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Soak Up the Sun: Exploring the Ability of Quantum Dots to Increase PAR Transmission in Seaman Corporation's *Dura-Grow* Greenhouse Film to Improve Plant Growth

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Background and Significance

Importance of Greenhouses

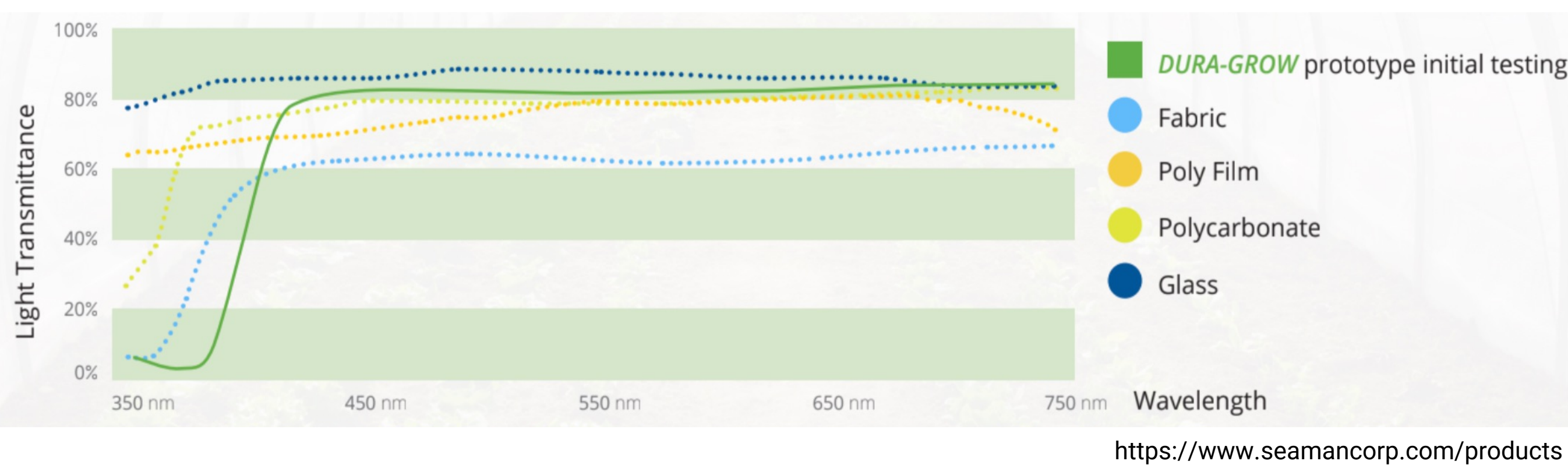
- Combats growing global food demand
- Controlled environment
- Allow solar radiation (SR) absorption and factor manipulation
- Supply produce during off-season
- Protects from pests and adverse climates

Plant Growth Factors

- Sunlight is key component for plant growth
- SR ranges from ultraviolet (UV) to infrared (IR)
- SR region between 400-700 nm used for photosynthesis
 - Photosynthetically active radiation (PAR)

