The influence of water on the changes in appearance as a result of weathering of polymeric materials

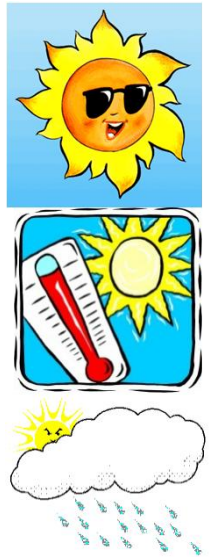
Pieter Gijsman

HEALTH · NUTRITION · MATERIALS

Weathering is due to a complex combination of factors

Decreasing Scientific Knowledge

- UV radiation, visible light
  - spectral distribution; intensity
  - season, exposure angle, latitude
- Heat, thermal cycling
  - sample temperature
  - backing
- Moisture
  - rain, humidity
- Acid rain, other pollutants
- Mechanical stresses, abrasion
- Biological attack
  - mold, mildew, bird droppings



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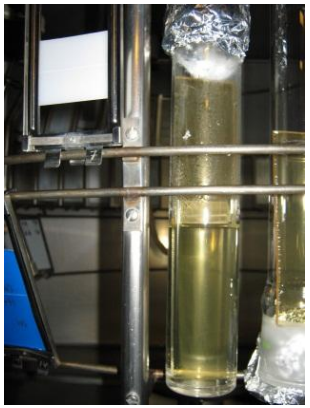
Experimental:

- Materials studied:
  1. Composite resin
  2. Glass fiber reinforced Polyamide 6,
  3. Powder coatings (Polyamide, Powder in-mold, Super durable Polyester)
- Accelerated weathering methods used

	Florida simulating condition (Dry/Wet)	Arizona simulating condition (Dry)
Accelerated test equipment:	Atlas Weather-Ometer, Ci65A	Atlas Weather-Ometer, C3000
Test standard:	ASTM G 155 (november 2000) (successor of ASTM G26); ISO 4892-2	PV3929 (Volkwagen)
Specification of test conditions:		
Light source:	Xenon light source filtered with inner and outer borosilicate S filters	Xenon light source filtered with inner and outer borosilicate S filters
Black standard temperature:	67 ± 2 °C	90 ± 2 °C
Test chamber temperature:	42-45 °C	50 °C
Radiation intensity:	0.35 ± 0.02 W/m2/nm at 340nm	0.6± 0.02 W/m2/nm at 340nm
Relative humidity (end of dry period):	50 ± 5 %	20 ± 5 %
Dry/wet cycle:	102 min dry/18 min front water spray	None
Light/dark cycle:	Continuous illumination	Continuous illumination



- Weathering in borosilicate vessels (Florida simulating conditions)

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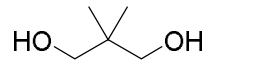
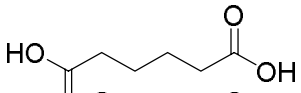
1. Influence of moisture on the weathering of a composite resin

Synolite 0270-N2 based on:

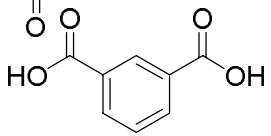
Neopentylglycol:



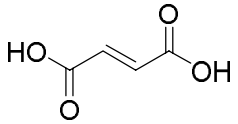
Adipic acid:



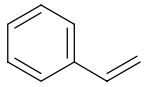
Isophtalic acid:



Fumaric acid:



Styrene:



J. Sampers, E. Hutten, P. Gijsman, Accelerated weathering of unsaturated polyester resins. Aspects of appearance change, Polymer Testing, 44 (2015) 208-223

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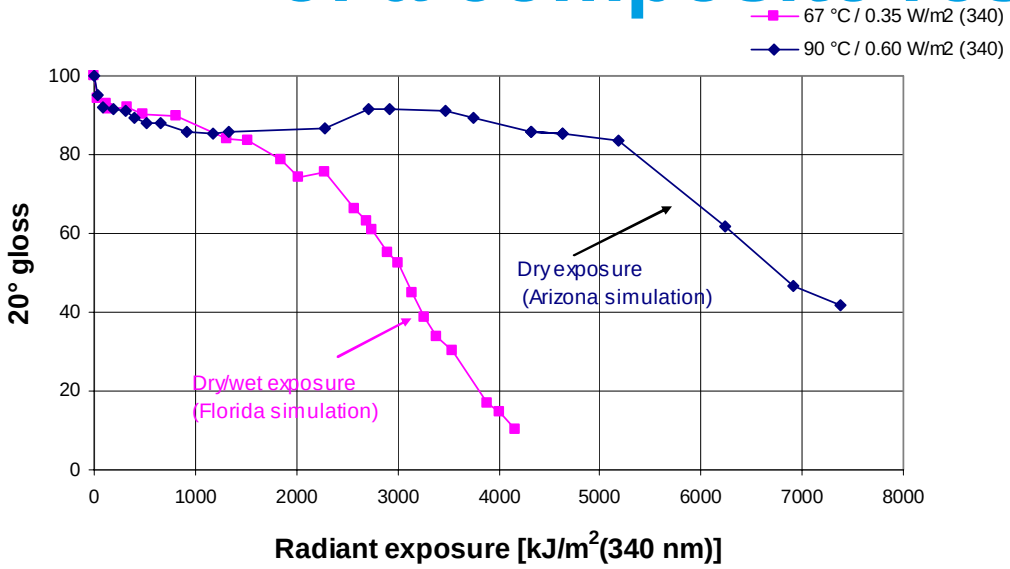

