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TEST REPORT

Laboratory:	Era Polymers – Banksmeadow Research Centre	Test report No:	WR54845
Manufacturer:	Intrepid Industries Inc	Pages:	7
Product:	Instant Set Polymer (ISP)	Issue Date:	18/5/2021

Weather Resistance of Instant Set Polymer (ISP) using QUV Weather-o-meter

Resistance to ultraviolet degradation is often measured using a Weatherometer – an apparatus that causes accelerated degradation by exposing the sample to round-the-clock exposure at elevated temperatures. The sample degradation is observed after exposure to artificial weathering – including ultraviolet light – for a prescribed period.

The aim of the test is to compare the differences properties that occur when exposed to UV over time.

The apparatus used in the weathering test is an accelerated weathering tester 'QUV Weather-o-meter' Model: QUV / Spray – QUV with UV-B.



Samples were placed in the UV weatherometer for continuous cycles consisting of 4 hours UV radiation and 4 hours condensation with deionised water spray.

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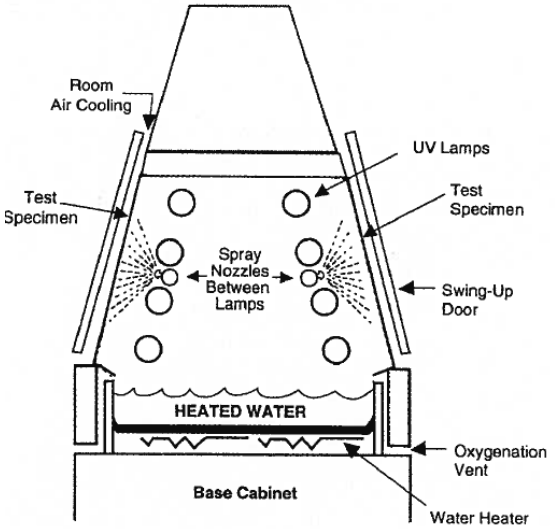

Water Spray System in Operation

Samples:

The samples for testing were prepared by Intrepid Industries Inc., La Porte, TX, USA.

Summary of results:

After 6 and 12 weeks of UV exposure, heat and moisture, Instant Set Polymer (ISP) showed excellent UV resistance with little change to the material properties.

Hours of Exposure:	1000 (6 weeks continuous UV-B radiation) 2000 (12 weeks continuous UV-B radiation)
Lamp:	UVB-313 EL Lamp, 0.46 watts/m²/nm (wavelength ~310nm)
Irradiance:	0.71W/m2/nm
Temperature:	45°C
Deionised water spray:	4 hours every 4 hours
Cycle:	4 UV hours @ 60°C, 4 hours condensation @ 50°C
Surface Color Change:	None
Surface Chalking:	None
Surface Cracking:	None

	Tensile strength /MPa	Elongation /%	Izod /KJ/m²	Hardness /Shore D	Impact resistance by large-diameter ball
Standard	ISO 37	ISO 37	ASTM D4812-11	ISO 868	ISO 4586-2
Initial	49.7 ± 3.7	5	19.1 ± 5	73	No change
after 1000hrs	47.7 ± 3.6	4	18.4 ± 5	72	No change
after 2000hrs	48.4 ± 3.6	3.3	18.3 ± 5	72	No change

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	FTIR	Tg (DSC) /°C
Initial	Initial	104
after 1000hrs	No change to bulk	105
after 2000hrs	No change to bulk	105

FTIR

Fourier-transform infrared spectroscopy (FTIR) is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. When IR radiation is passed through a sample, some radiation is absorbed by the sample and some passes through (transmitted). The resulting signal at the detector is a spectrum representing a molecular '**fingerprint'** of the sample.

