Analysis of microplastics in Hywind Scotland

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Outline

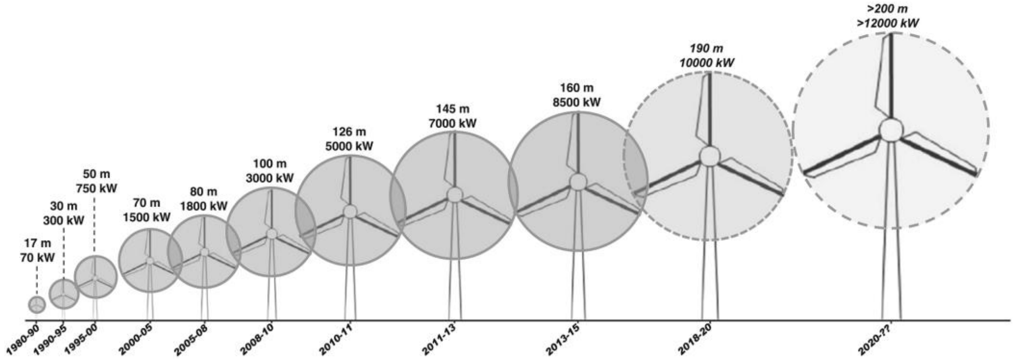
- Microplastics from wind turbines

  Leading-edge erosion
- Project on analysis of microplastics in sediments from Hywind Scotland Windfarm

Leading-edge erosion (LEE)

- Main mechanism for formation of microplastics from wind turbines in operation
- Erosion due to impact of raindrops, hail and particles on the leading edge of the turbine blade
- Mainly affecting the tip, due to high tip speed (70-90 m/s or more)
- Offshore turbines operate at their maximum speed for a large part of the time, which is good for production, but causes erosion
- Modern turbines are large and operate at high tip speeds that lead to LEE over time

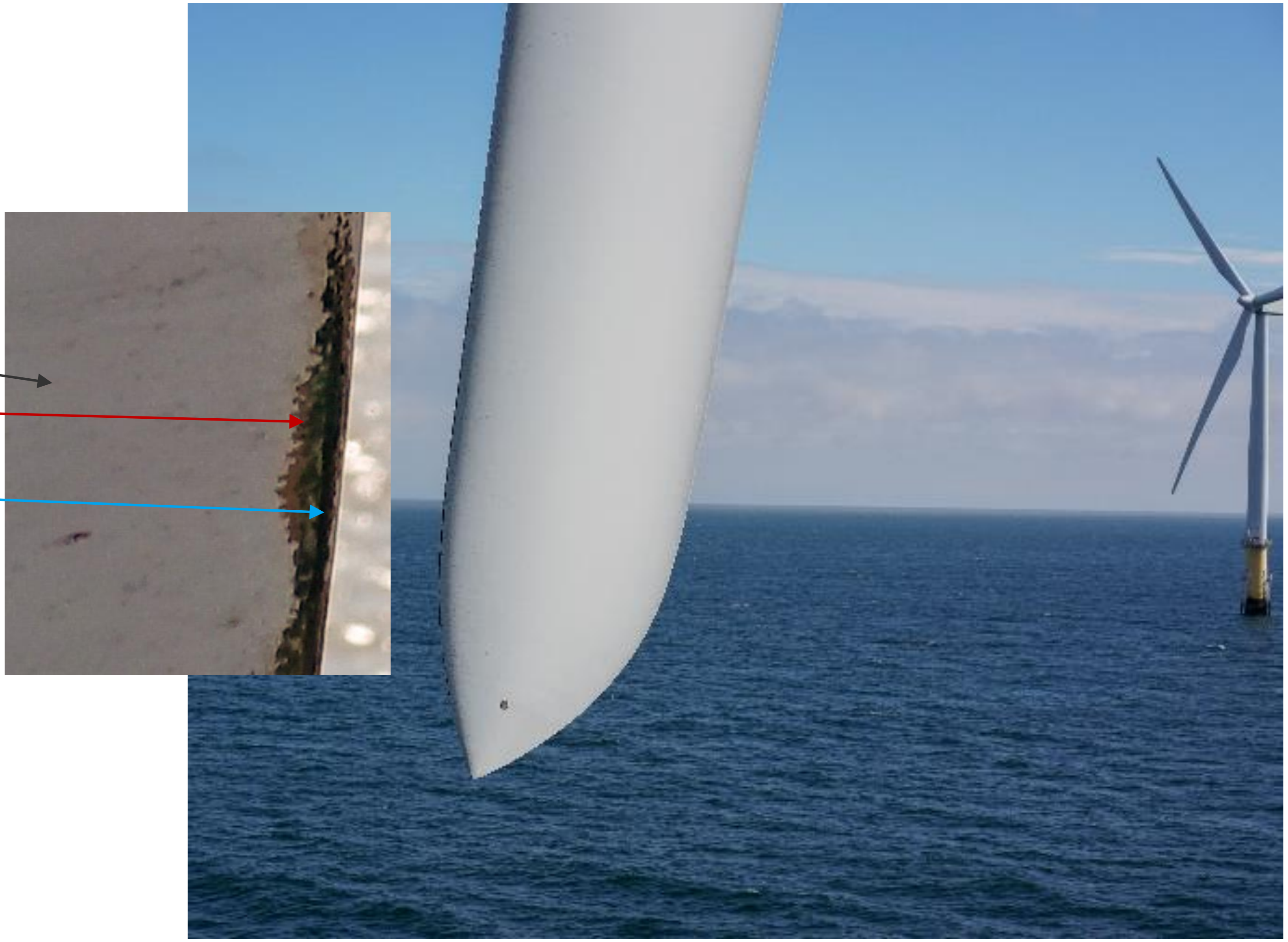
Ref: Telene, https://www.telene.com/leading-edge-protection/