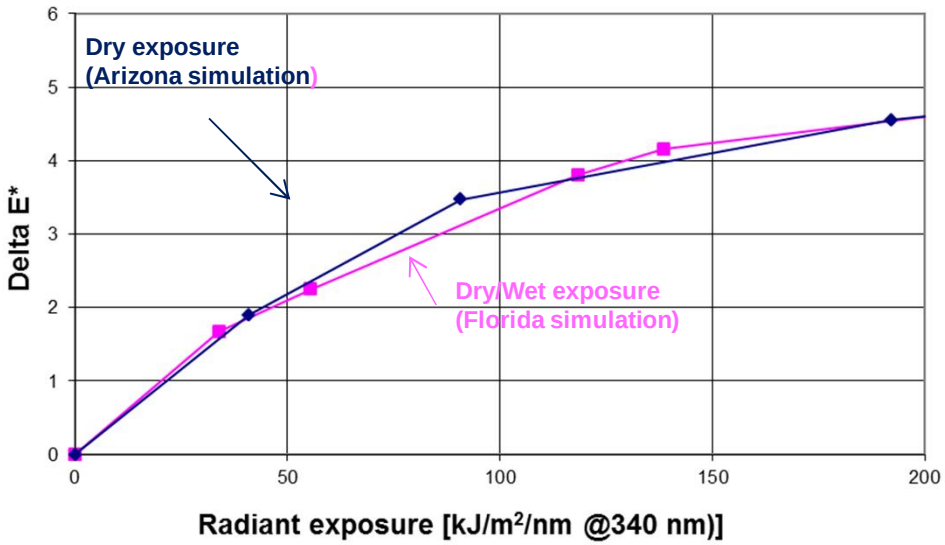

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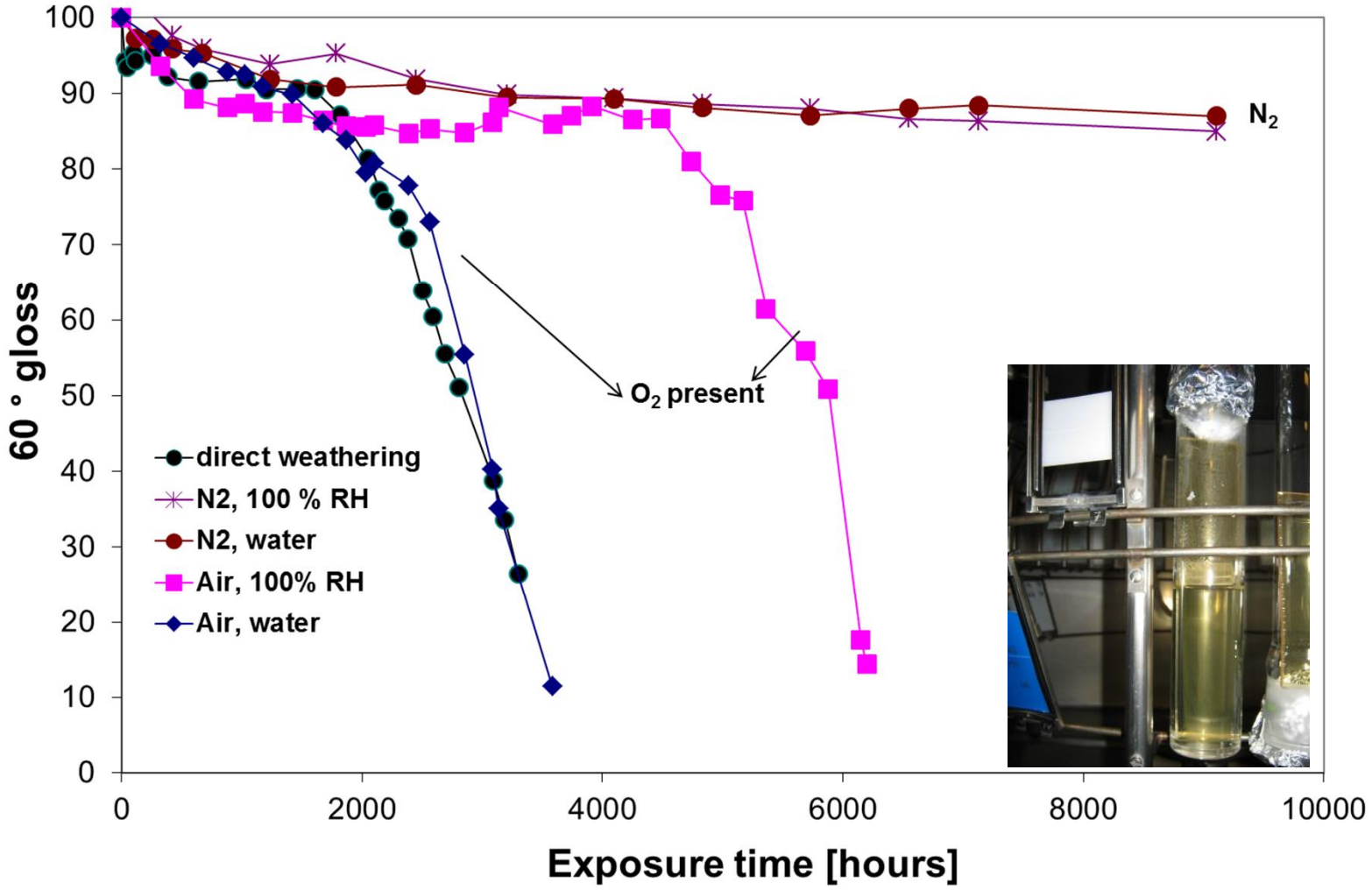

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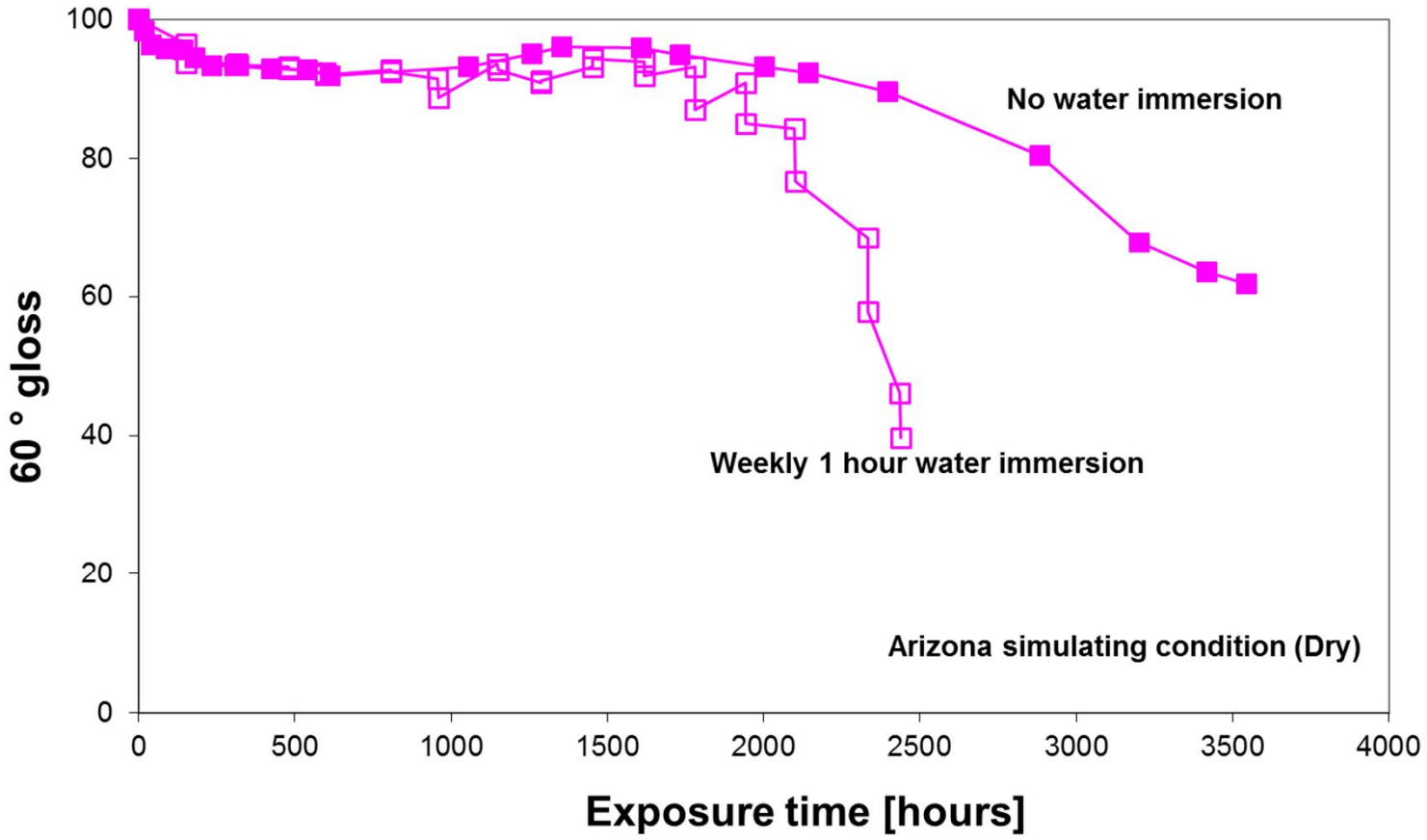