Product Improvement

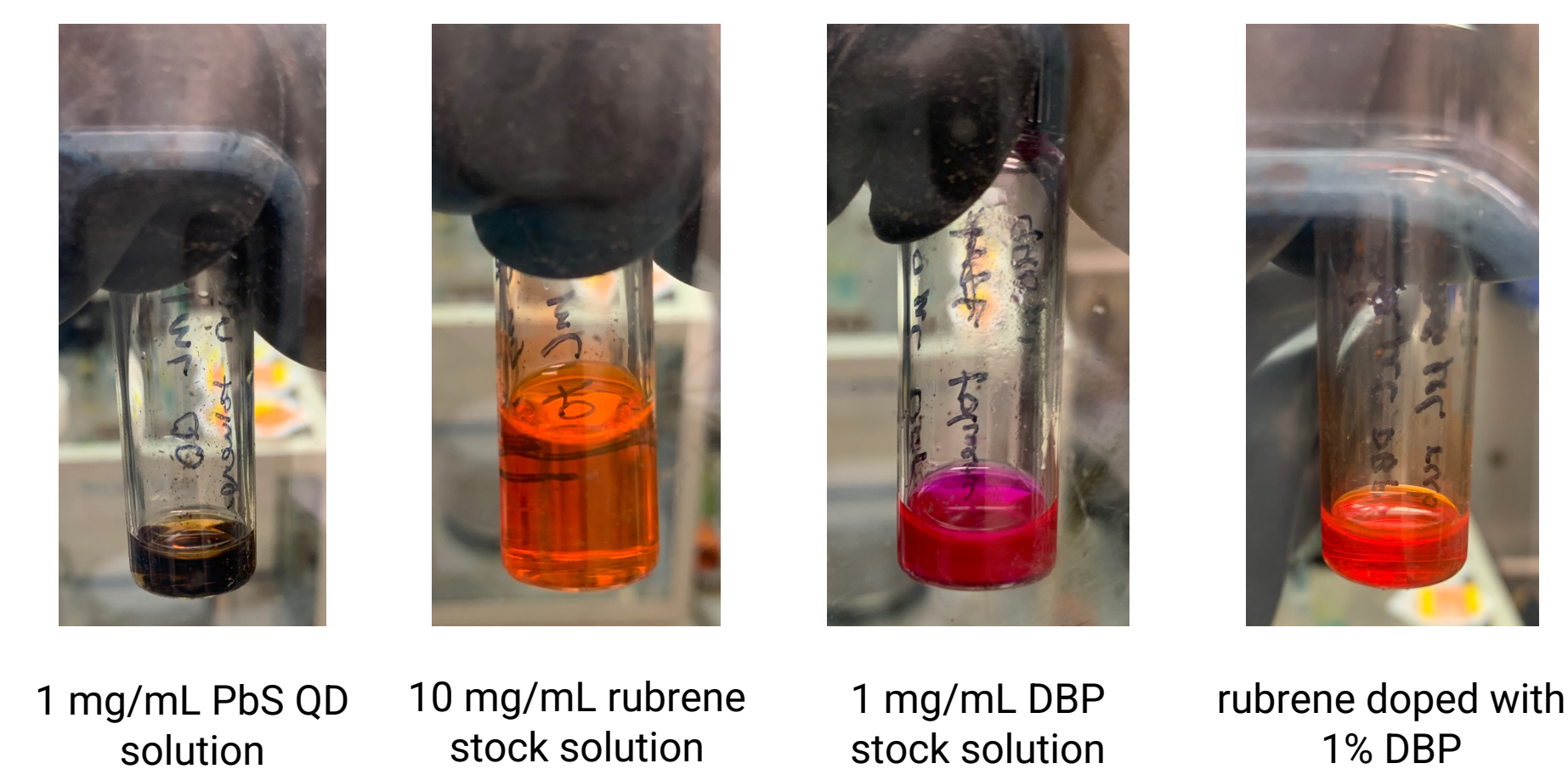
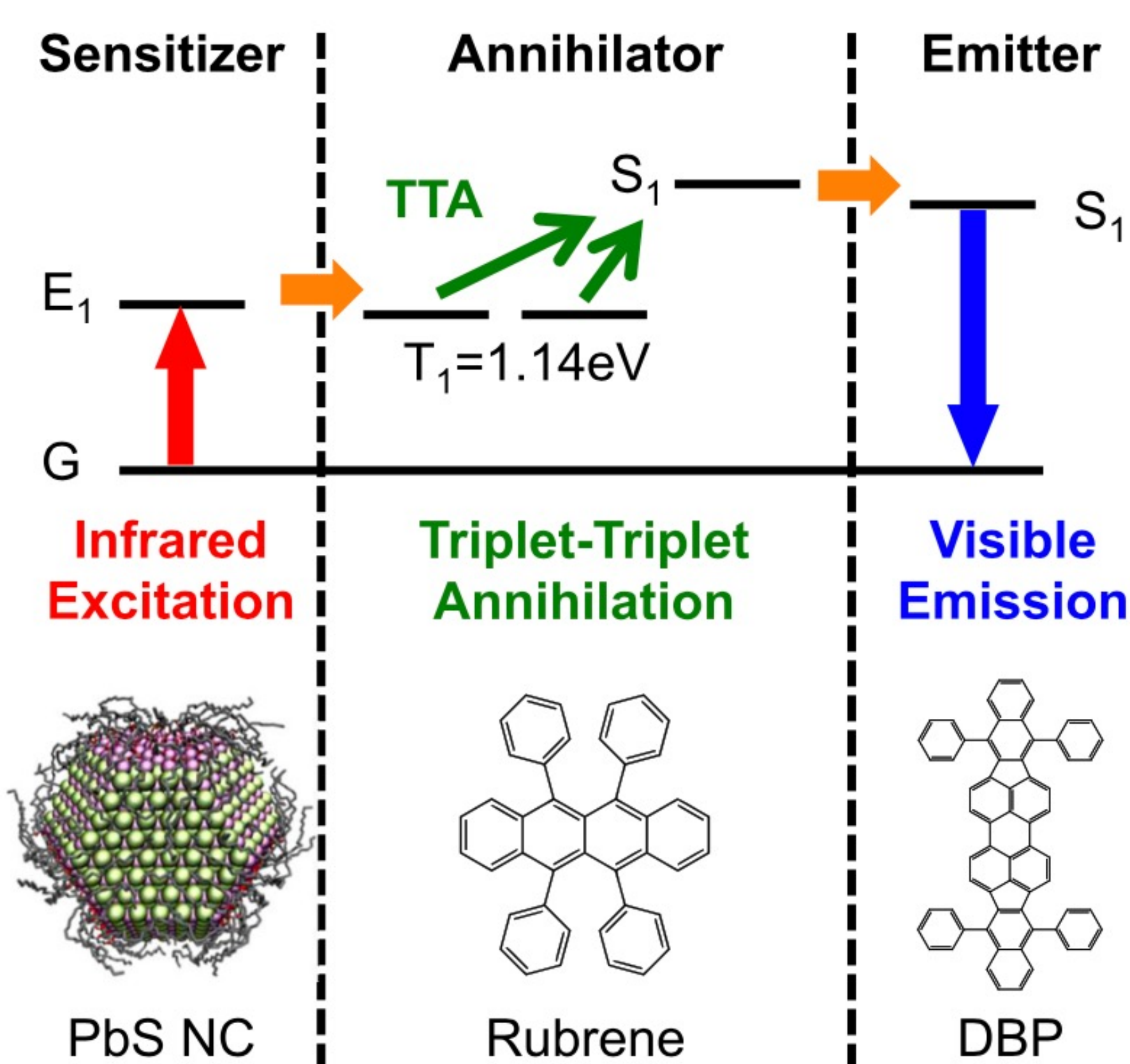
- Highly transparent material important in greenhouses to maximize plant growth
- **Seaman Corporation** developing *Dura-Grow HD10*
 - Cost-effective, high transmission rate, long lifespan
- Direct correlation between increased PAR transmission and increased crop growth



