Developments in weatherable Polyester Films For Photovoltaic Applications

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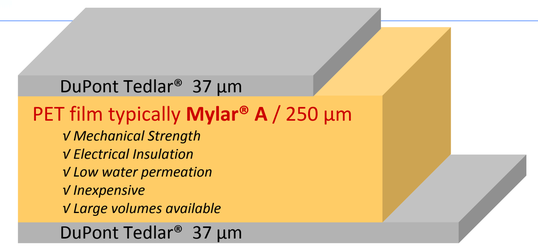
Polyester films have been used in c-Si PV module backsheets for many decades
E.g TPT ™ is a three-layer laminate of a poly(ethylene terephthalate) (PET) film such as Mylar® or Melinex® between two Tedlar® poly(vinyl fluoride) films:
PET chosen technically due to its excellent electrical insulation, low moisture permeation and high mechanical strength
PET chosen commercially because it is available in large volumes and relatively inexpensive vs other engineering polymers
PET restricted in the past to role as passive central layer due to standard grades having low hydrolysis and uv resistance

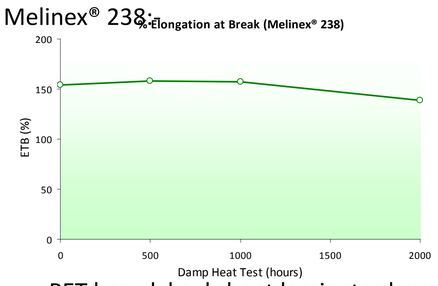
The fast growth of the PV market has been matched by the development of polyester films which are much more resistant to hydrolysis and uv degradation



PET film in TPT™ laminate structure

Hydrolysis Resistant PET Films

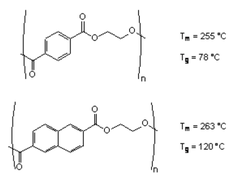
Chemistry dictates that standard PET film grades hydrolyse and therefore lose their mechanical properties when exposed to environments used for PV module testing eg the 85 Deg C /85% rh damp heat test . However PET films are now available which far exceed the 1000hr DHT eg Melinex® 238:

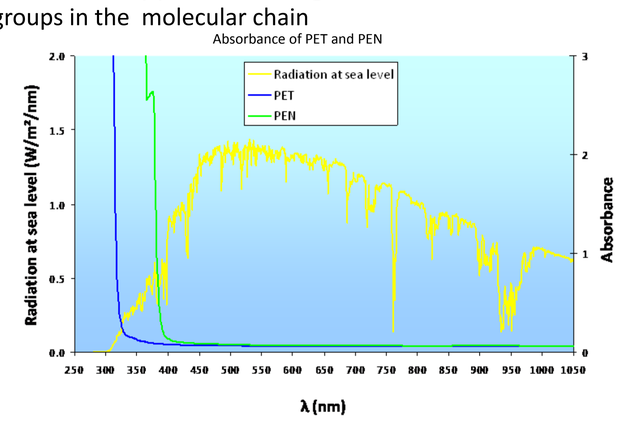


PET based backsheet laminates have been announced which go beyond even 3000 hours in the DHT

UV performance of PET and PEN polyester films

Unstabilised polyesters are chemically prone to uv degradation due to the presence of absorbing groups in the molecular chain





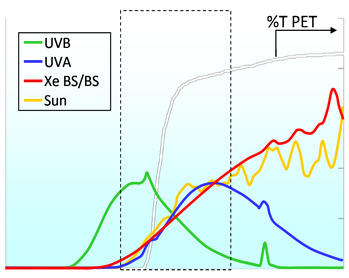
❑Upon UV light-induced degradation:

- Yellowness increases
  - formation of new light-absorbing chemical species
- Haze increases (clear films)
  - bulk + surface scattering
- Gloss decreases
  - surface roughens
- Light transmittance decreases
  - more absorption and scattering
- Mechanical properties i.e. %ETB, UTS decrease
  - chains break down

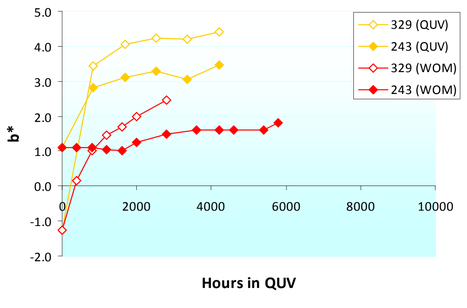
Off-the shelf polyester films would not be expected to pass comfortably standard PV qualification tests, but significant advances in polyester chemistry and polyester film production engineering have allowed the development and commercialisation of highly uv durable polyester films

Choice of weathering radiation source

Material durability is usually evaluated by accelerated weathering techniques. It may be tempting to use high energy light sources to accelerate aging.