Bartolomé, L. and Teuwen, J. 2020, Wind Energy 22, 1, 140-151

Turbine blade material composition: example

- Coating system:
  - Primer: e. g. epoxy
  - Topcoat: e. g. Polyurethane
- Filler: e. g. epoxy
- Composite: glassfiber with an epoxy- or UP binder



Once the coating has eroded, the layers beneath are exposed to environmental factors (UV-light, water)

Approximate amount released: 200 g/turbine, year*

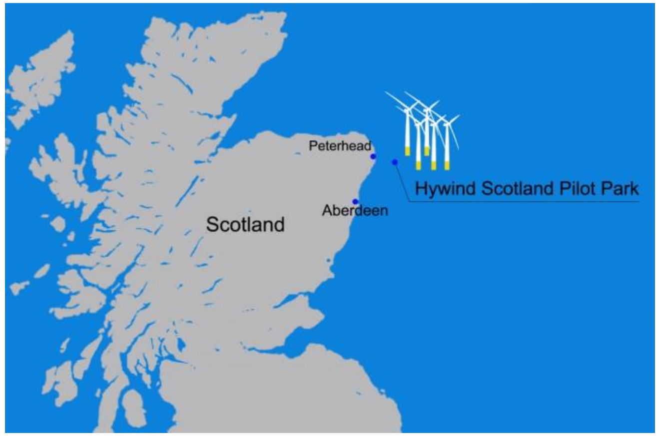
Once formed, the particles are too small and scattered to be collected

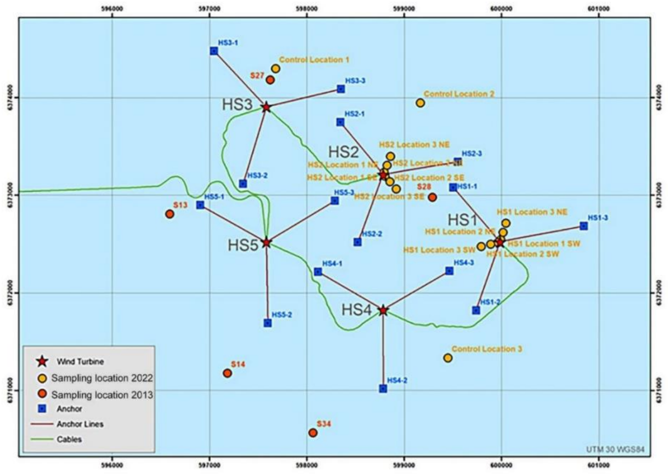
Formation of microplastics is avoided/limited by use of leading edge protection, LEP

