PREPARATION AND OPTICAL PROPERTIES OF SOME NATURAL DYES (IXORA COCCINEA &TRADESCANTIA SPATHACEA)

Aye Mya Khaing[1], Khaing Nway Win[2], Yin Maung Maung[3], Than Than Win[4]

Abstract

PoneNaYeik petal (**IxoraCoccinea**) and TainPyarTaungNyo leaf (**TradescantiaSpathacea**) dyes were extracted with acidified solvent, ethanol to study the effects of solvent type on the extraction. UV-vis spectrometer can analyze the optical properties of these natural extract dyes. Characterization results showed high absorbance values 0.5494, 0.5845 and 0.3994 at 450 nm for PoneNaYeik dye. The sharp absorbance values in this study were 1.5244, 1.0997, 1.3577 at 435 nm and 0.9136, 0.6518, 0.7981 at 665 nm for TainPyarTaungNyo. The electrochemical properties of these dyes were observed by cyclic voltammetry (CV). These were indicative of the extract can be used as dye sensitized solar cells. Fourier Transmission Infrared Spectroscopy (FTIR) indicated the structural properties of these dyes.

Keywords: Natural dyes, optical absorption, electrochemical properties, FTIR

Introduction

DSSC has been increasingly used because it provides high energy conversion efficiency. [Nurezyanic S et al 2017]. This type of cells exhibits potential for future photovoltaic applications because of its simple fabrication process, low manufacturing cost, low environmental impact, and flexibility. [R. Syafinar et al 2015] Natural dye solar cells are a sub category of organic solar cells. Natural dyes are relatively easy to obtain and extract from plants, fruits, flowers, and leaves, reducing the cost manufacturing of DSSC, as opposed to the production of synthetic dyes. [Zularif Z et al 2015] [Michael Grätzel 2003]

The natural dyes used in this study were obtained from petals of red colored IxoraCoccinea (coded as "PNY"), species- I. coccinea, family-

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Rubiaceae and leaves of Tradescantia Spathacea (coded as "TPTN"), species- T. spathacea, family- Commilinaceae by using ethanol solvent. These plants were found in various places of Myanmar. In this investigation, the samples were collected from Yangon region. The effect on temperature and band gap and molecular energy levels of extracting dyes were investigated systematically by UV-vis spectroscopy and cyclic voltammetry methods. FTIR spectral analysis was used to determine the functional group in the natural dye.

Experimental Procedure

Preparation of Dyes

25g of petals of Ixora Coccinea and 25g leaves of Tradescantia Spathacea, each of one was ground and mixed with 150 mL of 70% ethanol and then stored overnight in the refrigerator at 4°C. On the following day, the extracted samples were stirred using magnetic stirrer at 25°C, 45°C and 65°C for two hours. The procedure continued with the filtration of the samples to remove large residue. Subsequently, the extracts were centrifuged at 4000 rpm using a Denley BS400 (UK) centrifuge machine for five minutes to separate any remaining residues. After that the extracts were placed in a 45–50°C water bath to dissolve more pigments into the extracting solvent.

