlorophyll are "chlorophyll a" present in all photosynthetic plants and "chlorophyll b" found widely in higher plants and algae (Wuletaw A. A., & Delele W. A., 2016).

Ye-Yo (Morinda Angustifolia Roxb.) plant is an evergreen plant as shown in Figure (1). The plant is a large shrub or a tree with few erect branches. It is a type of perennial plant that grows to a height of up to 15 feet high with an irregular, open and shiny crown. People grow Ye-Yo very well in Myanmar. The plant is harvested from the wild for local use as a medicine and food.

Botanical name - Morinda Angustifolia Roxb.

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Family	- Rubiaceae
Genus	- Morinda
Species	- Angustifolia Roxb.
Myanmar Name	- Ye-Yo

Traditionally Ye-Yo was used to heal the broken bones, bruises, wounds and sores. The leaves are simple, glossy green, elliptic-oblong; 20-45 cm long and 7-25 cm wide. Leaves are useful for dysentery, fevers, diarrhea, dizziness and headache. The dried leaves can be used externally for infections, burns and internally for boils pleurisy, inflamed gums, and arthritic pain. The fresh leaves can be used externally for burns and internally for fevers, hemorrhage, bacterial infections and inflammation (https://en.wikipedia.org/wiki/Morinda).

The dye solutions extracted from Ye-Yo leaves by using ethanol, methanol and ethanol with methanol (V/V) were studied by UV-Vis spectroscopy. The optical band gaps were also studied by using absorption and transmission spectra. The qualitative elemental analysis of Ye-Yo leaves was carried out by EDXRF method.

Figure (1) Photograph of Ye-Yo (Morinda Angustifolia Roxb.) Plant

MATERIALS AND METHODS

Preparation of Natural Dyes Extraction

The chlorophyll dyes were extracted from Ye-Yo (Morinda Angustifolia Roxb.) leaves. Firstly, the parts of the leaves were collected from Hinthada Township. Prior to be dried at room temperature, Ye-Yo (YY) leaves were cleaned and cut into small pieces. The dried material was then ground into smaller pieces and sieved at a mesh size of 0.045 mm. Each powder (1g) was dissolved with ethanol, methanol and ethanol: methanol (V/V) in the beakers, respectively.

Solution I - only 50ml of ethanol

Solution II - only 50ml of methanol

Solution III - 25ml of ethanol with 25 ml of methanol (V/V)

These solutions were kept at room temperature for about 24 hrs. These solutions were stirred with magnetic stirrer at 700 rpm for 1 hr and were annealed at 75 °C with water bath for 1 hr. Finally, impurities were filtered out by filter paper.

In this study, a Shimadzu 1800 VU-Vis Spectrophotometer was used to measure the absorption and transmission spectra of different natural dyes and optical energy band gaps of dye-solutions. The elemental concentrations of the powders of YY leaves were examined by EDXRF analysis.

EDXRF (Energy Dispersive X-ray Fluorescence) Analysis

In this research work, the EDX-700 X-ray fluorescence analyzer (EDXRF) system was used to analyze the Ye-Yo (*Morinda Angustifolia Roxb*.) leaves. The technique used in this research work is fundamental parameter (FP) method. Relative concentration (Wt%) of elements contained in dry powders of Ye-Yo (Morinda Angustifolia Roxb.) leaves was shown in Figure (2). Calcium (Ca) and Potassium (K) are major elements in this sample and it has minor elements such as chlorine (Cl), Sulphur (S), Iron (Fe), Manganese (Mn), Strontium (Sr), Zinc (Zn), Bromine (Br), Copper (Cu) by using EDXRF method. Figure (3) showed the EDXRF spectrum of dry powders of Ye-Yo (Morinda Angustifolia Roxb.) leaves.

Calcium is an important mineral in the body necessary for healthy bones and teeth. The content of calcium in food that provides for nutrition is the most abundant mineral in the human body. Roughly 99% of the body's calcium is found in the teeth and bones. Calcium is necessary for growth and development of bones and to regulate nerve and muscle functions. Calcium helps to prevent the onset osteoporosis, reduces the possibility of kidney stones and also helps to regulate blood clotting. Calcium plays a critical role in the normal functioning of the heart. This is important because heart diseases in women increase after menopause. Vitamin D increases calcium which exists inside cells.