Goal: Convert unproductive SR wavelengths in the IR region into wavelengths within the PAR region to increase crop yield

PbS Bilayer Device

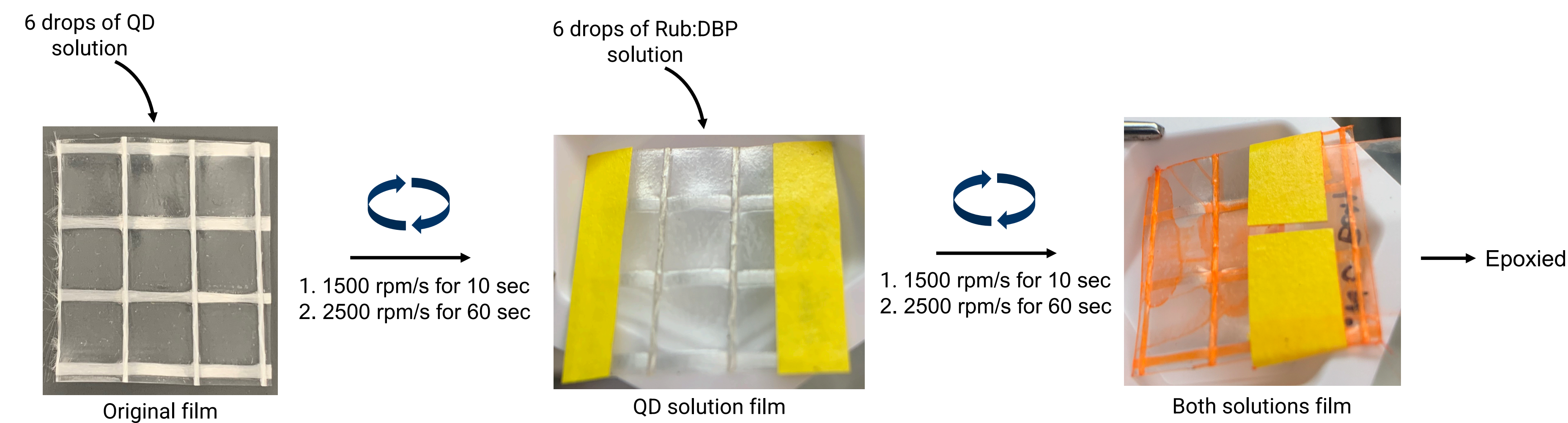
Photon Upconversion Mechanism



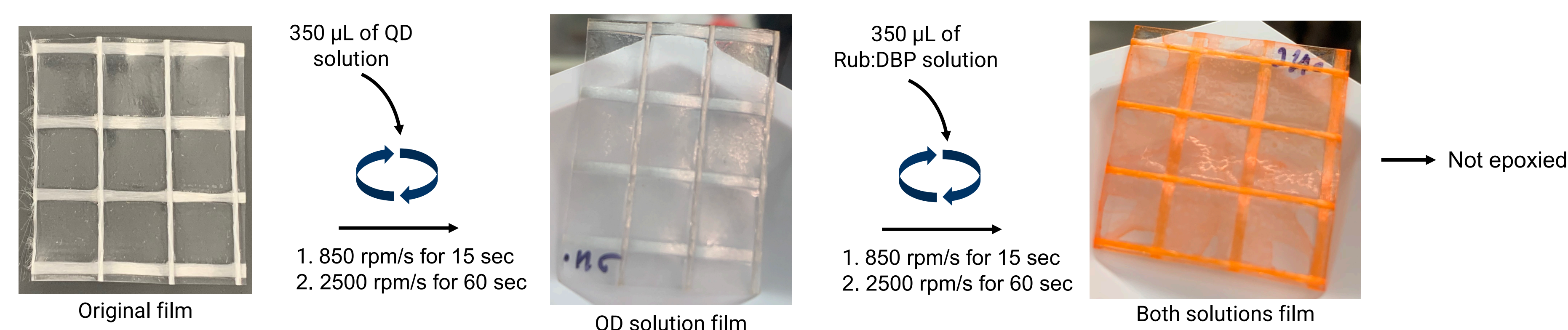
Application Parameter Optimization

Performed under nitrogen atmosphere | Used pre-synthesized QD with known emission (900 nm) | Solutions applied via spin coating