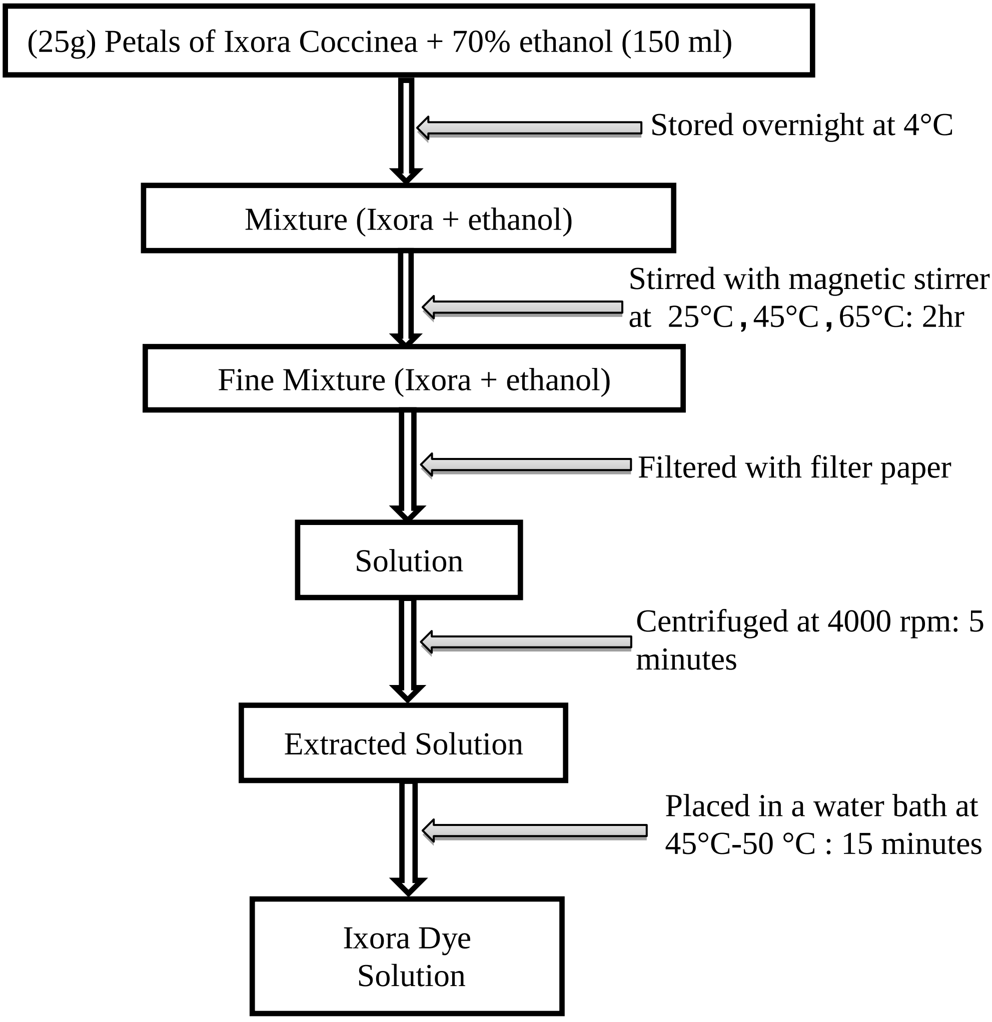


Figure 1: Flow chart of Ixora Coccinea dye extraction

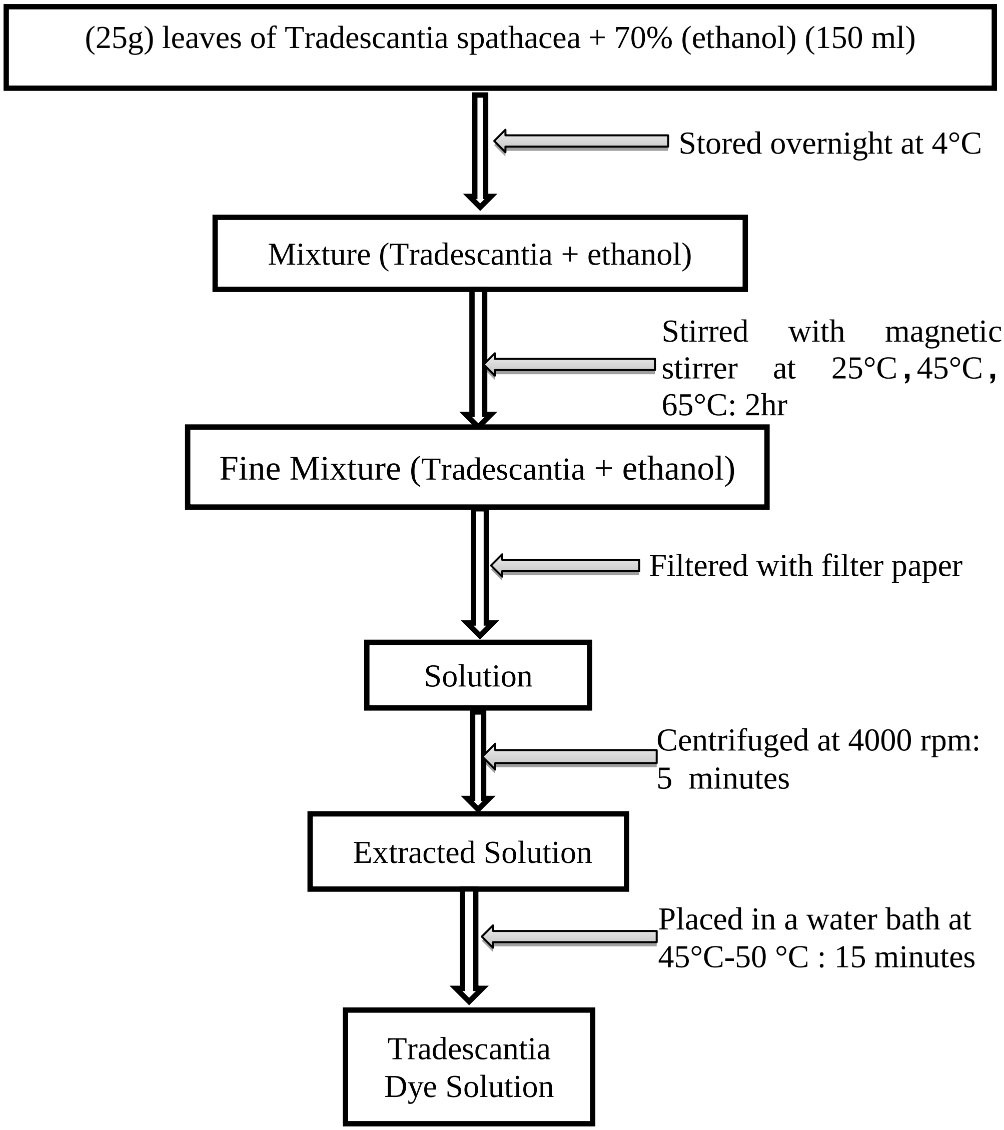


Figure 2: Flow chart of Tradescantia spathacea dye extraction

Characterization

The presence of anthocyanin and chlorophyll pigments in these natural dyes was determined by measuring their absorbance spectra using UV-Vis spectrophotometer (Shimadzu UV-1800, Japan). UV-vis spectroscopy can be used to measure the absorbance of ultra violet or visible light by organic dyes in the range of 400 nm to 700 nm. The functional groups of the sensitizers were determined via Fourier transform infrared spectroscopy (FTIR) (Perkin Elmer Spectrum 400 FT-IR).

Cyclic voltammetry Measurement

Cyclic voltammetry is a very suitable method for a wide range of applications and it is one of the standard techniques used for characterization. [Lucia L et al 2013] It is accomplished with