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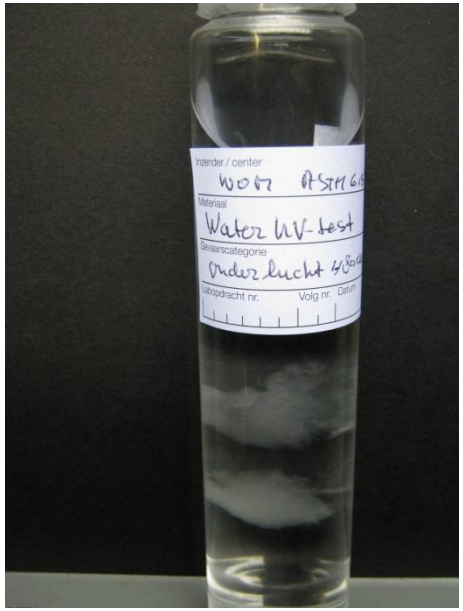
1. Influence of moisture on the weathering of a composite resin

- Conclusions:

  - Influence of moisture depend on evaluation criterion used:
    - Gloss loss: Large influence of moisture
    - Discoloration: No influence of moisture

  - Doping in water after dry weathering leads to a large gloss loss:

    - Washing away oxidized degradation products seems to be an important role of water



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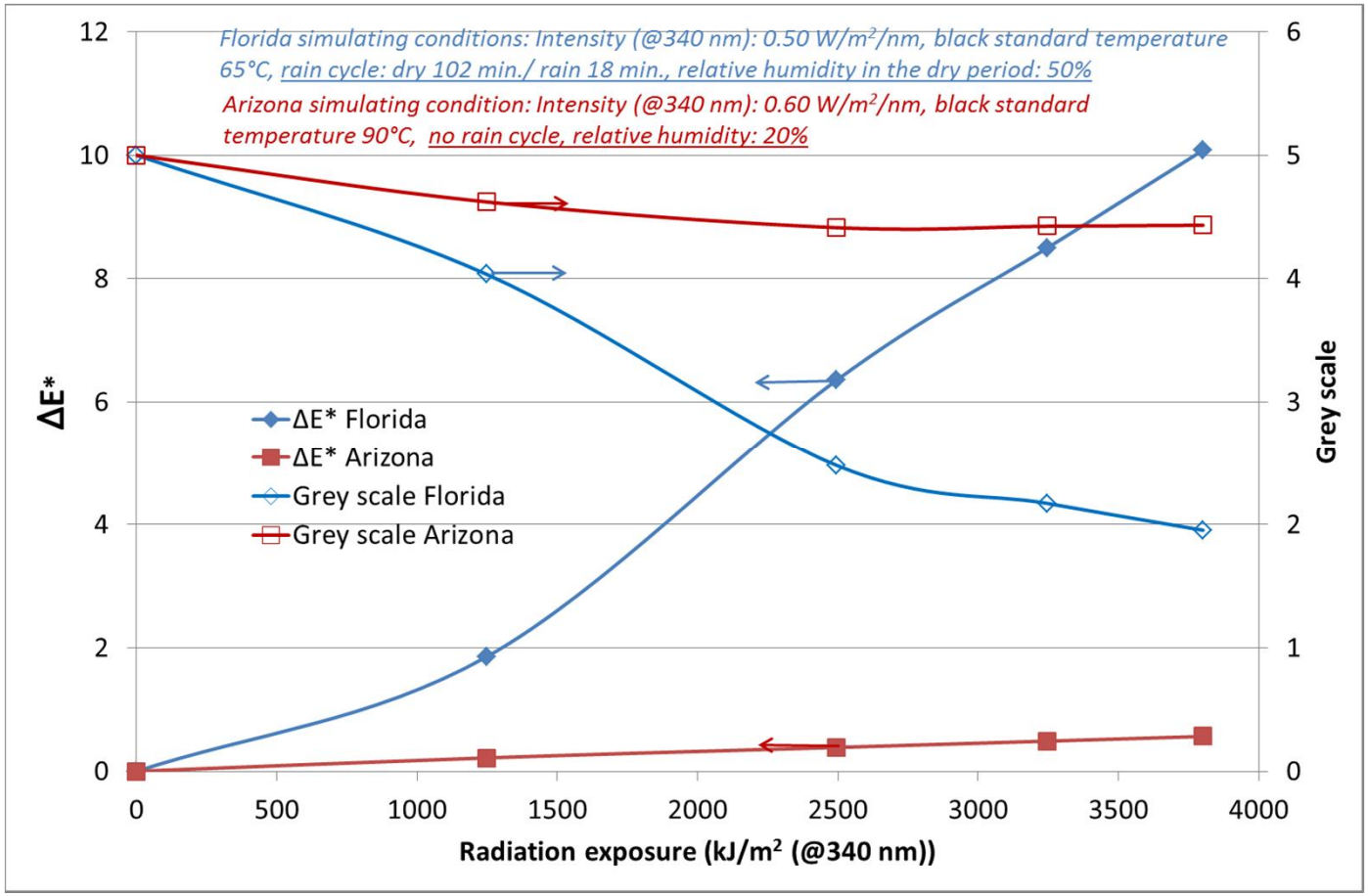
2. Influence moisture on weathering of grey GFR-Polyamide 6



