EFFECT OF DIFFERENT UV CUT OFF WAVELENGTHS IN EVA ENCAPSULANT ON CR-SI PV MODULE'S PERFORMANCE & RELIABILITY

Ashish Singh & Rajesh Singh
RenewSys India Pvt. Ltd.,
Bommasandra – Jigani Link Road Industrial Area, Bangalore – 560 105, India
Phone: +91-80-33494545, Email: ashish.singh@renewsysindia.com

ABSTRACT: High energy UV radiations are harmful for polymeric materials such as Encapsulant & Backsheet used in the manufacture of PV modules. To protect the PV modules against UV degradation, EVA Encapsulant is added with additive, which cuts off the harmful wavelength present in the sunlight. The PV industry is gradually moving towards Lower UV cut-off wavelengths for the front side of EVA Encapsulant in order to harness the UV radiation up to 300nm, as against 360nm conventionally. The present study was performed to validate (i). The effect of lowering the UV cut off wavelength on the optical & mechanical properties of EVA Encapsulant. (ii). The effect of lowering the UV cut off wavelength on the performance & durability of PV modules.

The cured EVA sheet of 360 nm, 300 nm & 234 nm UV cut-off wavelengths were exposed to UV radiation of 340 nm wavelength up to 1500 hrs. The performance of the EVA sheets were analyzed by measuring optical transmittance, yellowness index & tensile strength. It was found that there is no effect of lower UV cut-off wavelength on optical & mechanical properties of EVA Encapsulant.

The solar PV modules were made using 360 nm, 300 nm & 234 nm UV cut-off wavelengths EVA encapsulants on the front side of the module and 360 nm on the back side. Each modules with these EVA Encapsulant were exposed to UV radiation of 280nm -385 nm wavelengths for 2000 hrs. It was found that up to 1500 hrs of exposer, the power loss in all there type modules were comparable. However, the power loss after 2000 hrs was higher in case of lower UV cut-off wavelengths Encapsulants. The UV cut-off wavelength of 360 nm for the front side of EVA is recommended to exhibit better reliability.

Keywords: PV module, Reliability,

1. INTRODUCTION

The UV cut off wavelength of an Encapsulant is the irradiation up to which the wavelength of the spectrum is absorbed / stopped by the Encapsulant. The irradiation having wavelength more than UV cut off wavelength range is transmitted through the Encapsulant and generate electricity when fall on a PV solar device.

The UV spectrum consists of short wave (100 nm – 285 nm, UV-C), medium wave (285 nm-315 nm, UV-B) and long wave (315 nm-400nm, UV-A). The short waves are almost completely absorbed by ozone layer of atmosphere and do not reach to earth. The medium waves are also partially absorbed by ozone layer of atmosphere and only the small portion reaches on the earth. These irradiations vary with respect to geographical locations and seasons. The long waves (black light) which are not absorbed by the ozone layer, reach to earth almost completely and we need to deal with it always, be it health, fading of colours, degradation of synthetic or natural beings.

The solar irradiations falling on solar PV modules reach to solar cells via Glass & EVA. The solar glass has UV cut off wavelength of 290 nm which is blocking almost 100 % of medium wavelength UV up to 290 nm.

Currently in PV Industry, people started using front EVA Encapsulant with lower UV Cut-off wavelength assuming that it generates some extra power. The back EVA has 360 nm UV cut-off wavelengths. The lower UV cut-off wavelength targeted between 300nm- 200nm.

There were several studies already done on EVA degradation caused by UV exposer in the form of loss in transmittance [1] and degradation of solar cell ARC coating [2].

The present study performed by us is to understand the effect of lowering the UV cut-off wavelength on optical & mechanical properties of EVA Encapsulant and the performance and durability of solar PV modules.

2 EXPERIMENTAL PROCEDURE

2.1 Experiment

A- UV exposer of cured EVA sheet having UV cut-off wavelength of 360 nm, 300 nm & 234 nm was performed up to 1500 hrs in QUV at 340 nm. The Yelloness Index, Optical Transmittance & Tensile Strength of exposed EVA samples were measured at an onterval of 500 hrs.

B- Three coupon modules (one cell module) were made using 360 nm, 300 nm & 234 nm UV cut-off wavelength EVA as a front and 360 nm as a back EVA for each sample. UV exposer of all coupon modules were done at: Intensity-1.36 W/m2, Wavelenghth-340 nm, temperature- 60°C, duration- 2500 hrs. Visual inspection of all there samples was done after 500, 1000, 1500, 2000 & 2500 hrs

C- Two modules were made using 360 nm, 300 nm & 234 nm UV cut-off

wavelength EVA in front and 360 nm in back EVA for each module. UV exposer on all modules was done at: Wavelength 280nm -385 nm, temperature- 60°C, duration- 2000 hrs. Visual inspection and power measurement of all samples were done after 500, 1000, 1500 & 2000 hrs.

3 RESULTS & DISCUSSIONS

3.1 UV exposer test of cured EVA sheet

UV exposer test was done on Eva having regular UV cut-off wavelength and lower UV cut off wavelengths to understand the phenomenon of UV dehradation. The reduction in transparancy, incraese in yellowing & reduction in retention of tesile strength are the sign of degradation of polymer under UV exposer. The all these parameters were measured post exposing 1500 hrs in UV test and results are shown in figure(1) & (2).