Initial Conditions



Optimized Conditions



Initial

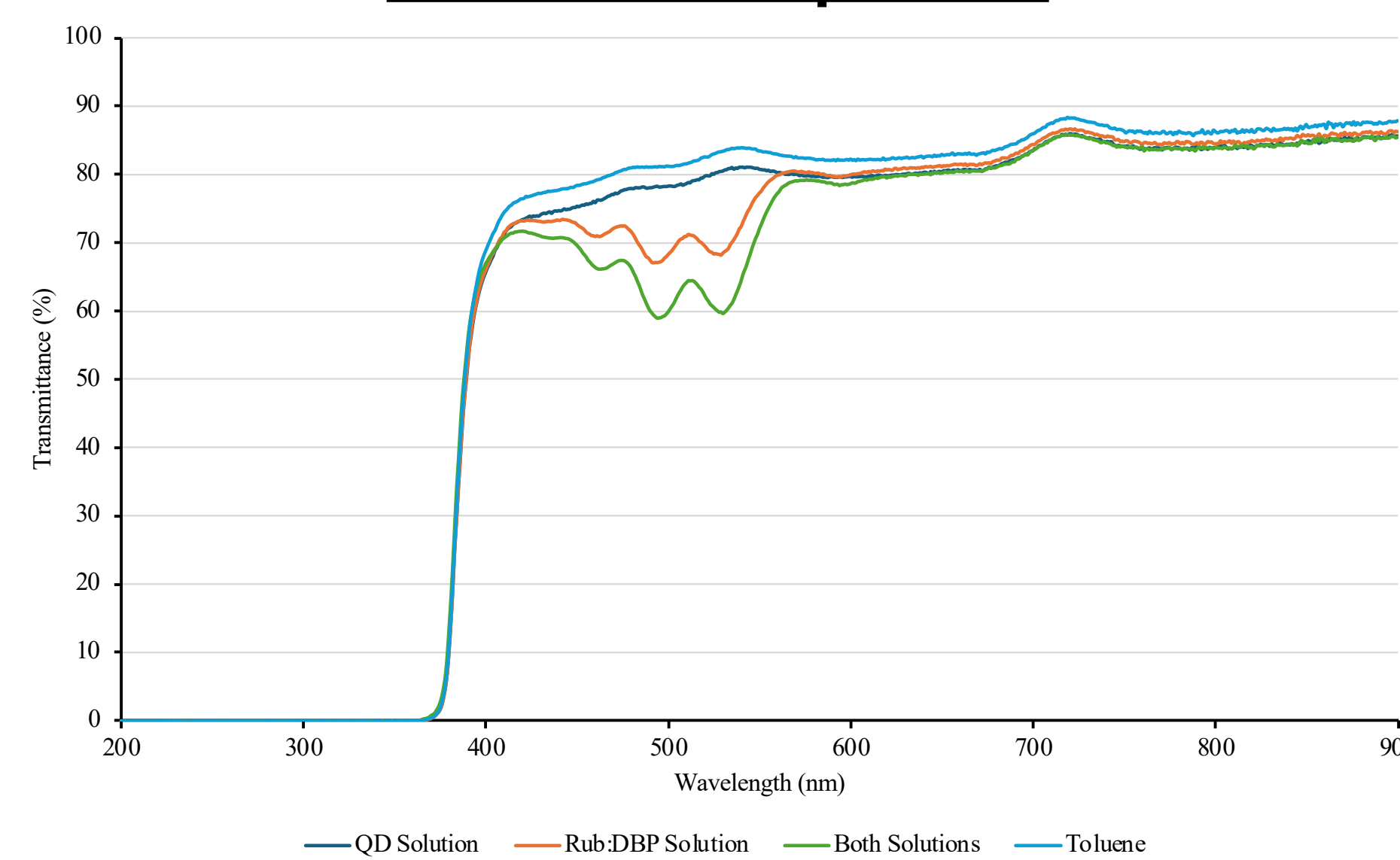
- Uneven application
- Epoxy prevents characterization

