Parallel natural weathering of laminated backsheets across Europe

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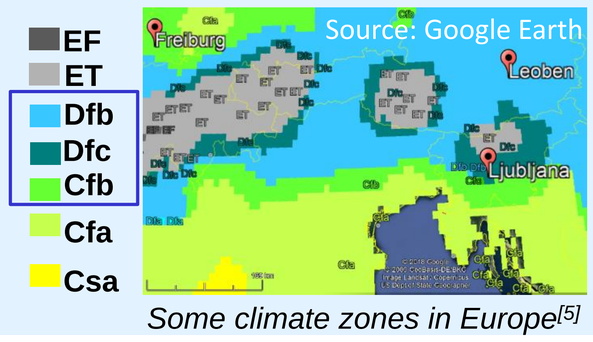
INTRODUCTION AND MOTIVATION

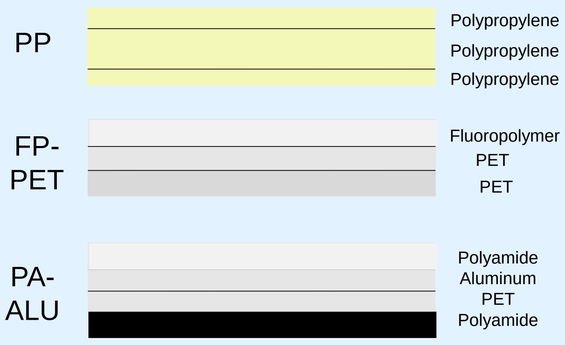
- Natural weathering of PV materials have proved to be a long term task in the study of the effect of combined climatic factors on polymer degradation.
- European weather can be considered moderated, in terms of ambient temperature and solar irradiation. Never the less, materials in outdoor conditions will inevitable start to age.
- In this work it is intended to study the ageing behavior of different backsheets placed outdoors at three different geographic locations, as well as to look for correlations with available climate data.



Some climate zones in Europe[5]