a three electrode arrangement such as a glassy carbon working electrode, platinum counter electrode, and Ag/AgCl reference electrode at a scan rate of 50 mV/s. [P.Petovra et al 2013]

Results and Discussion

Figure 3 showed the optical absorption spectra of PoneNaYeik dye with different growing temperature, 25°C, 45°C and 65°C for the same concentration. It was found that the maximum absorption peaks were found at 450 nm dye solution of PoneNaYeik at 25 °C, 45 °C and 65 °C.

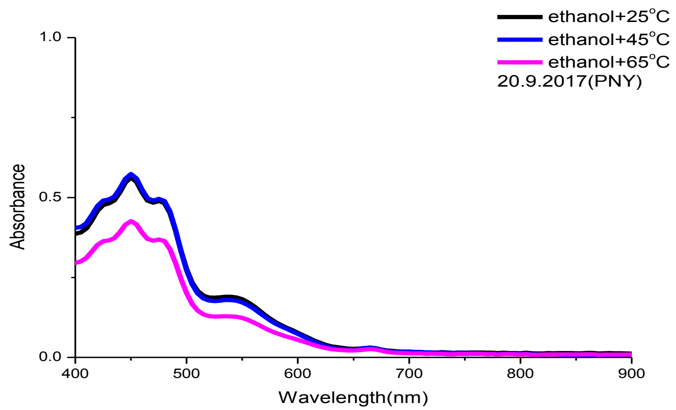


Figure 3: Optical absorption spectra of ***Ixora Coccinea*** (PoneNaYeik) dye extract in solvent ethanol (25^oC, 45^oC, 65^oC)

Figure 4 described the optical absorption spectra of Tain Pyar Taung Nyo dye at 25 °C, 45 °C and 65 °C for the same concentration. The sharp absorbance values were 1.5244, 1.0997, 1.3577 at 435 nm and 0.9136, 0.6518, 0.7981 at 665 nm for Tain Pyar Taung Nyo dye.