Moisture has a large influence on the weathering of GFR-PA6

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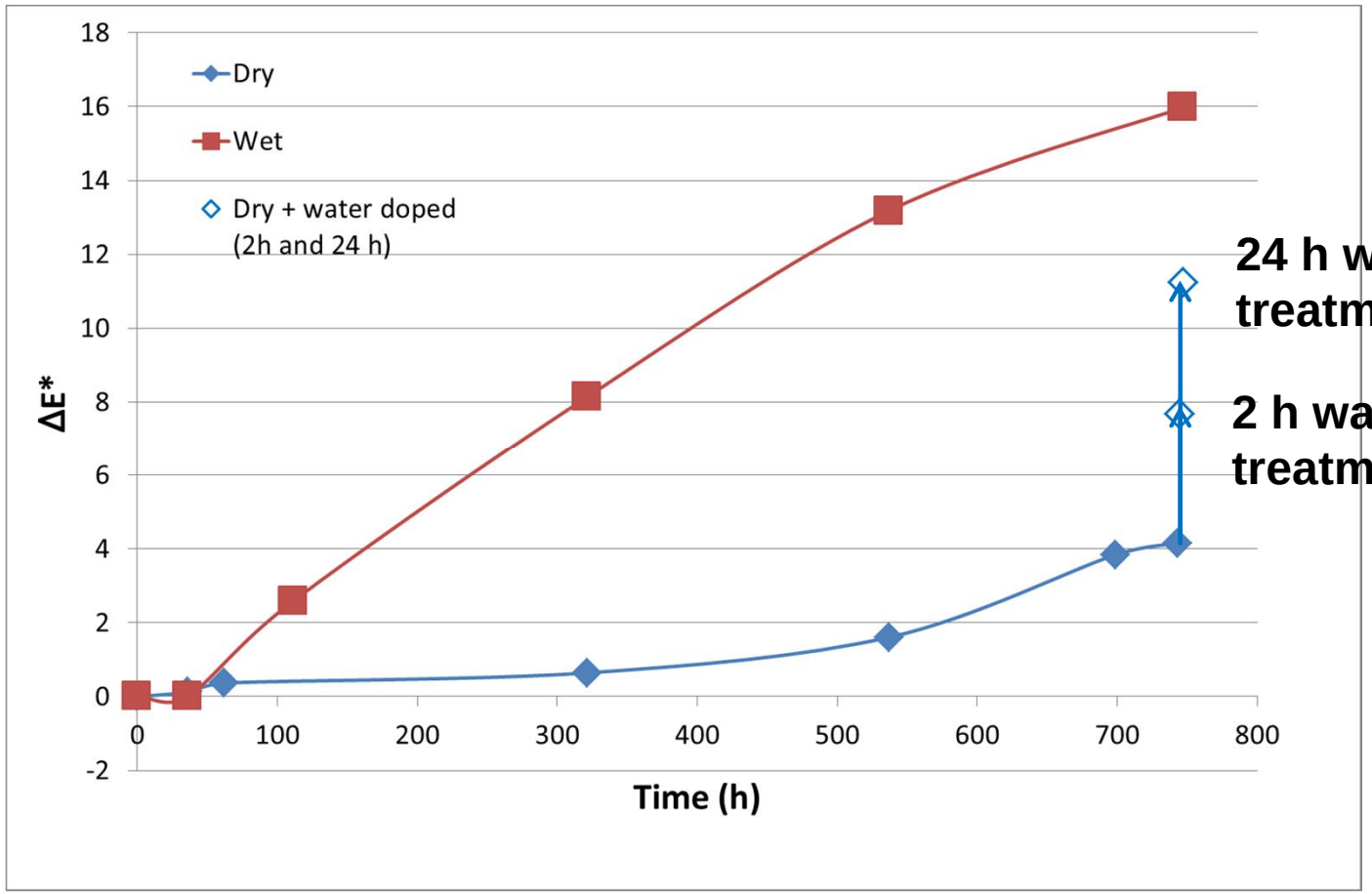
2. Influence moisture on weathering of grey GFR-Polyamide 6

Water treatment after dry accelerated ageing on colour



Water treatment has a large influence on ΔE.

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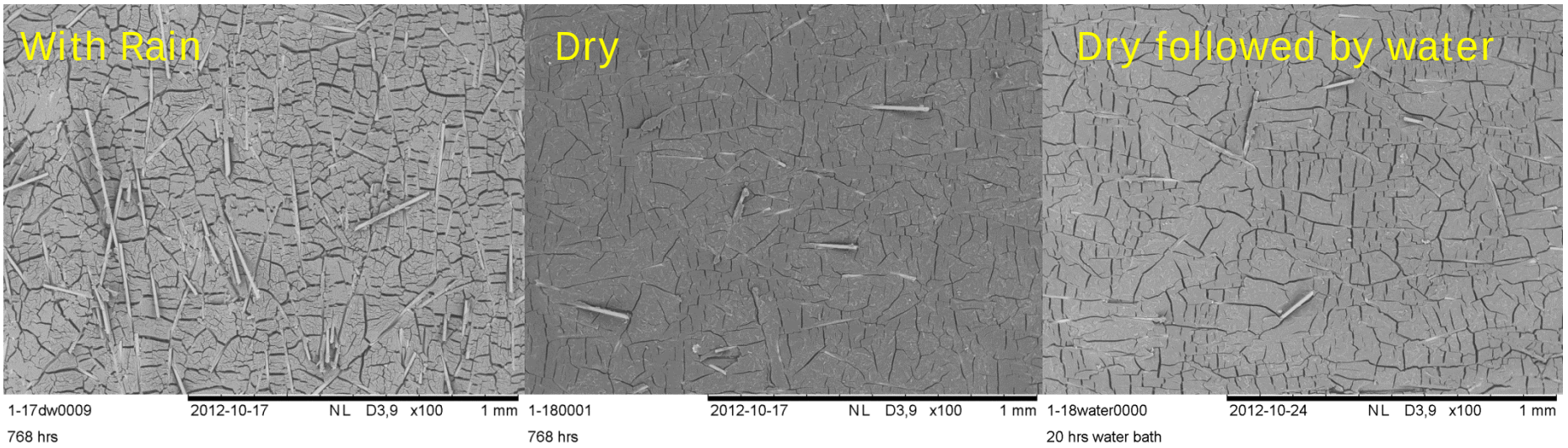

More glass fibers and cracks are visible after weathering with a rain cycle.

Cracks are more pronounced after water treatment of dry sample,

This suggests that degraded material has been washed away.