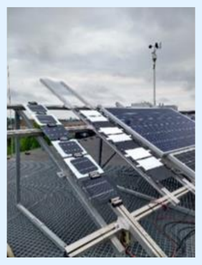
EXPERIMENTAL

Backsheets



Locations

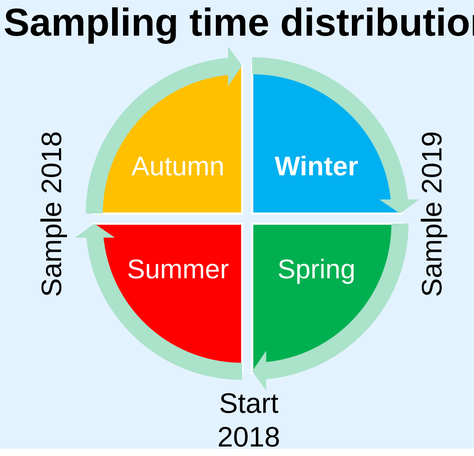
University of Leoben, Leoben, Austria



University of Ljubljana, Slovenia

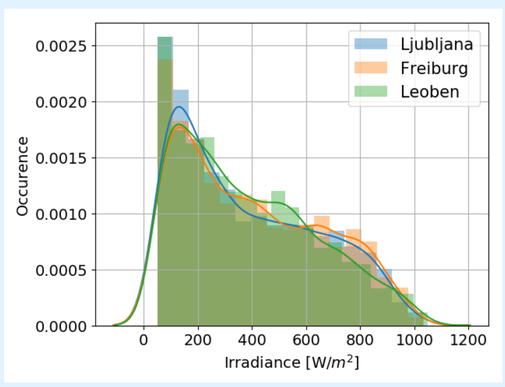
Fraunhofer ISE, Freiburg, Germany

Sampling time distribution

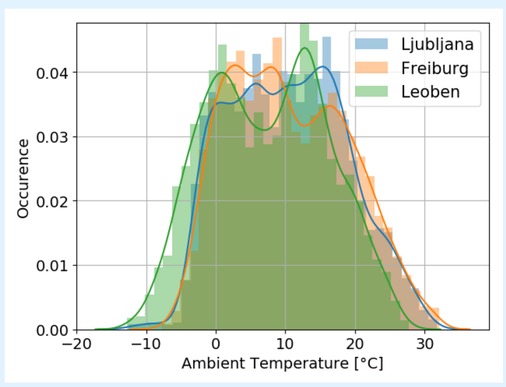


CLIMATIC FACTORS

Solar irradiation



Ambient temperature



Irradiation dosage levels

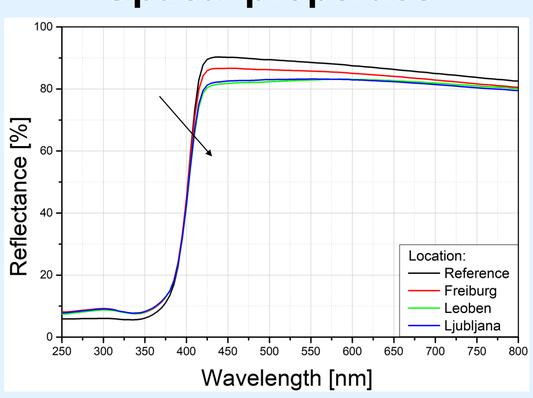
Location	167 days [kWh/m²]	333 days [kWh/m²]
Freiburg	695	1311
Leoben	814	1365
Ljubljana	703	1317

Solar irradiation, G_{POA} (wavelength range: 300 – 2500 nm)

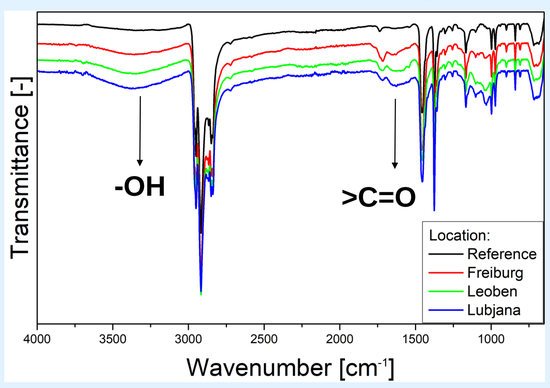
- In-situ measurements have been compared with the ERA5 climate reanalysis dataset.
- The main degradation factors are being extracted and modelled in hourly basis in 3 different locations