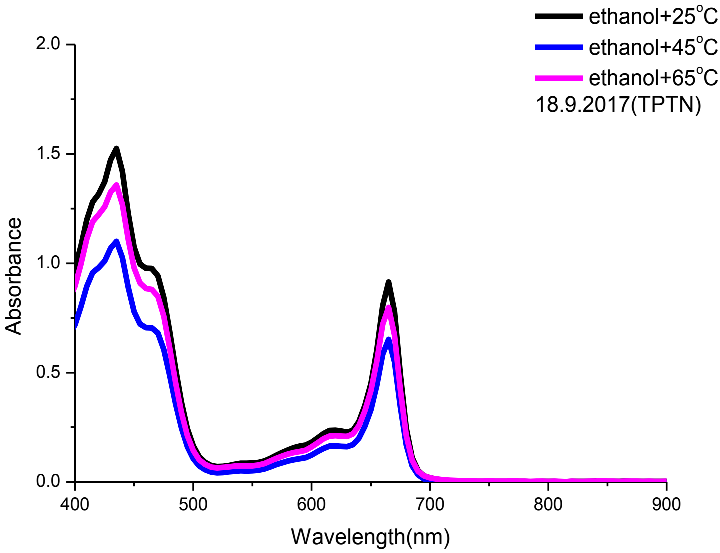


Figure 4: Optical absorption spectra of ***Tradescantia Spathacea*** (Tain Pyar Taung Nyo) dye extract in solvent ethanol (25°C, 45°C, 65°C)

Optical Properties the energy band gaps (E_g) of these samples at different temperatures were calculated by the following equation.

$$E_g = \frac{hc}{\lambda}$$

where $h =$ Planck's constant $= 6.626 \times 10^{-34}$ Js, $c =$ velocity of light $= 3 \times 10^8 ms^{-1}$ and $\lambda =$ wavelength

Electrochemical Properties

Electrochemical cyclic voltammetry (CV) was performed to determine the HOMO and the LUMO energy levels of the natural dyes. [P. Petrova et al 2013] Figure 5 (a-c) showed the cyclic voltammograms of Ixora Coccinea (PoneNaYeik) dye. Figure 6 (a-c) showed the cyclic voltammograms of Tradescantia Spathacea (Tain Pyar Taung Nyo) dye. The electrons from the lowest unoccupied molecular orbital (LUMO) and the highest occupied molecular orbital (HOMO) levels were determined from the following equations. [T.JAbodunrin et al 2015] [Changqing Ye et al 2012]

$$E_{Lumo} = -\left[E^{onset} + 4.4\right]eV$$

$$E_{Homo} = E_{Lumo} + E_g$$

The reduction onset potential E^{onset} is determined from the intersection of the two tangents drawn at the rising current and baseline of the CV traves. The optical band gap energies E_g were determined from the UV-Vis absorption spectra. The electrochemical energy levels and optical band gap energies of these dyes are listed in table 1 and 2.