*NVE: https://www.nve.no/energi/energisystem/vindkraft/kunnskapsgrunnlag-om-virkninger-av-vindkraft-paa-land/forurensning/ *(unknown reference)*

Study of microparticles in sediments at Hywind Scotland Windfarm (SINTEF)

- Investigate possible content of microplastic particles (300-5000 µm) in the sediments in the wind farm after 5 years in operation
- Get an overview of the 'general' microplastic content in the sediments
- In particular, look for particles that could be attributed to erosion of turbine blades
- Obtain data from before any significant erosion has occurred, to make it possible to monitor changes over time
- Sampling, isolation, quantification and identification of plastic particles from environmental samples is not fully standardized.
    - Therefore, the project also investigate methods for extraction and analysis of the particles





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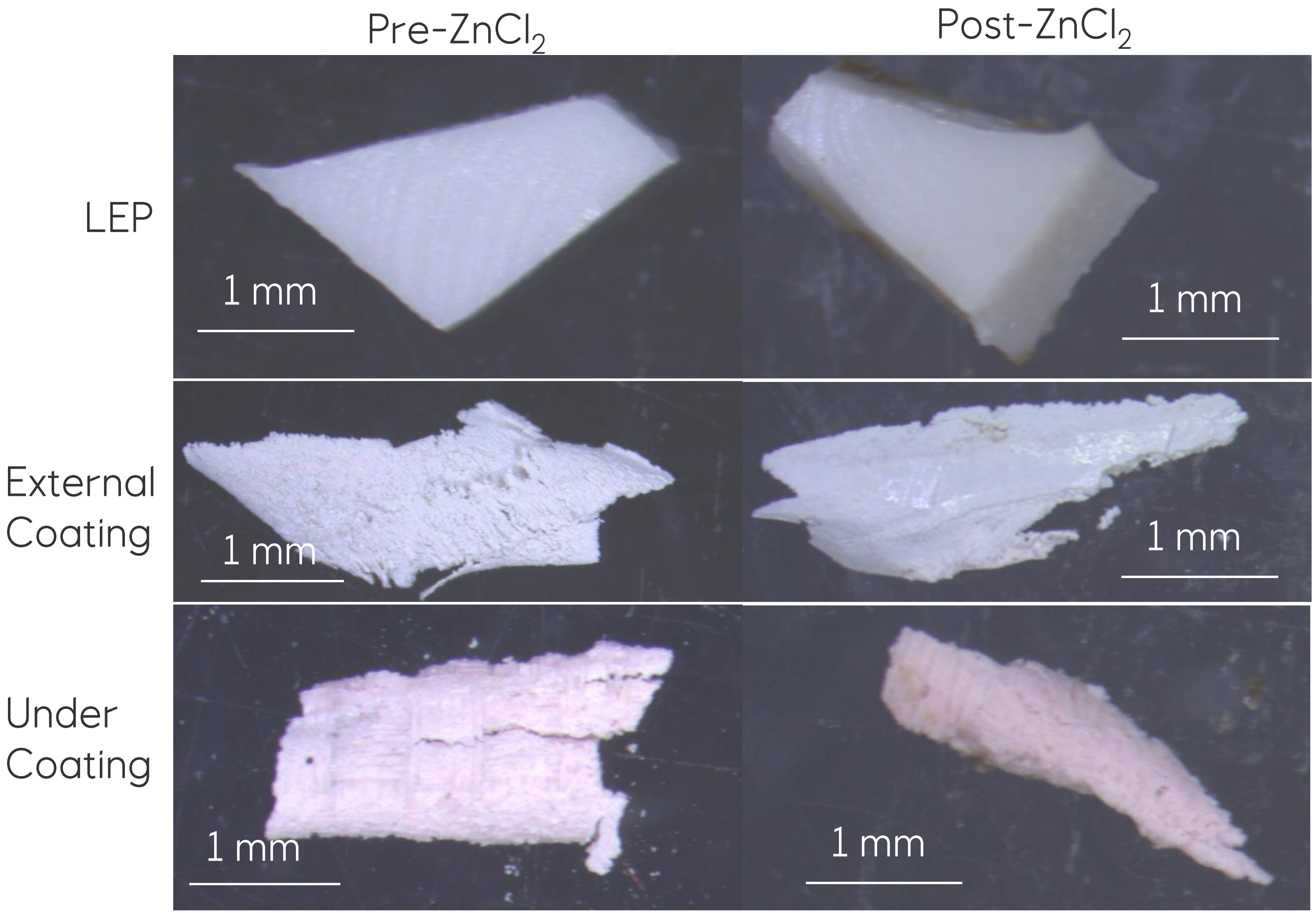
Test materials and pre-testing