FTIR RESULTS:

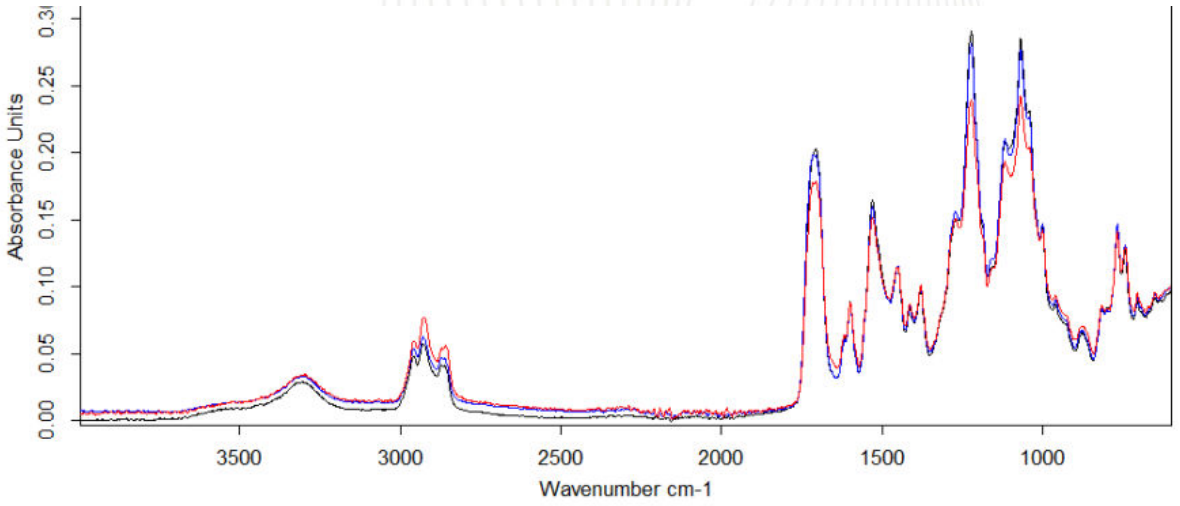
In the FTIR spectra below, there are NO additional peaks, or disappearance of any peaks, of the UV exposed and unexposed sections of the test sample when compared to the control.

The FTIR results show that after UV exposure the sample has not been adversely affected.

RED – Exposed surface on the 1000hr UV test sample

BLUE – Unexposed area of the 1000hr UV test sample (taken from under the Exposed surface to represent the bulk of the material)

BLACK – Control



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C:\Users\FTIR\Documents\Bruker\OPUS_8.5.29\DATA\MEAS\WR64906 - Intrepid control_20210323.2	WR64906 - Intrepid control	23/03/2021

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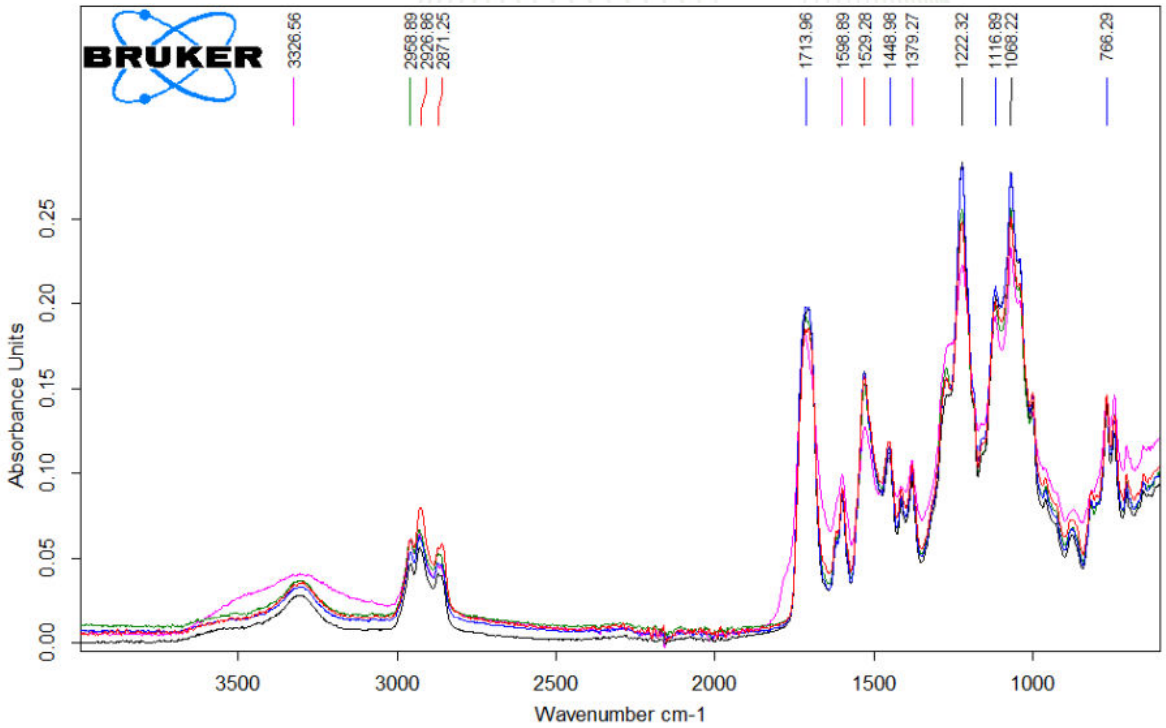
The spectra shows both samples, control (unexposed) and the exposed sample (1000 hrs). But you will see 3 graphs overlayed, the 3rd is under the UV exposed surface to confirm if there was any change and represents the bulk of the material.