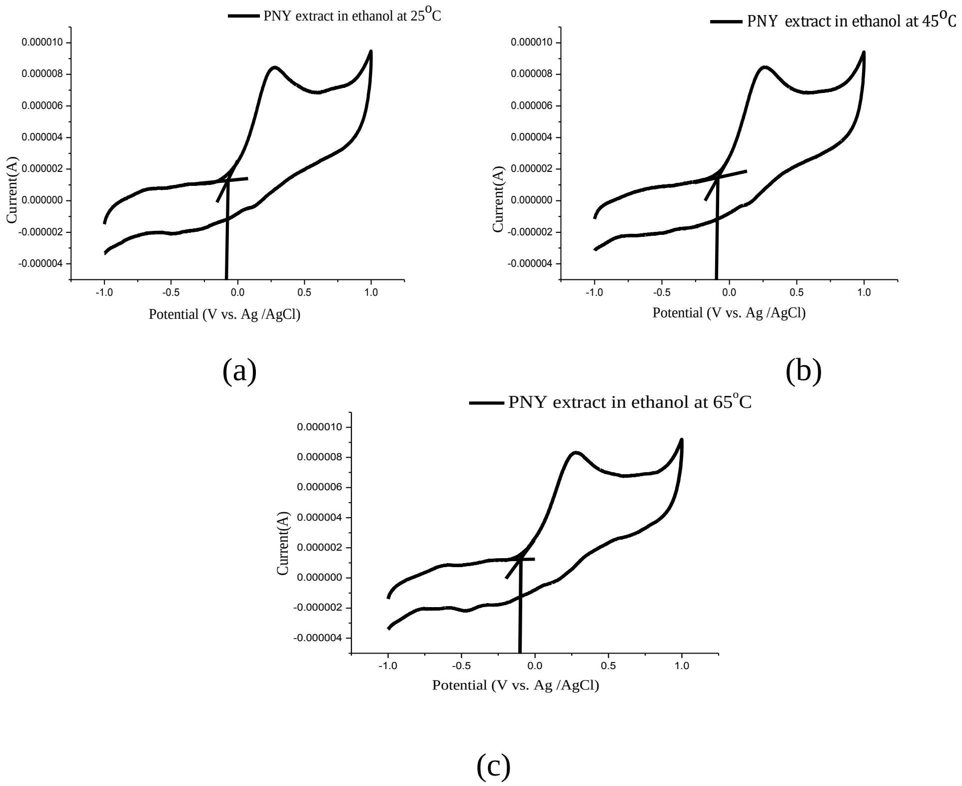
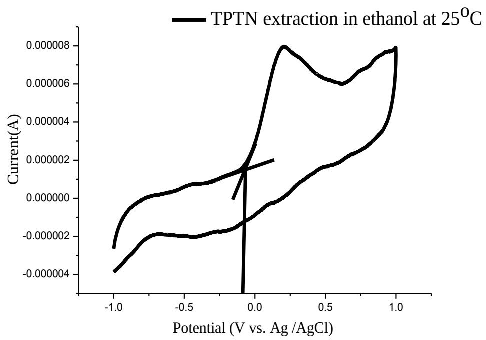
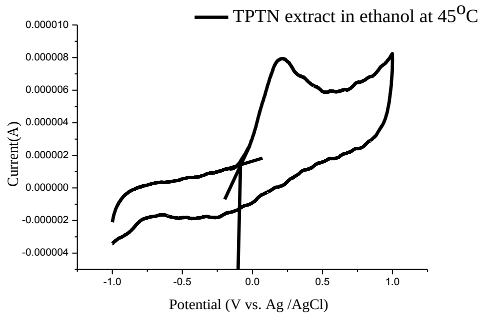


Figure 5: (a) The Cyclic Voltammetry curve for Ixora Coccinea at 25 °C, 2h
(b) The Cyclic Voltammetry curve for Ixora Coccinea at 45 °C, 2h
(c) The Cyclic Voltammetry curve for Ixora Coccinea at 65 °C, 2h



(a)



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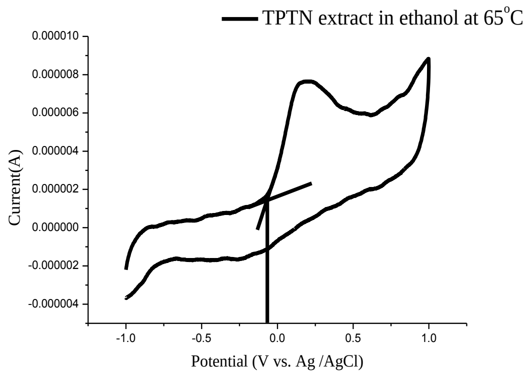

(c)

Figure 6. (a) The Cyclic Voltammetry curve for Tradescantia Spathacea at 25 °C, 2h
(b) The Cyclic Voltammetry curve for Tradescantia Spathacea at 45 °C, 2h
(c) The Cyclic Voltammetry curve for Tradescantia Spathacea at 65 °C, 2h