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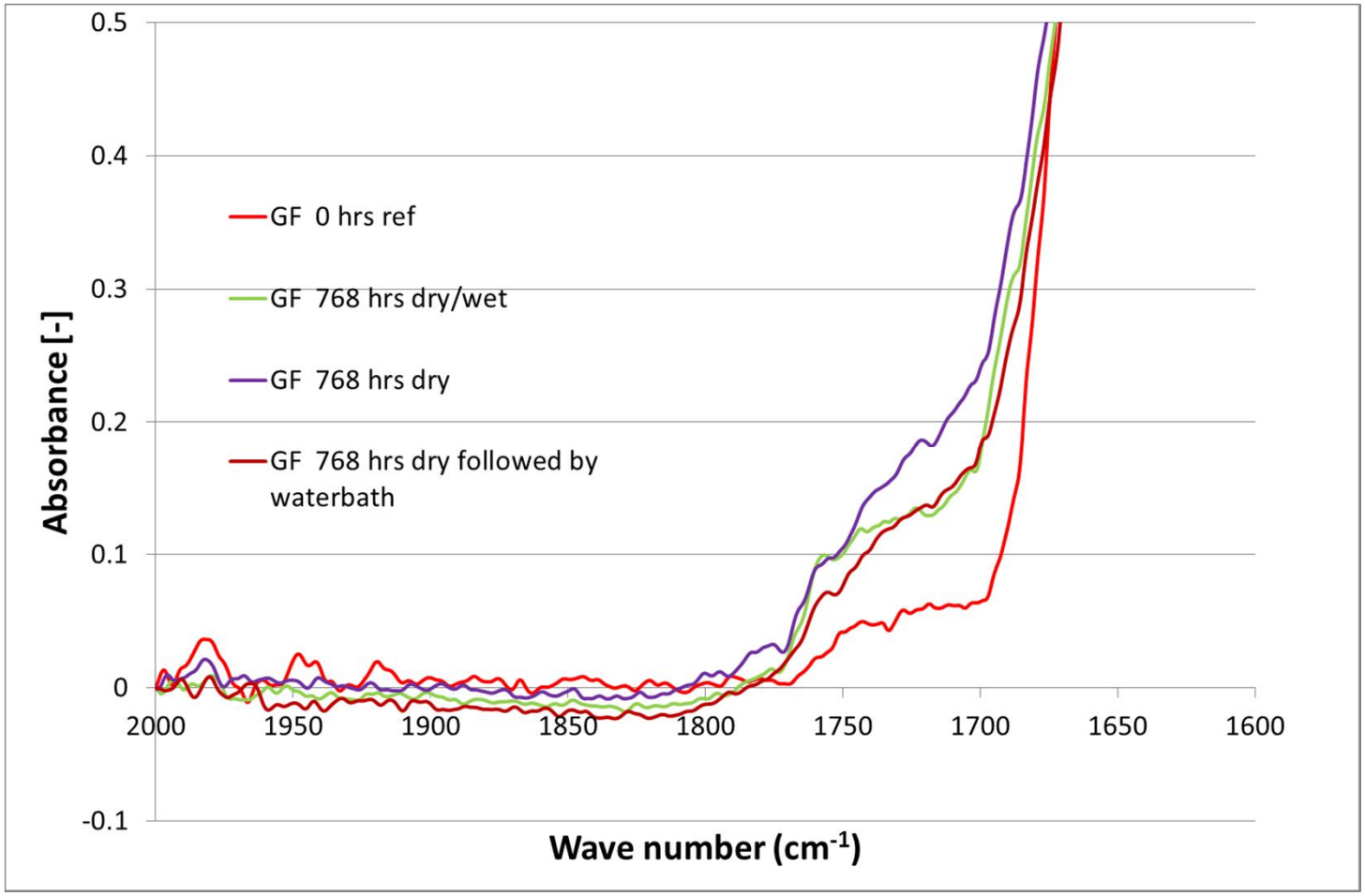

Water washes away oxidized polymer

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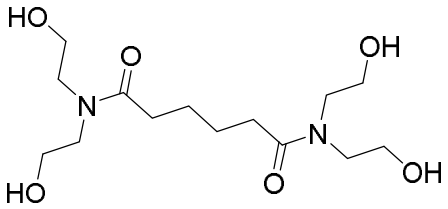
3. Influence moisture on the weathering of powder coatings

I. Polyamide powder coatings
   – Different coatings with as main components:
     Aliphatic/cyclo aliphatic diamines, aromatic and aliphatic diacids,
     Primid XL-552



N^1,N^1,N^6,N^6-tetrakis(2-hydroxyethyl)adipamide

II. Polyester powder in-mold coatings
   - Coatings based on :
     Unsaturated polyester based on isophtalic acid
     Vinylether functional urethane crosslinker
     Benzylperoxide

III. Super durable polyester powder coating
   - 100% Isophtalic acid based polyester resin cured with
     Primid XL-552

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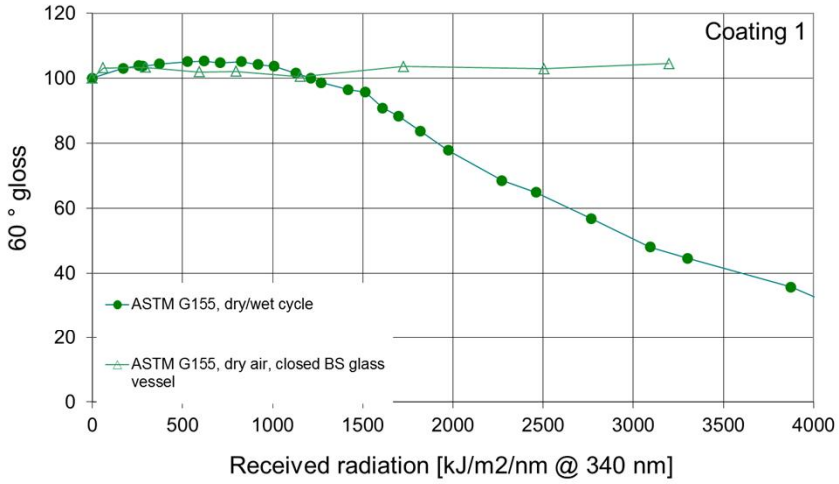
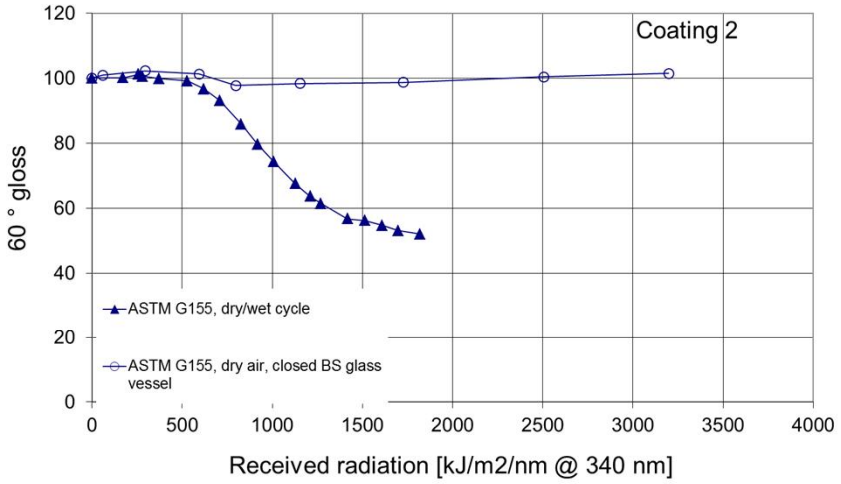
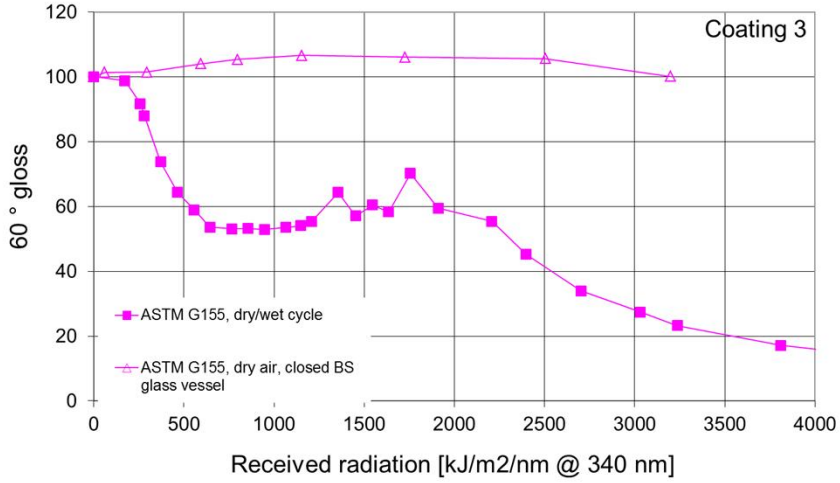
3.I Influence moisture on the weathering of polyamide powder coatings