Optimized

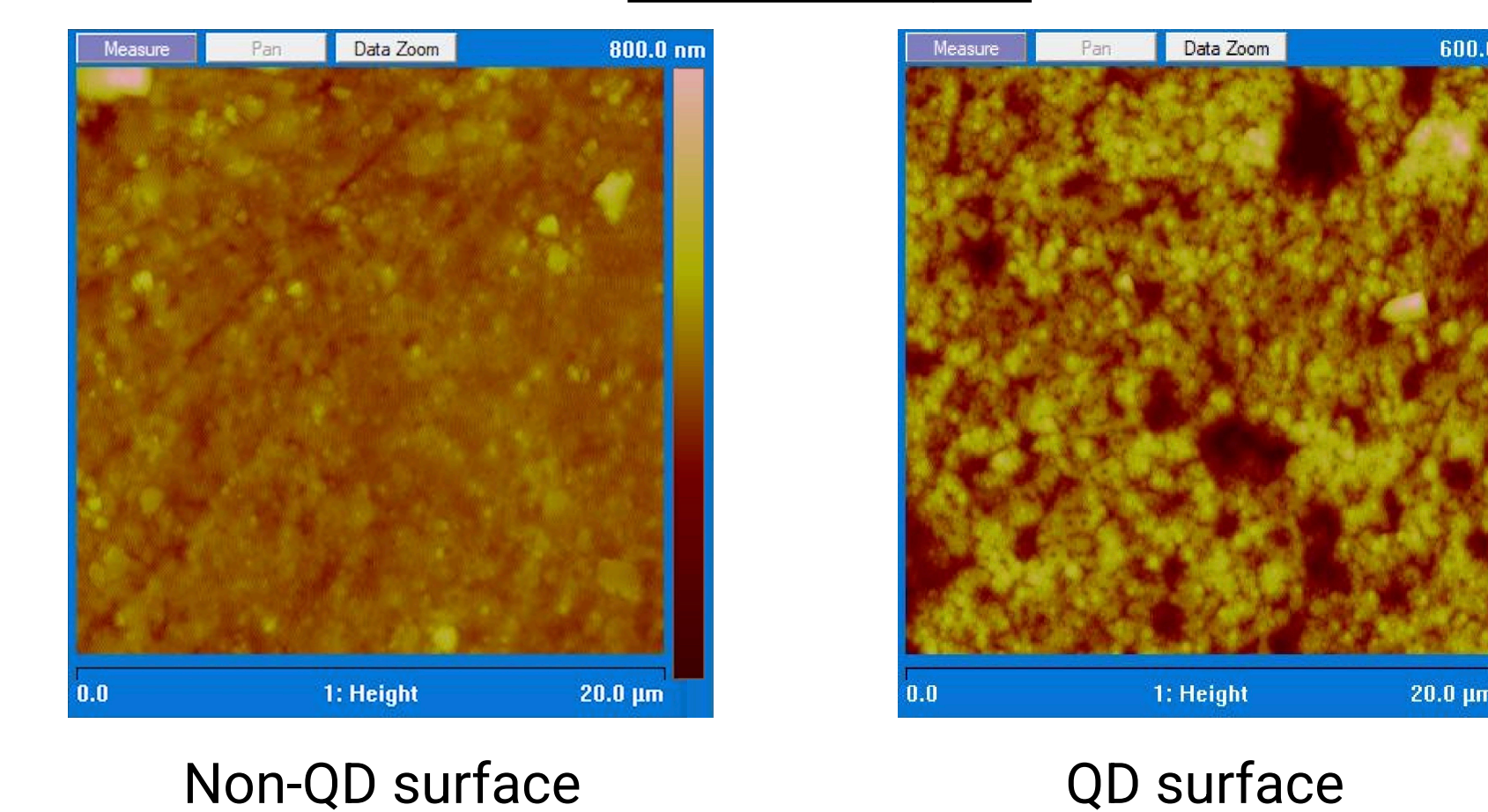
- Greater coverage
- Characterization possible