Potassium is a very important mineral for the proper function of all cells, tissues and organs in the human body. Potassium is a mineral that is crucial for life. It can also support the tonic effects for the body. It did not give toxic effects. Potassium is an element (and an electrolyte) that is essential for the body's growth and maintenance. Potassium is found abundantly in many foods and is especially easy to obtain from fruits and vegetables. It's necessary for the heart, kidney and other organs to work normally.

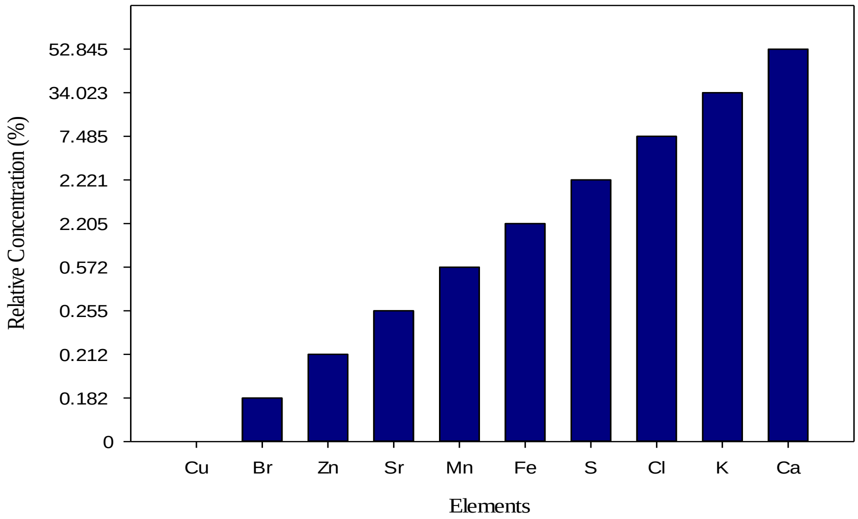

Figure (2) Relative concentration (Wt%) of elements contained in dry powders of Ye-Yo (Morinda Angustifolia Roxb.) leaves

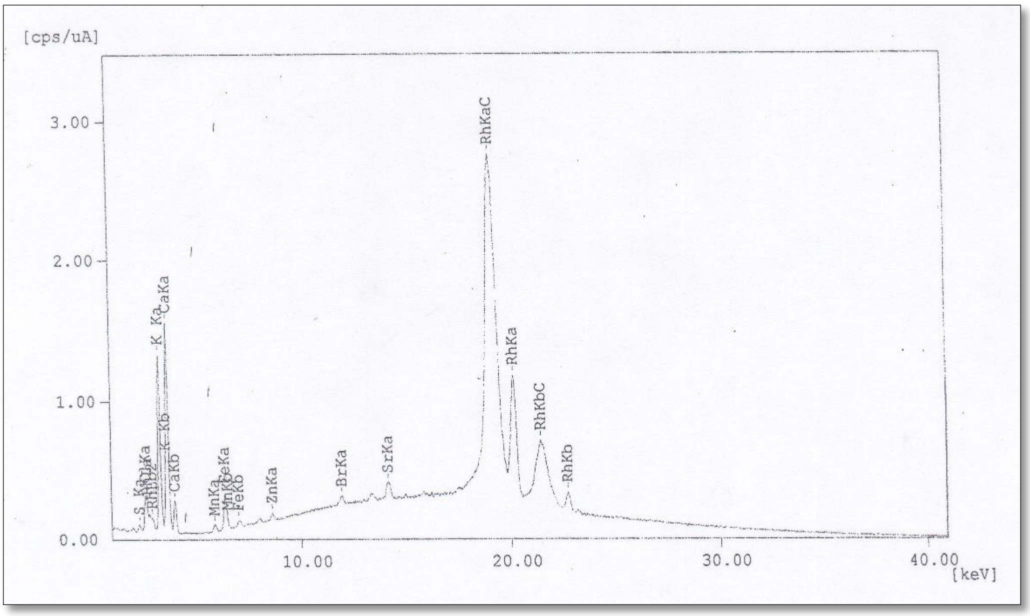

Figure (3) EDXRF spectrum of dry powders of Ye-Yo (Morinda Angustifolia Roxb.) leaves

UV-Vis Analysis

The optical properties of the dye solution of YY leaves were measured by using a SHIMADZU UV-1800 spectrophotometer in the region of 300.00 nm to 800.00 nm. Figure 4, 5 and 6 revealed the absorption and transmission spectra of YY leaf dye solution with different solvents.

