Light Stability Testing of Home and Personal Care Products

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Q-Lab Corporation
Q-Lab Corporation

- Founded in 1956
- Specialize in material durability testing equipment and services

Bolton, England
Q-Lab Europe

Cleveland, Ohio
Headquarters & Instrument Division

Shanghai, China
Q-Lab China

Saarbrücken, Germany
Q-Lab Outdoor Weathering Sites

Miami, Florida

Phoenix, Arizona

Cleveland, Ohio
Topics 1

- Weathering Testing vs. Light Stability
- Sunlight
- Interior Lighting
- Natural Exposures
- Xenon Arc Testing
  - Daylight and Window Spectra
  - Irradiance Control
  - Temperature & RH Control
Topics 2

• Fluorescent UV & Cool White Testing

• Testing Best Practices & Practical Considerations
Forces of Weathering

- Sunlight
- Temperature
- Moisture
Weathering Testing

- Simulation of sunlight—direct or through window glass
- Moisture (water spray) usually included
- Temperatures simulate realistic hot outdoor conditions
Light Stability

Sunlight

Artificial Light
Light Stability Testing

• Simulation of sunlight or indoor lighting
• No moisture
• May have RH control
• Test temperatures often simulate typical indoor environment
Definitions

Irradiance: The rate at which light energy falls on a surface, per unit area; usually given as W/m²

Spectral Power Distribution (SPD): Graph of irradiance vs. wavelength

Radiant Dosage: Irradiance x Time; accumulated light energy exposure per unit area over a period of time
Sunlight

- Direct
- Filtered through window glass
Sunlight--Direct and Through Window Glass

- Direct Sunlight
- Sunlight through Window Glass

Irradiance (W/m²) vs. Wavelength (nm)
Direct Sunlight

Noon Summer Sunlight/Air Mass 1
   – ASTM G177
   – CIE 85 Table 4
   – D65 (CIE & ISO)

Air Mass 1.5
   – ASTM G173
   – IEC 60904-3
Standard Sunlight Spectral Power Distributions

- CIE 85 Table 4
- SMARTS2 ASTM G177

Irradiance (W/m²/nm) vs Wavelength (nm)
Even Though It Is Only 5% of Sunlight...

UV Causes Most Photodegradation
## Wavelength Regions of UV

<table>
<thead>
<tr>
<th>UV - C</th>
<th>Found in outer space</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 – 280 nm</td>
<td></td>
</tr>
<tr>
<td>UV – B</td>
<td>Includes shortest wavelengths at earth’s surface: severe polymer damage; absorbed by window glass</td>
</tr>
<tr>
<td>280 – 315 nm</td>
<td></td>
</tr>
<tr>
<td>UV – A</td>
<td>Causes polymer damage</td>
</tr>
<tr>
<td>315 – 400 nm</td>
<td></td>
</tr>
</tbody>
</table>
Sunlight Spectrum – UV Region

![Graph of sunlight spectrum with wavelength on the x-axis and irradiance on the y-axis. The graph shows a rise in irradiance from 260 nm to 400 nm, with peaks and troughs indicating variations in irradiance across different wavelengths.](image_url)
Sunlight through Window Glass

![Graph showing irradiance vs wavelength for different thicknesses of glass.

- CIE 85 Table 4
- CIE 85 Table 4, 3 mm Glass
- CIE ID65, 6 mm glass]
Sunlight Through Window Glass

![Graph showing irradiance vs wavelength for different types of glass under direct sunlight.](image)

- **Direct Sunlight**
- **CIE 85 Table 4**
- **CIE ID65**
- **6 mm glass**
- **3 mm glass**

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**Light Stability Testing of Home & Personal Care Products**

*The most trusted name in weathering*
Interior Lighting
Commercial Indoor Lighting

SPD's of Common Indoor Lights
all at 500 lux - typical office or factory brightness

- cool white
- fluorescent
- high pressure sodium
- metal halide

Irradiance (W/m²)
Wavelength (nm)
Average Home Lighting

![Average Home Spectrum vs Glass-Filtered Fluorescent and Xenon](chart.png)
Natural Exposures
Natural Exposures

• Benchmark Commercial Sites
  – South Florida
  – Arizona Desert
  – Inexpensive
  – Reliable
  – Extreme environments create acceleration
  – “Scientific Window Sill Testing”
  – Convenient
# Florida Site

<table>
<thead>
<tr>
<th></th>
<th>Latitude</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$25^\circ\ 27'$</td>
<td>8 feet</td>
</tr>
<tr>
<td></td>
<td>North</td>
<td></td>
</tr>
</tbody>
</table>

| Annual Solar Energy:   | TUV $280\text{ MJ/m}^2$ | Total $6,588\text{ MJ/m}^2$ | %Sun $69\%$ |
| Under Glass           | $193\text{ MJ/m}^2$    | $5,416\text{ MJ/m}^2$        |             |

**Summertime Average Max Air Temp:**
- $32^\circ\text{C}$
- $90^\circ\text{F}$
### Arizona Site

<table>
<thead>
<tr>
<th></th>
<th>Latitude</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>33° 23’ North</td>
<td>1055 feet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Annual Solar Energy:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TUV</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>334</td>
<td>8,004 MJ/m²</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Under Glass</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>230</td>
<td>6,563 MJ/m²</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Summertime Average Max Air Temp:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40°C</td>
</tr>
</tbody>
</table>
DIY Natural Exposures
Xenon Arc
Q-Sun Xenon Test Chamber
Optical Filters

Daylight Filters
(exterior exposures)

Window Glass
(indoor exposures, textiles, inks, etc.)