Device Characteristics

UV-Vis of Components

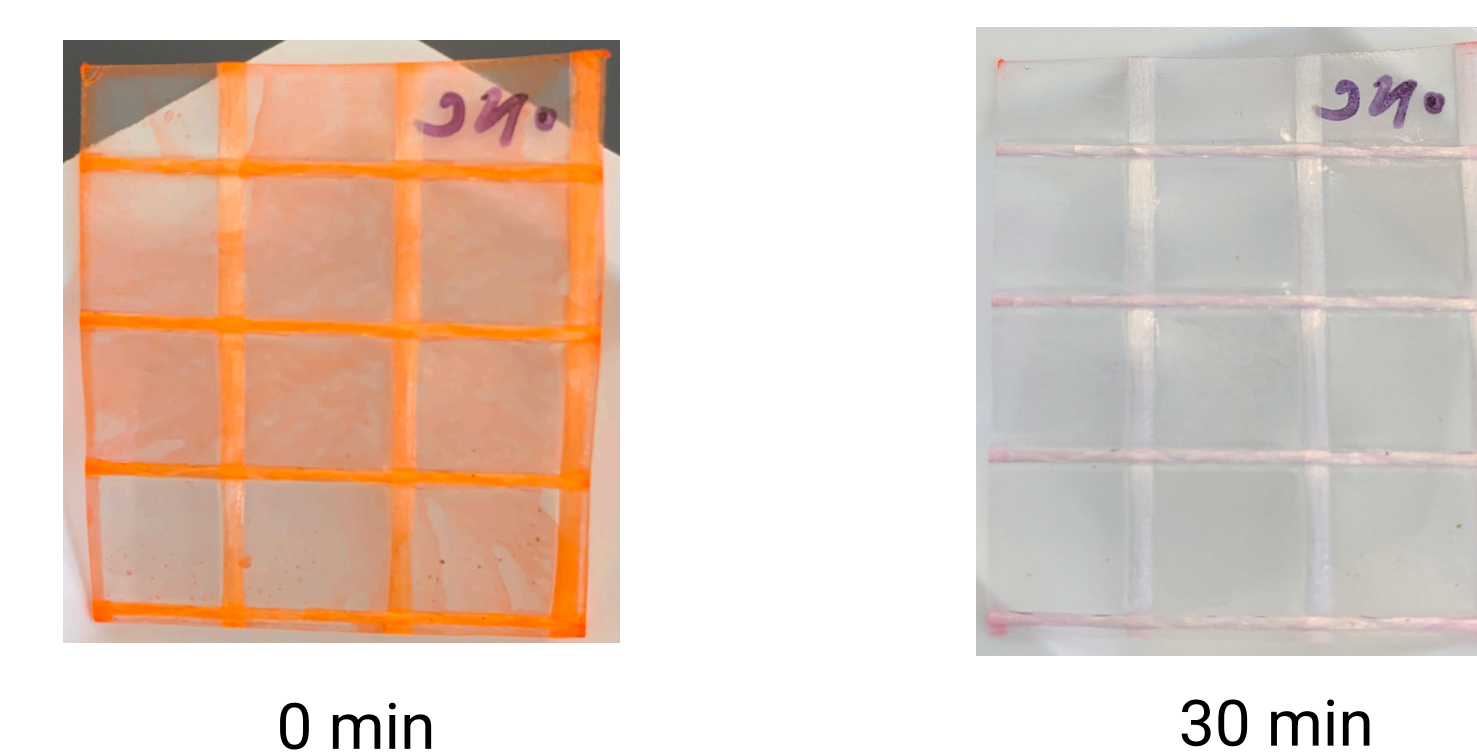
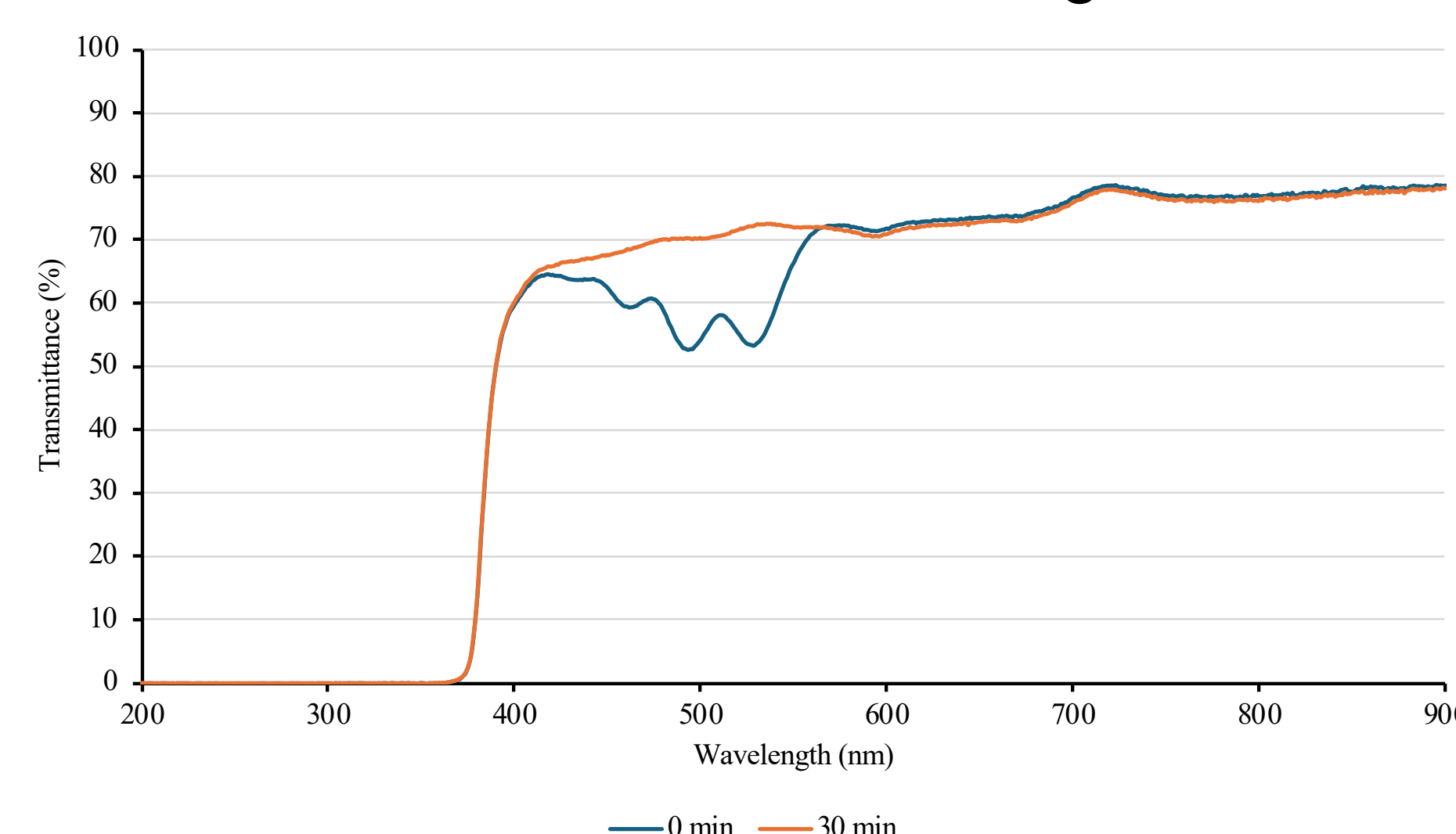