In Figure (4), the absorption peaks of YY leaf dye solution with ethanol were found to be 537.00 nm, 608.00 nm, and 660.00 nm. The transmission peaks were 524.00 nm, 579.00 nm and 626.00 nm. The cut off wavelength from absorption spectrum was 523.4 nm. In Figure (5), the absorption peaks of YY leaf dye solution with methanol were found to be

537.00 nm, 608.00 nm, and 661.00 nm. The transmission peaks were 461.00 nm, 524.00 nm, 580.00 nm and 627.00 nm. The cut off wavelength from absorption spectrum was 519.8 nm. In Figure (6), the absorption peaks of the YY leaf dye solution with ethanol + methanol were found to be 537.00 nm, 608.00 nm, and 660.00 nm. The transmission peaks were 454.00 nm, 537.00 nm, 608.00 nm and 659.00 nm. The cut off wavelength from absorption spectrum was 521.6 nm.

All absorption peaks of the dye solutions of YY leaves lie between the visible ranges of 400.00 nm and 700.00 nm. The absorption abilities of dye solutions were closely that of chlorophyll at room temperature. The absorption spectra were compared with standard chlorophyll spectrum and these dye solutions were included in the chlorophyll-a.

The optical energy gap was calculated by Planck's Method given below (R. Syafinar et al, 2015):

$$E_g = \frac{hc}{\lambda} \quad (1)$$

where E_g is energy band gap (eV), h is Planck's constant, c is the speed of light, and λ is the wavelength (nm). Table (1) showed the variation of energy band gaps of YY leaf dyes combined with different solvents by using Planck's Method.

Table (1) Variation of energy band gaps of YY leaf dyes with different solvents by using Planck's Method

No	Dye Solutions	λ_{cut} (nm)	E_g (eV)
1.	Ethanol (EtOH)	523.4	2.36
2.	Methanol (MeOH)	519.8	2.37
3.	Ethanol+Methanol (EtOH+MeOH)	521.6	2.37