Different coatings with as main components:
Aliphatic/cyclo aliphatic diamines, aromatic and aliphatic diacids,
Primid XL-552

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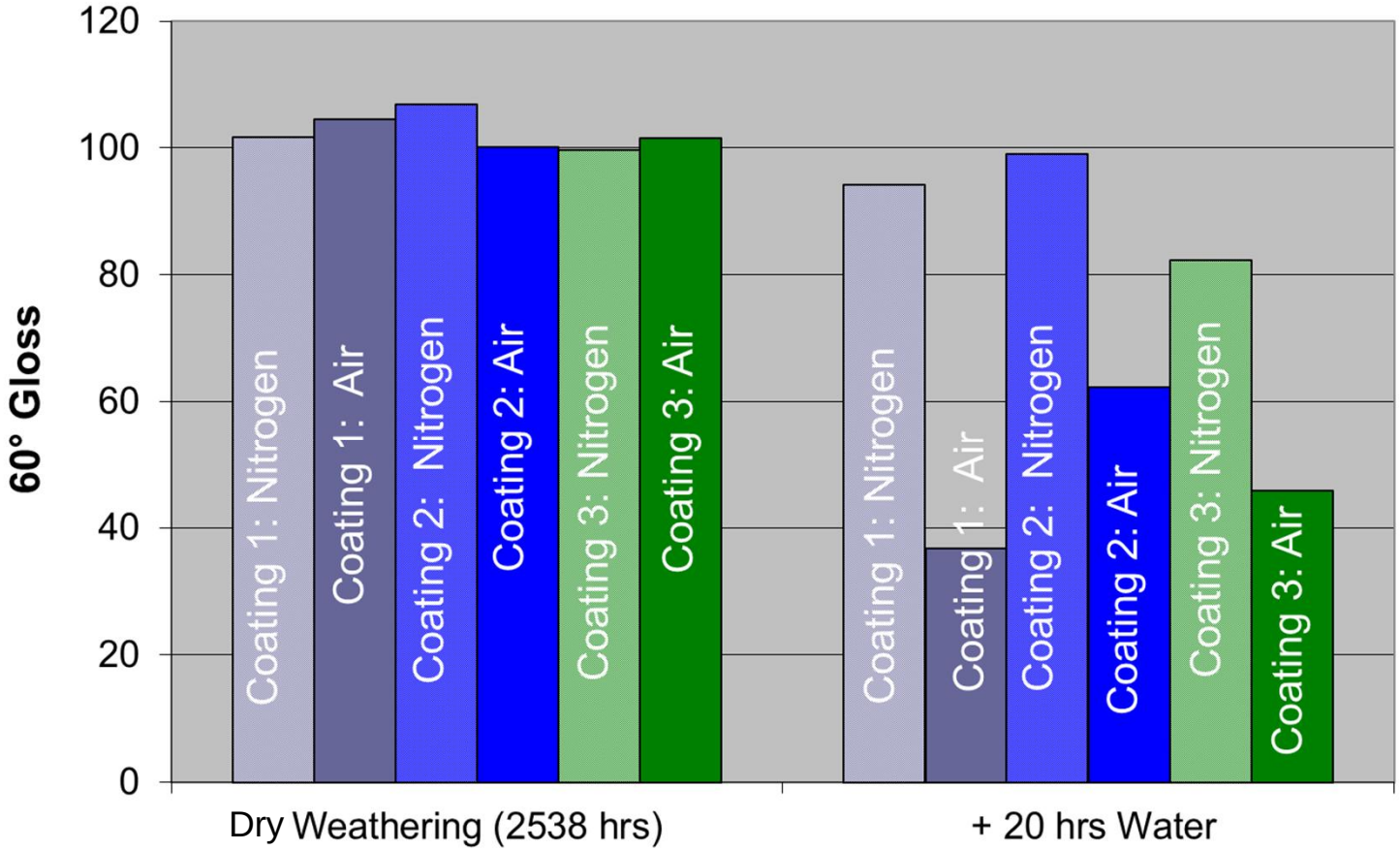

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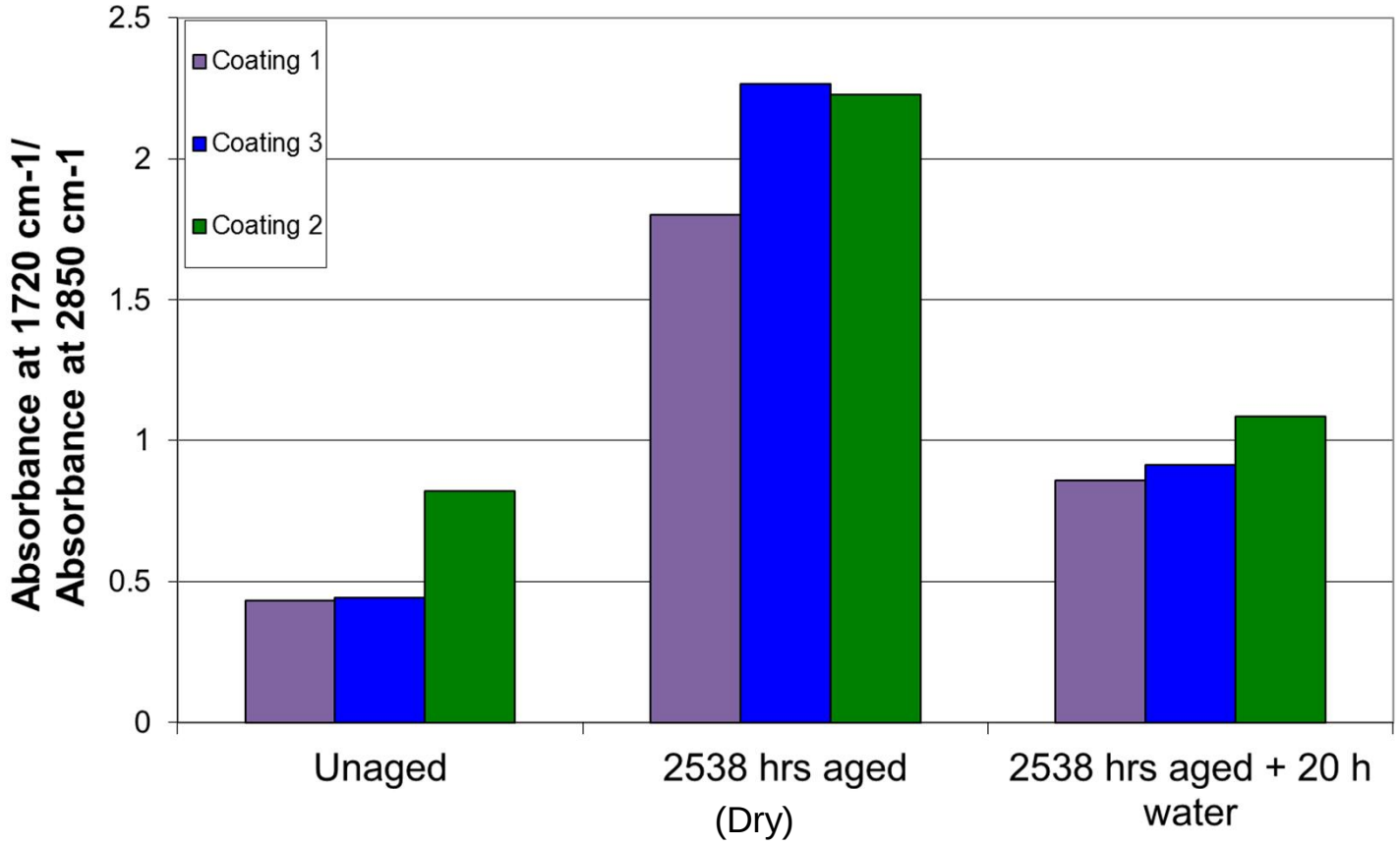