AFM of QDs



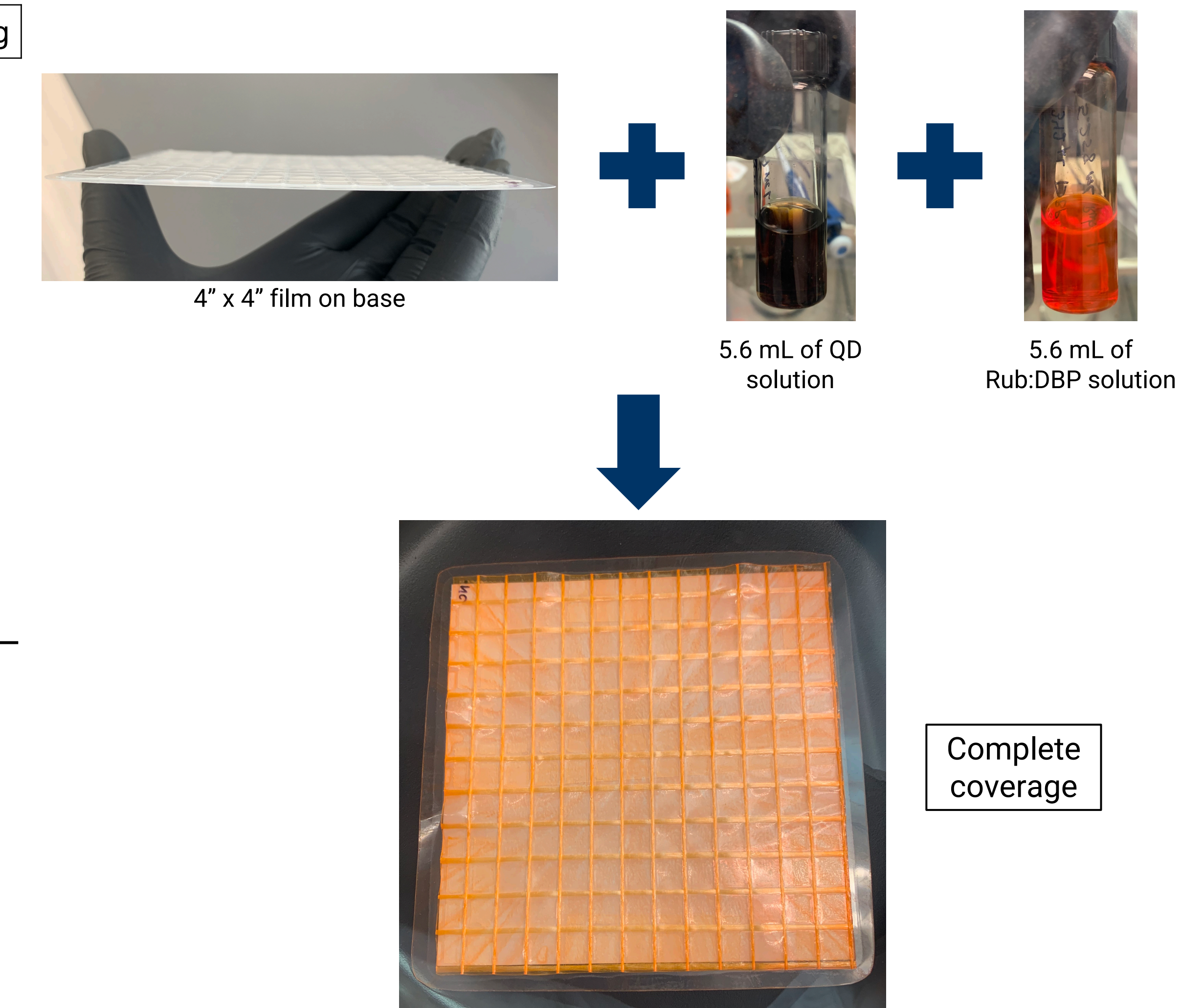
- QDs are on film surface
- Only Rub:DBP reacting with light