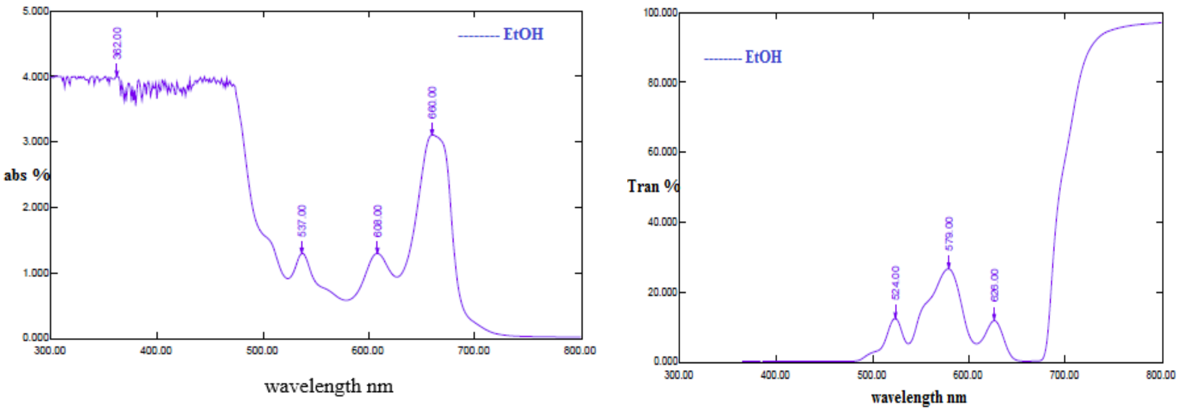

Figure (4) Absorption and Transmission spectra of YY leaf dyes with ethanol

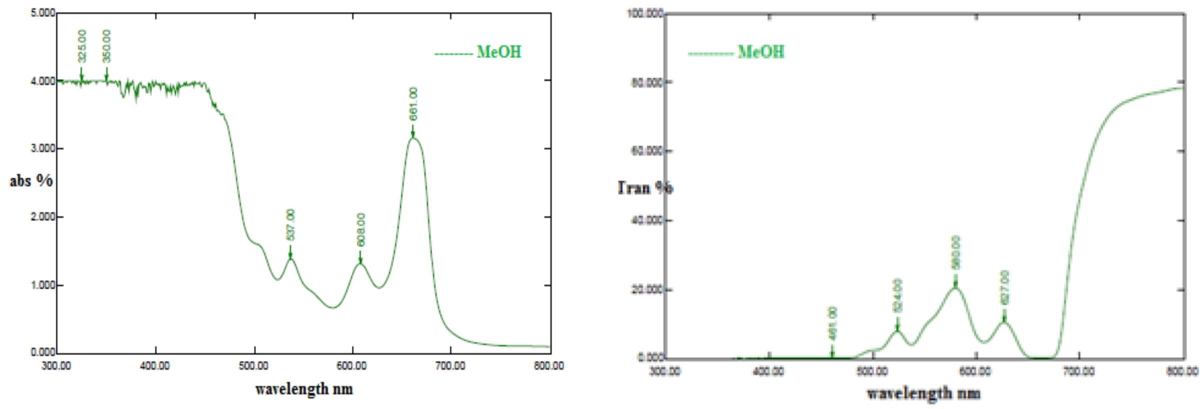

Figure (5) Absorption and Transmission spectra of YY leaf dyes with methanol

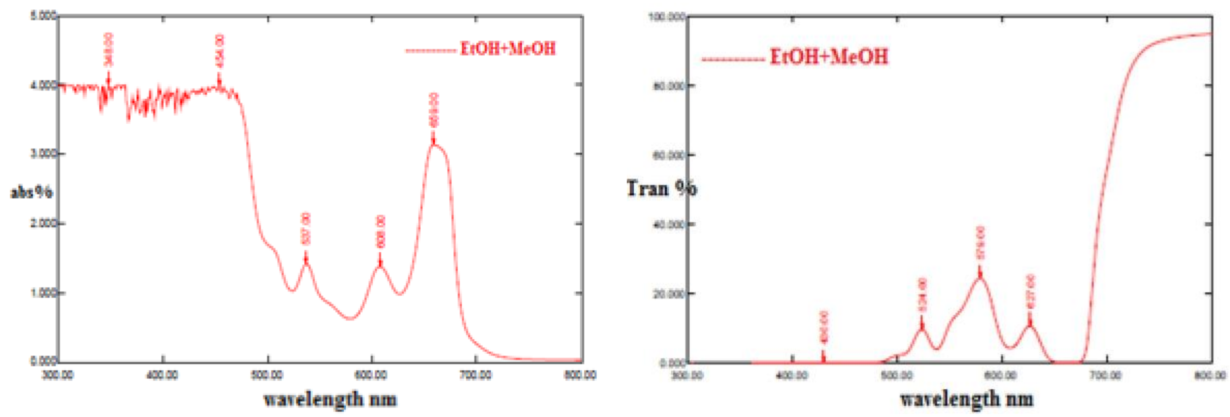

Figure (6) Absorption and Transmission spectra of YY leaf dyes with ethanol + methanol

The optical absorption coefficient was calculated from transmittance using the following relation (R. Syafinar et al, 2105);

$$\alpha = \frac{1}{d}\ln(T) \qquad (2)$$

where α is the absorption coefficient, T is the transmittance and d is the holder thickness, respectively (R. Syafinar et al, 2105).

The optical energy band gap (E_g) of the semiconductor is calculated by using Taue Method;

$$\alpha h\nu = K(h\nu - E_g)^{\frac{1}{2}} \qquad (3)$$

where h is Planck's constant, ν is the photon's frequency, α is the absorption coefficient, E_g is the band gap and K is a proportionality constant (Geetha G, 2015 & Nadir F. H, 2008). A plot of $(\alpha h\nu)^2$ versus hν shows an intermediate linear region, the extrapolation of the linear part can be used to calculate the E_g from intersect with hν axis. Figure 7, 8 and 9 revealed the plots of $(\alpha h\upsilon)^2$ vs hν for YY leaf dyes with different solvents. The optical band gap was obtained to be about 2.55 eV at ethanol, 2.56 eV at methanol and 2.56 eV at ethanol + methanol. Table (2) showed the variation of energy band gaps of YY leaf dyes with different solvents by using Taue Method.