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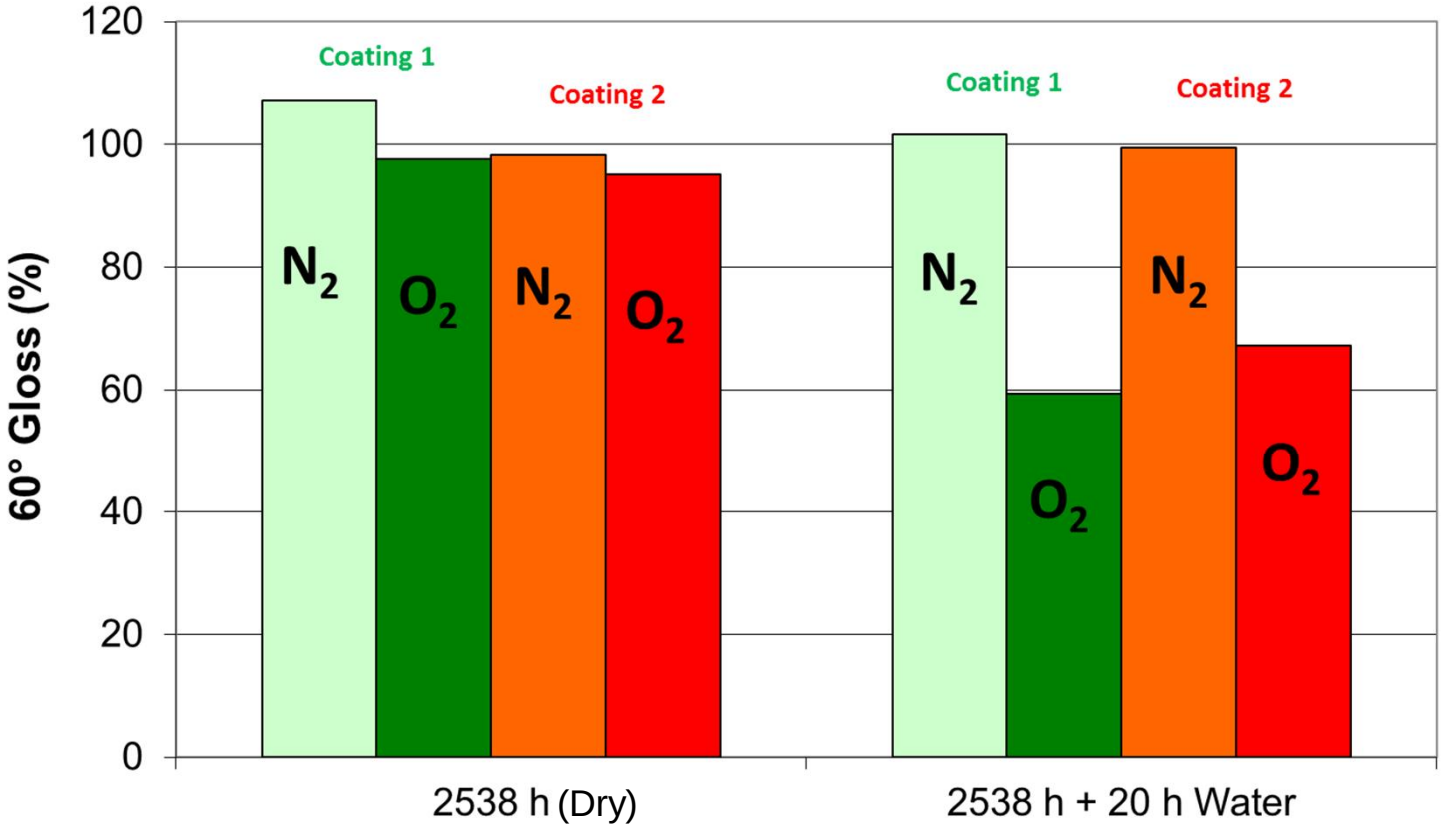
3.II Influence moisture on the weathering of powder in-mould coatings on Al plates



Coatings based on :