Table 1: Energy levels & Band gap energies for IxoraCoccinea (PoneNaYeik) at 25 °C, 45 °C and 65 °C, 2h

Temperature (℃)	Band Gap Energies (eV)	LUMO (eV)	HOMO (eV)
25	2.445	-4.484	-2.039
45	2.459	-4.496	-2.037
65	2.474	-4.496	-2.022

Table 2 : Energy levels & Band gap energies for Tradescantia Spathacea (TainPyarTaungNyo) at 25°C, 45°C and 65°C, 2h

Temperature (℃)	Band Gap Energies (eV)	LUMO (eV)	HOMO (eV)
25	2.533	-4.316	-1.783
45	2.538	-4.298	-1.760
65	2.533	-4.333	-1.800

FTIR Analysis

FTIR spectroscopic results of IxoraCoccinea with ethanol studied in Figure 7 revealed the presence of various chemical constituents in the extract of with various peaks values corresponding with 3371.68, 2933.83, 1732.13, 1612.54, 1523.82, 1442.80, 1363.72, 1251.84, 1064.74, 819.77, 767.69 and 609.53cm^{-1} stretching frequency when it was compared with the standard. The IR stretching frequencies at 3371.68 cm^{-1} could be due to the Alcohol O-H stretching frequency. The band at 2933.83 cm^{-1} was due to Alkane C-H stretching. A peak at 1732.13 cm^{-1}assigned Aldehyde C=O stretching. The bands at 1612.54 and 1523.82 cm^{-1}were due to Aromatic and Alkene C=C stretching. The IR stretching frequencies at 1251.84 and 1064.74cm^{-1} were due to Carboxylic acids, Ester C-O stretching and Anhydrides O-C stretching. A peak at 1442.80, 1363.72,819.77, 767.69 and 609.53cm^{-1} confirmed the presence of Sulphur compounds such as Esters S-OR and Sulphate S=O. [Asmaa Soheil Najm et al 2016] [Kasim Uthman Isah et al 2015] [Jayaprada Rao Chunduri et al 2016]