AGEING INDICATORS

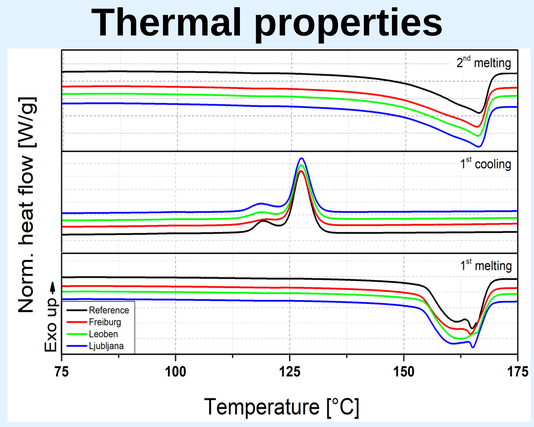
Optical properties



Surface chemistry

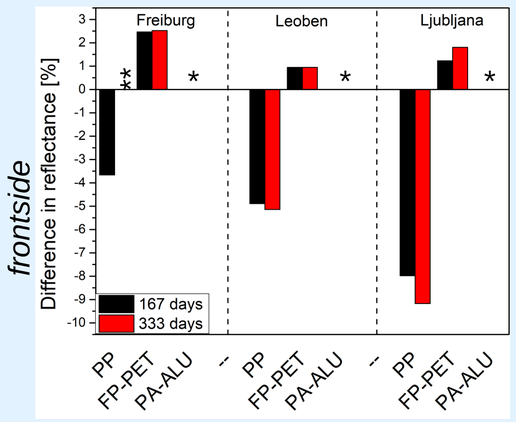


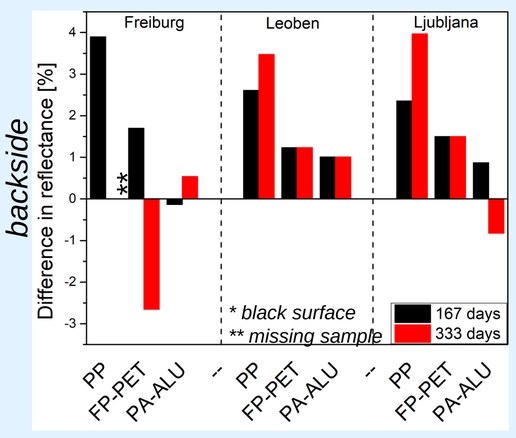
Thermal properties



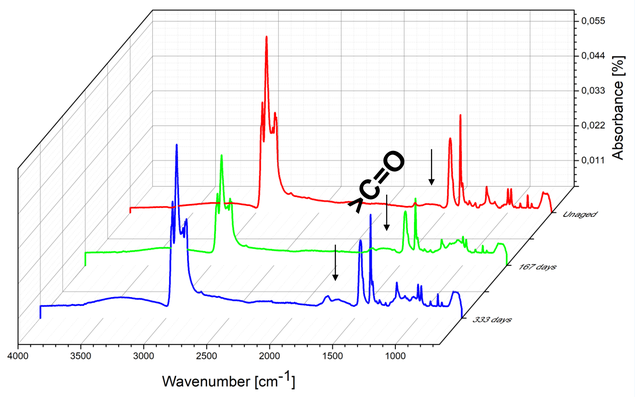
- UV-VIS-NIR: Measurement of the reflectivity and transmittance of the materials.
- FTIR: Measurement of the presence and formation of functional groups on the surface.
- DSC: Determination of the melting and temperature.

FINDINGS AND RESULTS





- PP backsheets show a reduction in optical reflectance on the front side in all locations.
- FP-PET and PA-ALU backsheets present an increase in reflectance on the backside of the backsheet in all locations
- Optical transmittance is also reduced in PP backsheets, but not in FP-PET backsheets.
- PP backsheets from Leoben and Ljubljana have permanent soiling.
- Weathered backsheets show a peak at 300 nm when compared to the reference.



- FTIR analysis on the surface of PP backsheets shows signs of photo-oxidation.
- FP-PET and PA-ALU backsheets show no signs of changes in their surface.
- DSC show an increased melting enthalpy for all backsheets, in all locations, indicating post-crystallization processes

CONCLUSIONS

- Parallelism in ageing behavior between Leoben and Ljubljana has been found but not with Freiburg, even though these locations have a similar weather.
- Weathered polypropylene backsheets shows the most changes in measured properties, but no embrittlement, cracks or delamination have been found
- Natural weathering causes an initial change in material properties, these changes stay constant over time.
- Results from natural weather samples with 417 days of exposure show a similar trend than those of 333 and 167 days, signaling stable materials.

[1] Introduction to Polymers. Robert J. Young and Peter a Lovell. Third edition pp. 9
[2] Gottfried W. Ehrenstein, Sonja Pongratz. Resistance and Stability of Polymers.
ISBN 978-3-446-41645-1. PP. 27, 28, 35, 36, 39, 45, 66, 69, 144-145.
[3] Bettina Ottersböck, Gernot Oreski, Gerald Pinter. Comparison of different microclimate effects on the aging behavior of encapsulation materials used in photovoltaic modules, Polymer Degradation and Stability, Volume 138, 2017, Pages 182-191, ISSN 0141-3910,
[4] Service Life Prediction of Polymers and Plastics Exposed to Outdoor weathering Edited by Cristopher C. White, Kenneth M. White and James E. Picket. PP. 1-15.

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