From the FTIR spectra, we look for the **disappearance** of any peaks compared to the control, or the **appearance** of additional peaks as the material degrades.

The **height of the peaks are NOT significant**, as it represents the force we put on the sample to hold it down during the scan, the sample thickness, and the degree of contact between the sample and the sensor.

2000 hr UV exposure:
RED – Exposed surface on the 1000hr UV test sample
BLUE – Unexposed area of the 1000hr UV test sample (taken from under the Exposed surface to represent the bulk of the material)
BLACK – Control
GREEN - Unexposed area of the 2000hr UV test sample (taken from under the Exposed surface to represent the bulk of the material)
PURPLE – Exposed surface on the 2000hr UV test sample



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FTIR shows observable changes to the **exposed surface** after **2000 hrs of UV exposure**. The peaks in general are becoming more broad, especially prominent in the urethane peak at 1710 cm-1, signifying some degradation of the urethane linkages **on the surface**. However, under the exposed surface (representing the bulk of the material), there is **NO change**. This modified surface layer ("skin") continues to **provide a protective layer for the bulk of the material.**

DSC

Measurement of Tg by differential scanning calorimetry (DSC)

The glass transition temperature (Tg) of a polymer is the point when a hard, solid, amorphous material undergoes its transformation to a soft, rubbery, liquid phase. The Tg can shift to a lower temperature as the material softens or can rise as the material becomes more brittle with degradation.

a) From our experience, a **change greater than 10°C is significant** on the DSC.
b) The position on the vertical axis of the DSC curve is insignificant. Only the temperatures are meaningful.

The Tg results show that after 1000 hr UV exposure the **sample has not been affected**.
Tg remains unchanged after 2000 hr UV exposure.

Tg for the unexposed sample (control) is 103.74°C
Tg for the exposed sample (1000 hr) is 104.95°C
Tg still remains unchanged after 2000 hr UV exposure at 104.87°C.

The difference in Tg is not significant and the shape of the curve is unchanged.