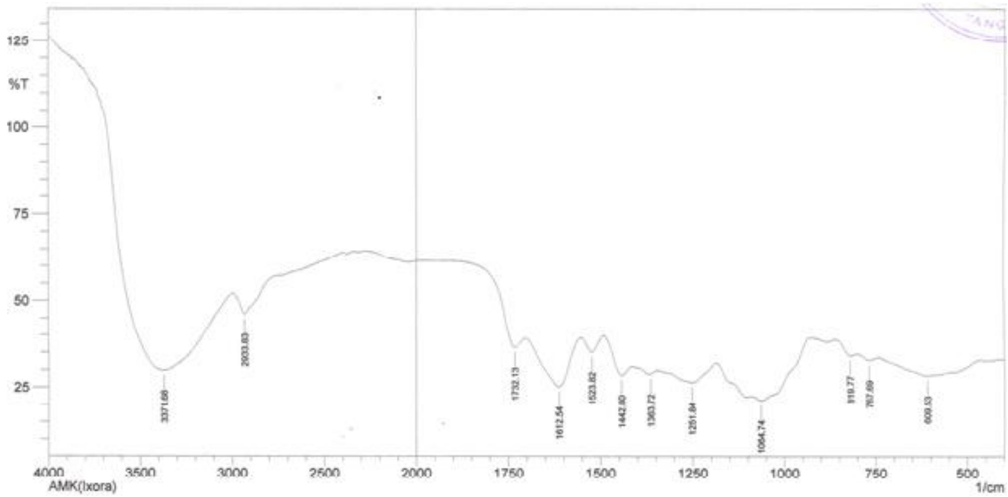

Figure 7: FTIR spectrum of IxoraCoccinea extracted from ethanol solvent

In the case of Tradescantia Spathacea with ethanol FTIR spectrum-Figure 8, the intense bands occurred at 2999.41, 2883.68, 2306.94, 1604.83, 1433.16, 1145.75, 1084.03, 966.37, 829.42, 763.84 and 694.40 cm^{-1}stretching frequency. 2999.41 and 2883.68 cm^{-1} stretching frequencies indicated the presence of Alkane C-H stretching and Carboxylic Acids O-H stretching. The bands at 2306.94 cm^{-1} was due to Phosphine P-H stretching and Silane Si-H stretching. The IR stretching frequencies at 1604.83, 1084.03,966.37, 829.42, 763.84 and 694.40 cm^{-1}could be due to the Nitrogen Compound Amines NH_2, C-N, NH_2 & N-Hand Amine Oxide (N-O) aliphatic stretching. The bands at 1433.16 and 1084.03cm^{-1}indicated the presence of Sulphur compound Sulphate S=O and Tricarbonyl C=S stretching. The peaks at 1145.75 and 966.37cm^{-1} were due to Phosphorous compound Phosphine oxide P=O, P-H and Phosphate P=O stretching. A peak at 1084.03cm^{-1} confirmed the presence of Silicon compound Silane Si-OR stretching frequency. [Asmaa Soheil Najm et al 2016] [Kasim Uthman Isah et al 2015] [Jayaprada Rao Chunduri et al 2016]

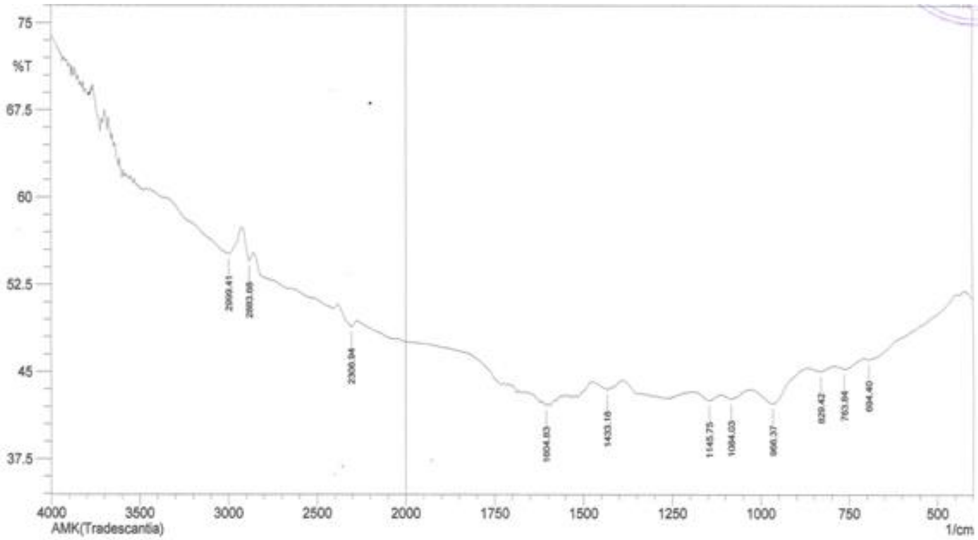

Figure 8: FTIR spectrum of Tradescantia Spathacea extracted from ethanol solvent

Conclusion

The natural dyes extracted from petal of ***IxoraCoccinea*** (Pone Na Yeik) and leaf of ***Tradescantia Spathacea*** (Tain Pyar Taung Nyo) were used to build dye-sensitized solar cells. They were characterized by UV-vis spectrophotometer. The absorption spectrum from UV-vis can give to calculate the maximum energy band gap. The results from this work for Ixora Coccinea dye are 2.445 eV at 25°C, 2.459 eV at 45°C and 2.474 eV at 65°C. In Tradescantis Spathacea dye, the results are 2.533 eV at 25°C, 2.538 eV at 45°C and 2.533 eV at 65°C. The energy band gaps of all these dyes are nearly to 2.5 eV for organic dyes. So the dyes extracted in this research work may be applied in use for a part of dye sensitized solar cells. According to the results of Cyclic Voltammetry measurements, the largest value of LUMO was found -4.496 at 45°C and 65 ^{o}C for IxoraCoccinea dye while -4.333 at 65 ^{o}C for Tradescantis Spathacea dye. The results of FTIR showed IxoraCoccinea dye and Tradescantis Spathacea dye solution were AMANO LIPASE Compound which contained Carboxylic acidic group. So the dye extracted in this research work may be applied in use for a part of dye sensitized solar cells.

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