Table (2) Variation of energy band gaps of YY leaf dyes with different solvents by using Taue Method

No	Dye Solutions	E_g (eV)
1.	Ethanol (EtOH)	2.55
2.	Methanol (MeOH)	2.57
3.	Ethanol+Methanol (EtOH+MeOH)	2.56

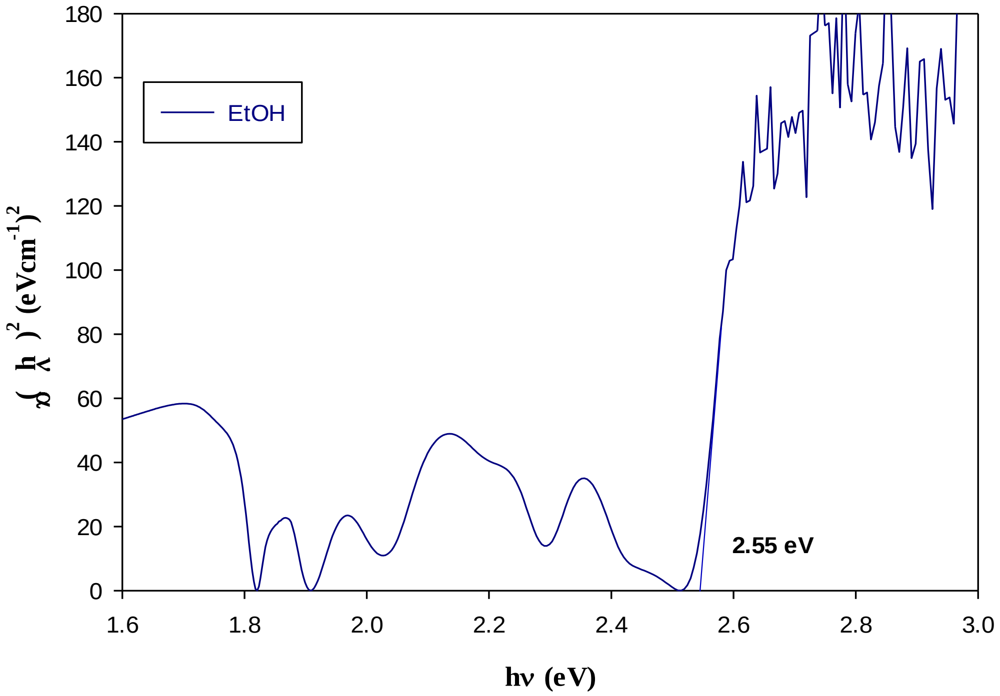

Figure (7) $(\alpha h\upsilon)^2$ vs hν for YY leaf dyes with EtOH

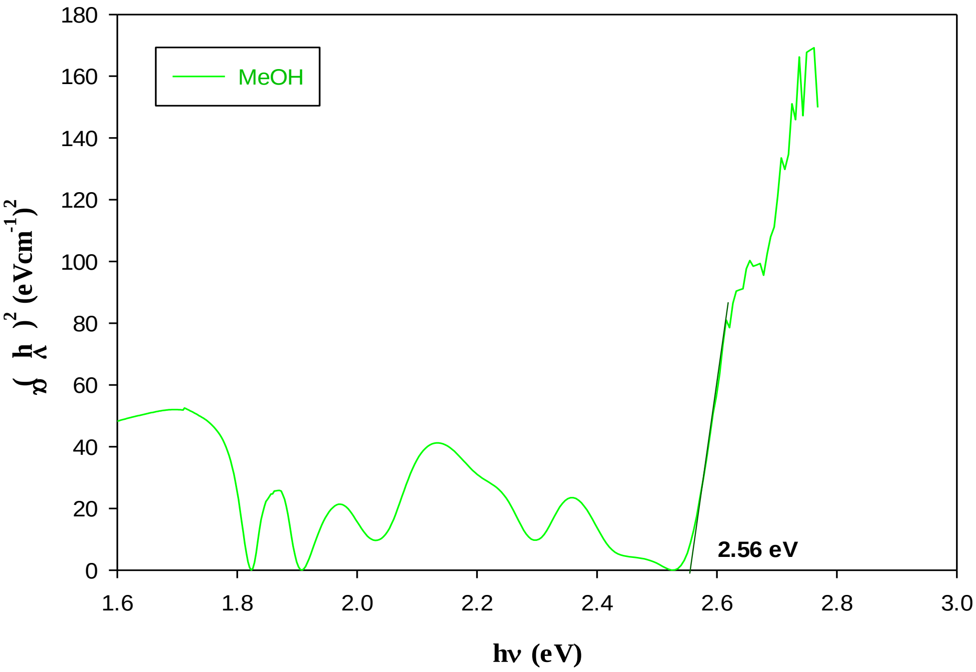

Figure (8) (αhν)^2 vs hν for YY leaf dyes with MeOH

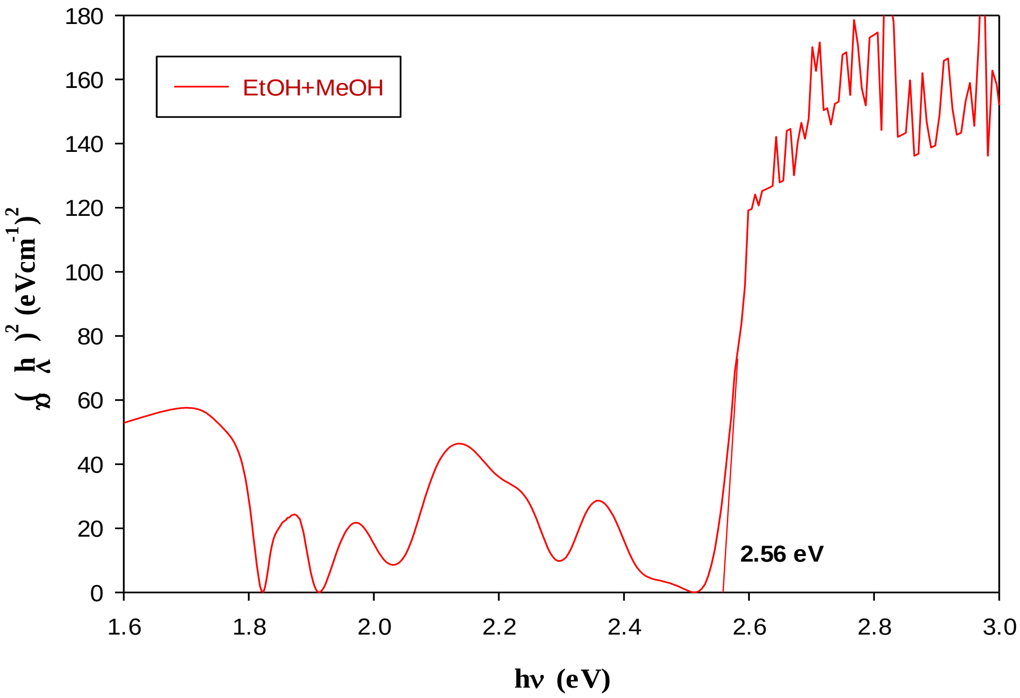

Figure (9) (αhν)^2 vs hν for YY leaf dyes with EtOH + MeOH

RESULTS AND CONCLUSION

Natural chlorophyll dye solutions were extracted from YY leaf dyes with ethanol, methanol and ethanol: methanol (V/V). And then its optical properties have been studied. According to UV-Vis analysis results, absorption peaks were found between 537.00 nm and

661.00 nm. In fact, all absorption peaks in the visible region indicated that the three samples exhibited the chlorophyll members. The band gap calculated from absorption spectra is about 2-3 eV. As the obtained results, it is concluded that these dyes are quite credible and useful for the application of dye sensitizer in DSSC. EDXRF analysis examined that calcium (Ca) and potassium (K) were mainly found in YY leaves. Ye-Yo (Morinda Angustifolia Roxb.) leaves can be used safely for public health because of its nutrition and they can support good health.

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