Rapid evaluation of ethylene vinyl acetate degradation using online UV irradiation Py-GC/MS

[Background] Polymers are known to undergo photo, thermal and oxidative degradation when irradiated by ultraviolet (UV) light. The degree of degradation is often temperature dependent. Frontier Laboratories has developed an online UV irradiation UV/Py-GC/MS system[1)] which enables the analyst to determine the volatile products formed as a result of the UV irradiation. The residual polymer can be further characterized using evolved gas analysis (EGA)-MS[2)] or pyrolysis (Py)-GC/MS. Using this analytical system, the photo, thermal, and oxidative degradation of ethylene vinyl acetate (EVA) resin was studied.

[Experimental] A powdered EVA sample was placed in a sample cup having two side openings. The sample cup was attached to the optical fiber of the UV irradiator: UV-1047Xe (280-450 nm, 700 mW/cm^2) equipped with a xenon lamp (contains Hg). The cup was positioned in the furnace of the Multi-Shot Pyrolyzer (EGA/PY-3030D). The furnace temperature was 60ºC. The sample was irradiated for a given period of time in an air atmosphere. Volatile degradation products were cryo-trapped at the head of a separation column using liquid N_2. Upon completion of the irradiation, the liquid nitrogen trap was removed and the volatiles analyzed using GC/MS. The irradiated EVA residue remaining in the cup was then characterized using EGA-MS.

[Results] The chromatograms comparing the volatile compounds released from the EVA sample before and after UV irradiation are shown in Fig. 1. The major volatile degradation compounds released as a result of UV irradiation are acetic acid, formaldehyde, acetaldehyde, and acetone. The changes in the thermal properties of the EVA before, after 2 hours and after 20 hours of irradiation are shown in Fig. 2. It is apparent that after 20 hours, the peak apex temperature of the thermogram decreases 13ºC and the degradation peak is significantly broader. Also, the 20 hour desorption/degradation onset temperature decreases greatly. These results indicate that the EVA main-chain has been significantly altered as a result of the UV irradiation. These observations demonstrate that the UV/Py-GC/MS system is useful for the rapid characterization of the photo, thermal, and oxidative degradation of EVA polymer.

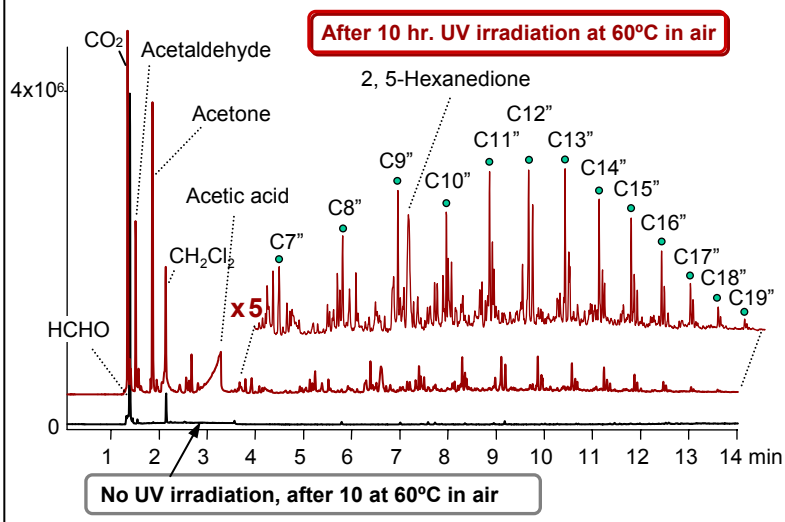

Fig. 1 Volatile degradation products formed during 10 hr.. of UV irradiation in air

TD temp.: 60 - 200ºC (20 ºC/min, 5 min hold)
GC oven temp.: 40ºC (2 min hold) - 280ºC (20 ºC/min)
Separation column: Ultra ALLOY$^+$-1 (dimethylpolysiloxane), L=30 m, i.d.=0.25 mm, df=0.5 µm
Column flow rate: 1 mL/min He, split ratio: 1/50, sample wt.: 0.1 mg

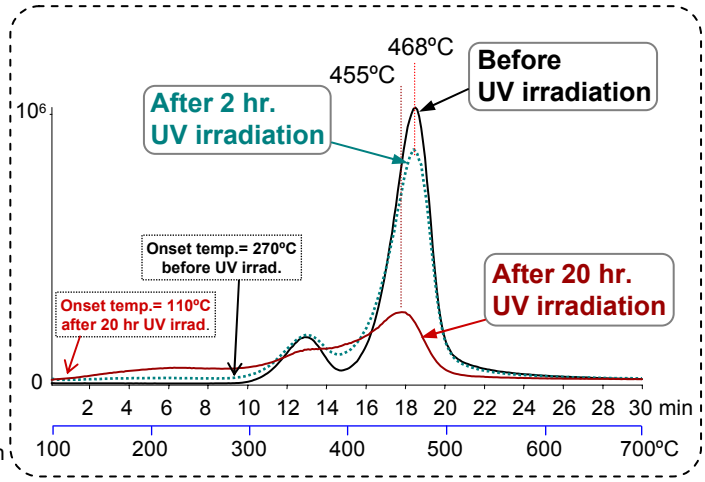

Fig. 2 EGA thermograms before and after UV irradiation

Py temp.: 100 - 700ºC (20 ºC/min)
GC oven temp.: 300ºC
EGA tube: deactivated metal tube, L=2.5 m, i.d.=0.15 mm,
Column flow rate: 1 mL/min He, split ratio: 1/50, sample wt.: 0.1 mg
Detector: MS (scan speed: 3 sec/scan)

Ref.:
1) C. Watanabe et al.; Polymer Degradation and Stability, 94 (2009) 1467-1472
2) Technical note PYA5-004E

Keyword : EVA, UV irradiator, Weather meter, EGA, “Photo, thermal, oxidative degradation”, Thermal desorption

Applications : Weatherability test

Related technical notes : PYA5-006E

Please forward your inquiries via our web page or send us a fax message.

R&D and manufactured by :
Frontier Laboratories Ltd.
1-8-14 Saikon, Koriyama,
Fukushima 963-8862 JAPAN
Phone: (81)24-935-5100 Fax: (81)24-935-5102
http://www.frontier-lab.com/