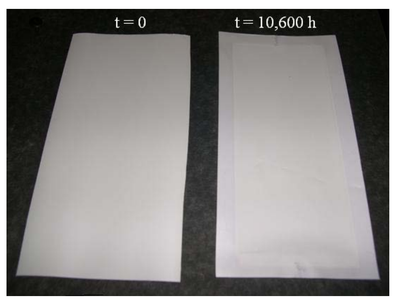


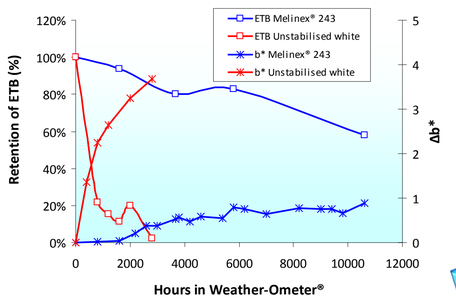
Radiation with λ < 300 nm, which occurs very little at sea level, will unnaturally age polymers and results will not correlate well with outside tests. UVB ageing is still used as a cheap but rather unreliable method to predict polymer lifetime. UVA also only emits in a specific portion of the UV light range and can be highly misleading since photooxidation of the initially generated yellow species happens upon exposure to the 370-430 nm range, a process known as photobleaching. Thus using a UVA lamp PET can appear yellower after UVA testing despite not much degradation having occurred.



White PET PV backsheet films

Weatherometer data again shows the effect of uv stabilising a white polyester film. The data below is for two films, Melinex® 329, a 50um thick standard white film and Melinex® 243, a stabilised 50 um film used for c-Si backsheets. After 10,600 hours Melinex®243 shows excellent retention of elongation to break and very little increase in yellowness, hardly noticeable by visual inspection.



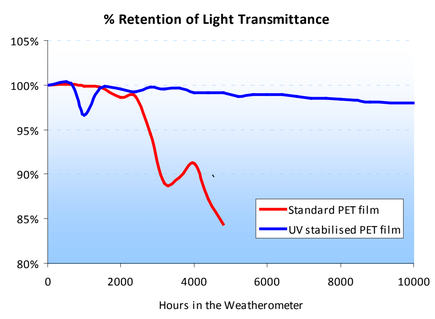


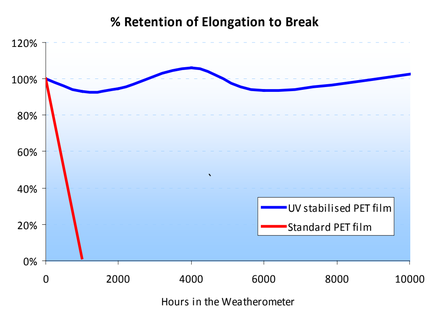
Estimation of PET backsheet lifetime

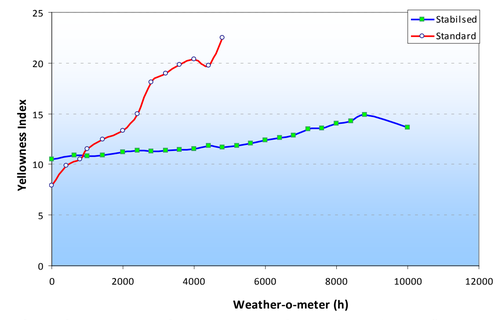
From intensity of lamp 1 year in Florida direct sunshine is 1637 hours in WOM
Back sheet not directly exposed to sunlight
•Most of irradiation typically by reflectance
Most surfaces will typically have 10 – 20 % reflection in wavelength range that causes degradation to PET
•So use 15 % reflection ie multiply exposures by factor of 1/0.15 = 6.7
•For 1637 hours in weatherometer = 1year in Florida direct sunlight
•1637 hours = 1x 6.7 years in Florida diffuse reflected
•25 years given by 25x1637/6.7= 6100 hours in weatherometer
•So 10000 hours sample above should safely simulate 25 years

UV stabilised polyester films

DTF has marketed uv stabilised PET films for over 20 years . Xenon arc lamp ageing in an Atlas Ci5000 Weather-Ometer® (calibrated at 0.55 W/m2/nm at 340 nm, according to ISO 4892-2) was used to age DTF UV-stabilised grades . Results for clear 175 um films are shown for the three main properties mentioned to be degraded by uv exposure in standard PET films in comparison with non uv stabilised films







This technolgy has been used in external applications for 20 years now and has recently been applied to white and black films used in PET/PET/EVA laminates for PV backsheets