- 3 test materials
- Subjected to the $ZnCl_2$ density separation step and filtration recovery used for the real sediment samples
- Assessing recovery and potential impact/damage to particles
- IR Spectra and Mass Spectra fingerprints generated for ID

Quantification and characterisation of reference particles before and after density separation with $ZnCl_2$

equinor

LEP	No. particles	Weight (mg)	Dim1 (±SE) (mm)	Dim2 (±SE) (mm)
Before density separation	25	38.34	2.25 (±0.1)	2.23 (±0.1)
After density separation	25	42.35	2.19 (±0.1)	2.06 (±0.1)

- No change in particle number
- No change in particle dimension
- Slight change in mass due to $ZnCl_2$

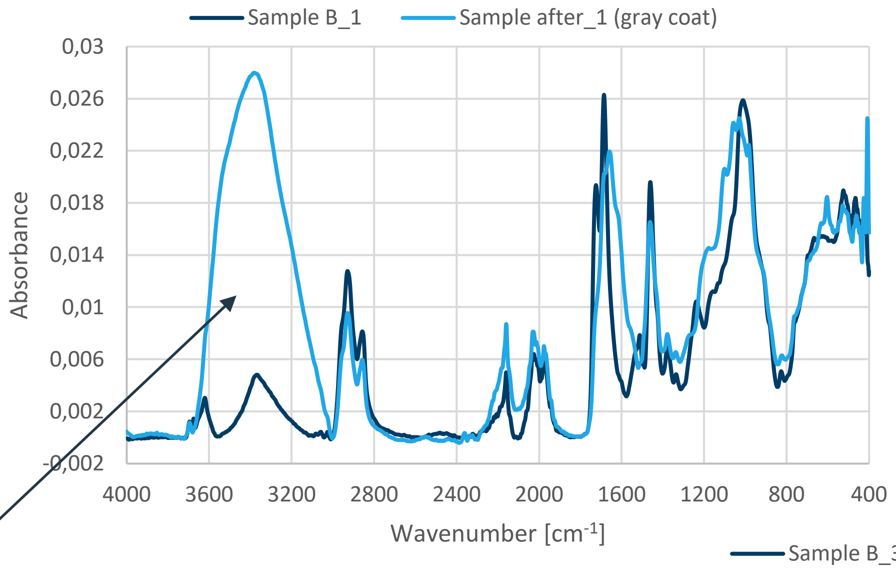
External coating	N o. particles	Weight (mg)	Dim1 (±SE) (mm)	Dim2 (±SE) (mm)
Before density separation	25	6.95	4.35 (±0.2)	2.1 (±0.2)
After density separation	39	7.35	2.96 (±0.2)	1.19 (±0.2)