Unsaturated polyester based on isophtalic acid
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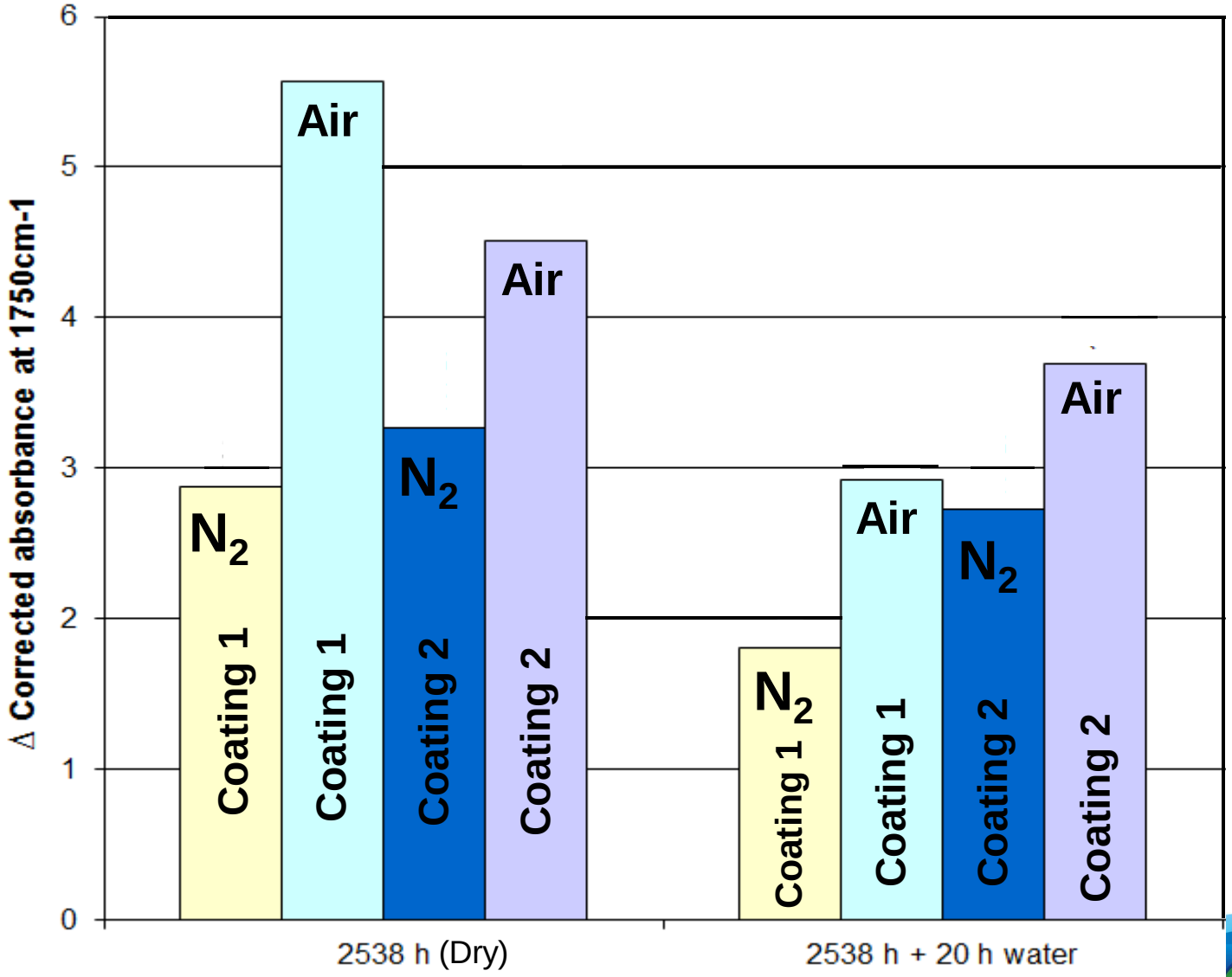

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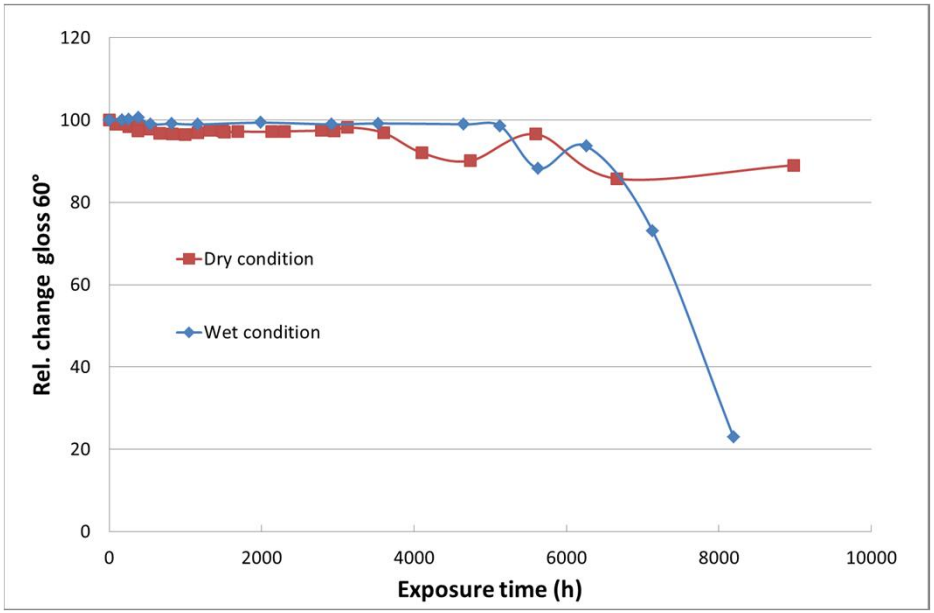
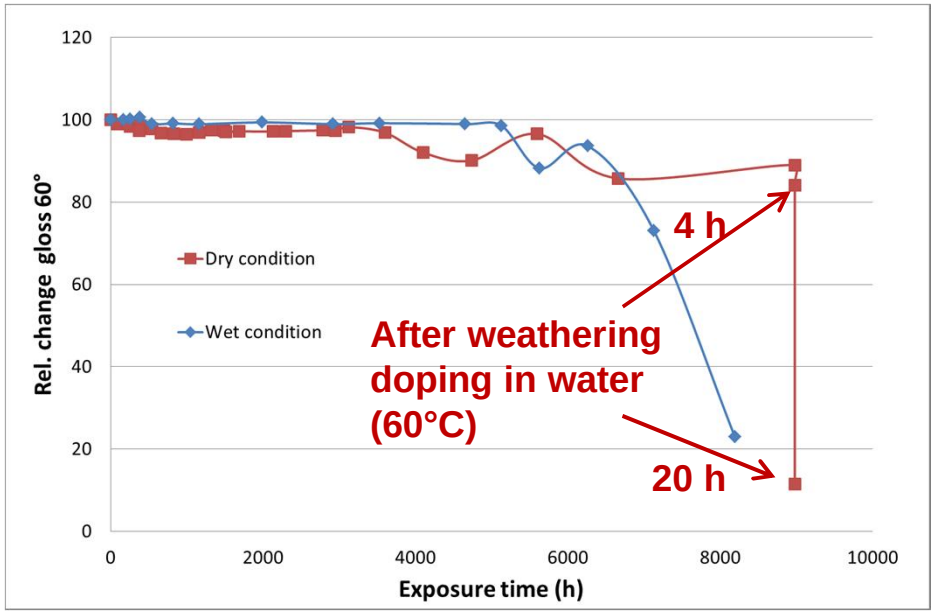
3.III Influence moisture on the weathering of a super durable polyester based powder coating

(IPA based powder coating cured with 5% Primid XL-552)





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Conclusions

- Moisture plays an important role during weathering of polycondensates

- Possible roles of water:
  - Hydrolysis
  - Drying wetting tension
  - Plasticizer (decrease modulus and Tg)
  - Wash the surface (erosion)

- In all cases washing away by photo-oxidation formed degradation products is the most plausible mechanism

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Acknowledgement

- Jacques Sampers
- Marjolein Diepens
- Manon Mak

PDDG
The Polymer Degradation Discussion Group

for inviting me

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for allowing me to present

You for listening

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