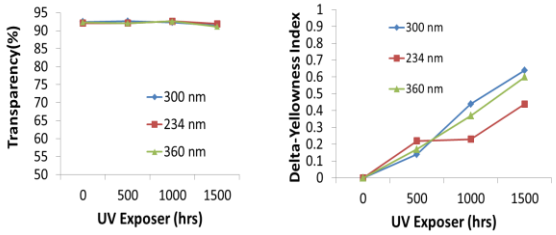

Figure 1: Optical performance of cured EVA sheet

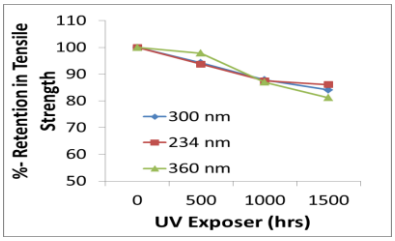

Figure 2: Mechanical performance of cured EVA sheet

The transparency of the EVA films have no significant reduction and it is consistent > 91% after 1500 hrs of exposer. The yellowness index has also identical trend in all EVA and change in yellowness index is <1.

The retention of tensile strength of all EVA is also identical and it has retention of 80 % which seems to be good. From above all data it is clear that the effect of lowering UV cut of has no significant effect on performance parameters of EVA sheet after 1500 hrs UV exposer test.

3.2 UV exposer of coupon modules

To simulate the effect of lower UV cut off in actaul module UV exposer test was conducted on coupan modules. In the actual module, the light isfalling on EVA via glass. The UV cut off wavelength of glass may change the results. The UV cut off wavelength of glass was also measured and it was found to be having 290 nm, this means that glass blocks UV light up to 290 nm.

To see the effect of Glass's UV cut-off on all EVA tested in section 3.1, coupan modules were made with same EVA. The front EVA was 360nm , 300 nm & 234 nm UV cut-off wavelength while back EVA is having 360 nm UV cut off wavelength in all coupons.

The UV exposer was done up to 2500 hrs at same test condition as mentioned in sec 2.1 (B). The visual inspection of cpupan modules were done to see any remarkable colour change due to EVA degradation

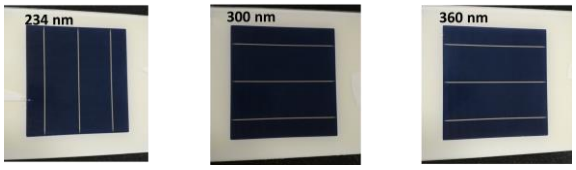

Figure (3): UV degraded cpoupon modules

There was no significant colour change found in any coupon modules post 2500 hrs. It seems that all EVA are having similar degradaion rate in UV exposer irrespective of UV cut-off wavelength.

3.3 UV exposer of Solar PV modules

The effect of lowering UV cut-off wavelength was done in section 3.1 & 3.2. To understand the effect of lower UV cut-off wavelength on module performance & durability, UV exposer test was done on solar PV modules having 360 nm, 300 nm, & 234 nm UV cut-off wavelength in front Encapsulant & 360 nm UV cut-off wavelength in back Encapsulant in all modules. There were two modules made using each type of front EVA. Apart from front EVA, remaining materials of the modules were identical.

The UV exposer test was done at test condition mentioned in section 2.1(C). The module's visual inspection, insulation test and power measurement was done after at 500 hrs interval. The control module was used to offset the module power data to prevent any error in module power due to flasher uncertainty.

There was no visual defect or color change observed in any nodule after 2000 hrs UV. The insulation resistant was found as per specification and having no effect of UV cut-off wavelength.

The power of each module after the interval of 500 hrs is shown in figure (4).

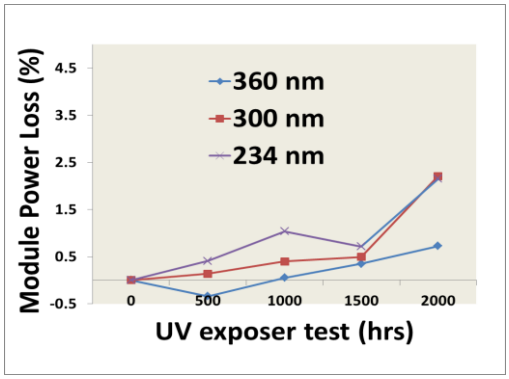

Figure 4: Module power after UV test exposer hrs

From the figure (4) it seems that the module output power loss is below 0.5% up to UV exposer of 1500 hrs in all the three module.

There was a sudden increase in power loss of modules made by lower UV cut off EVA after 2000 hrs exposer. The module made

with 360 nm front EVA has also power loss after 2000 hrs but is very minimal as compared to lower UV cut off wavelength EVA modules. The two possible reasons for power loss may be loss in transmittance of EVA [1] and due to solar cell ARC coating [2] The lower UV cut-off wavelength EVA allows more UV to fall on cell as compared to 360 nm UV cut off wavelength.

From the visual inspection, it was found that there was no color change observed in any module and suspect of transmission loss has very little probability.

4 CONCLUSION

The effect of lowering UV cut off wavelength was not found on EVA performance parameter but there was small power loss observed in module made with lower UV cut-off wavelength EVA as compared to conventional 360 nm UV cut-off wavelength. The reason may be due to loss in transmission of EVA or degradation of ARC coating or both. Lowering UV cut off wavelength seems a risky call for module durability and performance. The UV cut-off wavelength of 360 nm looks a better choice to have better EVA and hence module durability against UV light.

5 REFERENCES

1- C. G. Zimmermann, “Time dependent degradation of photovoltaic modules by ultraviolet light,” Applied Physics Letters, vol. 92, no. 24, p. 241110, 2008.

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