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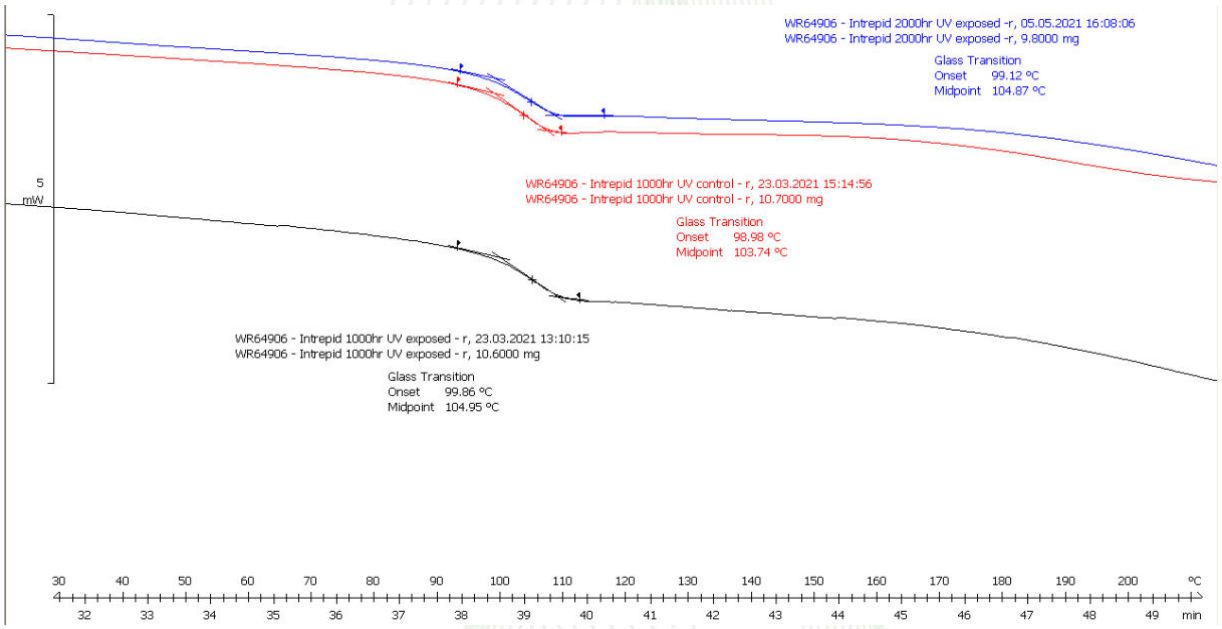
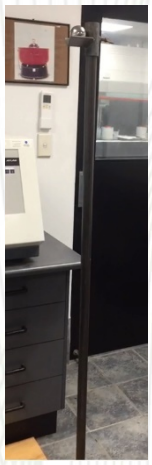


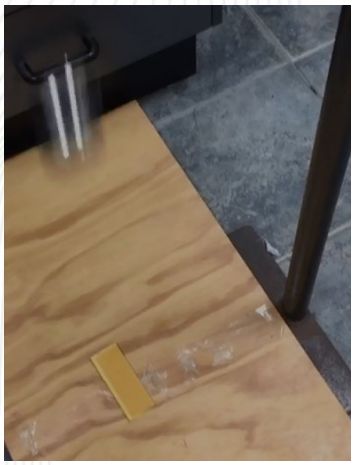
ISO 4586-2: 13 Resistance to impact by large-diameter ball

A specimen from the sheet under test (bonded to wood chipboard) is covered with a sheet of carbon paper and subjected to the impact of a steel ball which is allowed to fall from a known height. Impact resistance is expressed as the maximum drop height which can be achieved without incurring visible surface cracking or producing an imprint greater than a specified maximum diameter.

Apparatus:

Free-fall test apparatus, as shown in photo





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Polished steel ball, of mass 534 g and diameter 50 mm was used instead of 324 g ± 5,0 g and diameter 42,8 mm ± 0,2 mm, having no damaged or flattened areas on its surface.

Specimens:
Control: Intrepid polymer with no QUV exposure
Sample 1000hr: 1000 hours of QUV exposure
Sample 2000hr: 2000 hours of QUV exposure

Results:
No difference between results before QUV and after 1000 and 2000 hours QUV exposure

Product	Time of QUV Exposure /hour	Impact Resistance /cm	Indentation Diameter /millimetres	Observed cracking Yes/No
Control	0	170 (maximin limit of apparatus)	21	No
Sample 1000hr	1000	170 (maximin limit of apparatus)	21	No
Sample 2000hr	2000	170 (maximin limit of apparatus)	21	No

Deviation from the test method:

- Polished steel ball was much heavier than required: the steel ball used was 534g (50mm dia) instead of 324g.
- Highest height of apparatus is 170 cm

Jim Kostouros
Testing Officer