Degradation in Ambient Environment

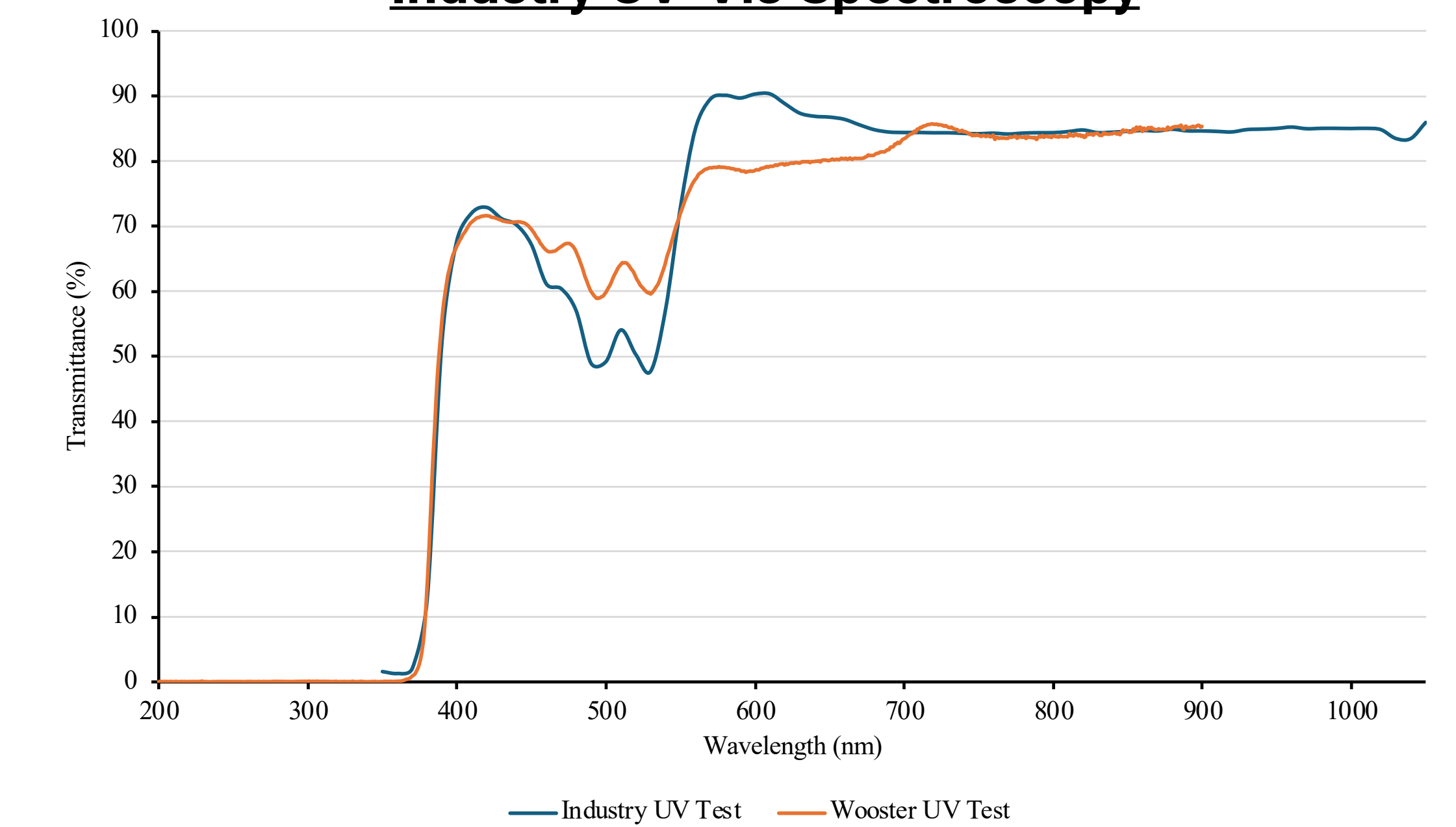


Complete degradation of solutions after 30 min in air and sunlight

Scale-Up Application



Industry UV-Vis Spectroscopy



Increased transmittance around 600 nm, not seen in other data

Conclusions

Optimal coverage of film:

- Excess solution is applied
- Put on firm base to maximize flatness

Light transmittance:

- QDs successfully applied
- No absorption in the IR region
- Only the Rub:DBP is reacting
- Higher transmission around 600 nm appears when longer wavelength used

Overall:

- Bilayer device is not suitable to increase the light transmission
 - prominent absorption in the PAR region
 - accelerated degradation in ambient conditions

Acknowledgements

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