Extended UV
(automotive, aerospace, etc.)
Light Spectrum

• Critical Factor
• UV “cut-on” or “cut-off”
• Not all “Window” or “Daylight” filters are the same
• Commercial filter names create confusion
Xenon with Daylight Filters

![Graph showing irradiance vs. wavelength for different light conditions: Daylight - B/B, Daylight - Q, Direct Sunlight, Daylight - F]
Daylight Filters – UV Region

Irradiance (W/m²) vs Wavelength (nm)

- Daylight - B/B
- Daylight - Q
- Daylight - F
- Direct Sunlight
Xenon with Window Filters vs. CIE85 through 3mm Glass

Irradiance (W/m²)

Wavelength (nm)

Window-Q
Window-B/SL
Window-IR

CIE 85 Table 4, 3 mm Glass

Light Stability Testing of Home & Personal Care Products

The most trusted name in weathering
Xenon with Window Filters vs. CIE85 through 3mm Glass

Irradiance (W/m²)

Wavelength (nm)

280 300 320 340 360 380 400 420

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4

Window-Q

Window-B/SL

Window-IR

CIE 85 Table 4, 3 mm Glass
Xenon with Window Filters vs. ID65 (6mm glass)
Xenon with Window Filters vs. ID65 (6mm glass)
Irradiance Control

• Narrow Band
  – 340 nm
  – 420 nm

• Total UV (300-400 nm) Wide Band

• Global (300-800 nm) – not recommended
  – Shorter wavelengths cause more photodegradation
  – Fails to account for xenon lamp aging
Narrow Band Control

Sensor detects single wavelength and maintains constant irradiance at that wavelength.

420 nm Control

340 nm Control

Sunlight thru glass

Q-Sun Window - Q

Irradiance (W/m²/nm)

Wavelength (nm)
Wide Band Control -- TUV

Sensor detects energy from 300 to 400 nm and maintains constant irradiance
Global Control (300-800 nm)

Sensor detects energy from 300 to 800 nm and maintains constant global irradiance.

Sunlight thru glass

Q-Sun Window - Q

Irradiance (W/m²/nm)

Wavelength (nm)
Irradiance Control Points

Example: Window B/SL Filter
These represent the same intensity:

<table>
<thead>
<tr>
<th>Control Point</th>
<th>Irradiance</th>
</tr>
</thead>
<tbody>
<tr>
<td>340 nm</td>
<td>0.35 W/m²</td>
</tr>
<tr>
<td>420 nm</td>
<td>0.95 W/m²</td>
</tr>
<tr>
<td>TUV (300-400 nm)</td>
<td>43 W/m²</td>
</tr>
<tr>
<td>Global (300-800 nm)</td>
<td>442 W/m²</td>
</tr>
</tbody>
</table>
Temperature Control

• Black panel
  – Hotter than ambient in sunlight
  – Not necessarily same as specimen temperature
  – Exists for test repeatability and reproducibility

• Chamber air
  – Controlled somewhat independently
  – More relevant for some applications

• Chiller System
  – Removes heat to allow normal indoor temperatures inside xenon arc test chamber
Black Panel Temperature

Two types of black panels!
QUV Fluorescent UV Weathering Tester and Cool White Light Stability Tester
QUV Specimen Holders
QUV Spectra vs. ASTM G177 Sunlight

- ASTM G177 Sunlight
- QUV with Cool White, 20 kLux
- QUV with UVA-340
- QUV with UVA-351
UVA-340 Lamps

Sunlight (ASTM G177)

UVA-340

Irradiance (W/m²)

Wavelength
Cool White Lamps

QUV/cw Spectral Power Distribution

Irradiance (W/m²/nm) vs. Wavelength (nm)
Best Practices for Light Stability Testing

1. Perform natural exposures
   – Necessary for understanding accelerated results
   – Does lab test correctly rank material performance?
Best Practices for Light Stability Testing

2. Test until failure (forced degradation)
   – Required for drug products
     • Identify impurities resulting from photodegradation
     • Determine degradation pathways
   – Necessary for developing rank order performance
Best Practices for Light Stability Testing

3. Expose a control with your test specimen
   • Use Control Material of Known Durability
     – Outdoor performance
     – Lab performance
   • Similar Composition to Test Material
   • Similar Degradation Mode to Test Material
Benefits of a Control

• Compare performance of control to a known material
• Allows confidence in lab exposure
• Assure that lab tester is operating properly
Example: Correlation using Control Material

• Background
  – New products must be lightfast
  – Ingredients to make it lightfast are expensive
Correlation with Control Material

- Selected a control product
- Included control with all new product testing
- Test 36 hours
- If new product fails, add lightfastness ingredients
- Retest
Best Practices for Light Stability Testing

4. Test your product “In the package” in order to simulate the actual service environment.
Conclusions

• Understand and define the service environment
• Define what constitutes product failure
• Obtain real world results
• Define evaluation method and understand the variability
• Test both constituent parts, finished product and product in packaging
Questions?