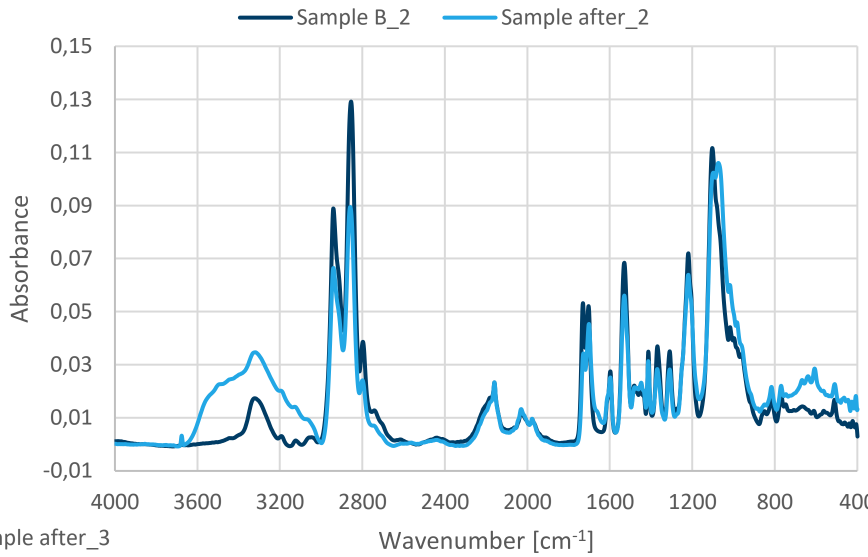
- 56% more particles
- Approx. ½ original size
- Fragmentation
- Slight change in mass due to $ZnCl_2$

Under coating	*N particles*	*Weight (mg)*	*Dim1 (±SE) (mm)*	*Dim2 (±SE) (mm)*
Before density separation	25	4.4	3.13 (±0.2)	1.09 (±0.1)
After density separation	36	1.62	2.01 (±0.1)	0.74 (±0.1)

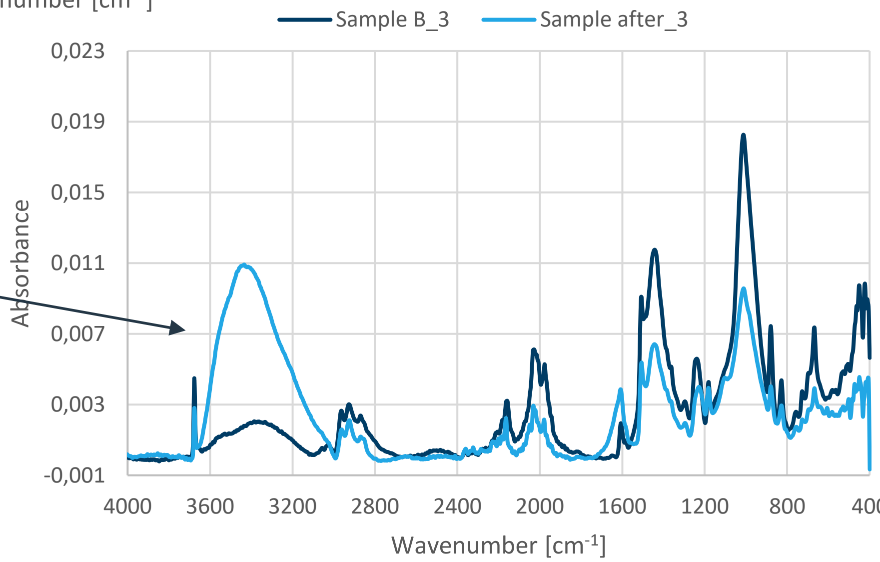
- 44% more particles
- Small reduction in particle size
- Fragmentation
- 36% reduction in mass - very small fragments lost during extraction?

Coating characterization by Attenuated Total Reflectance- Fourier Transformed Infrared Spectroscopy (ATR-FTIR)

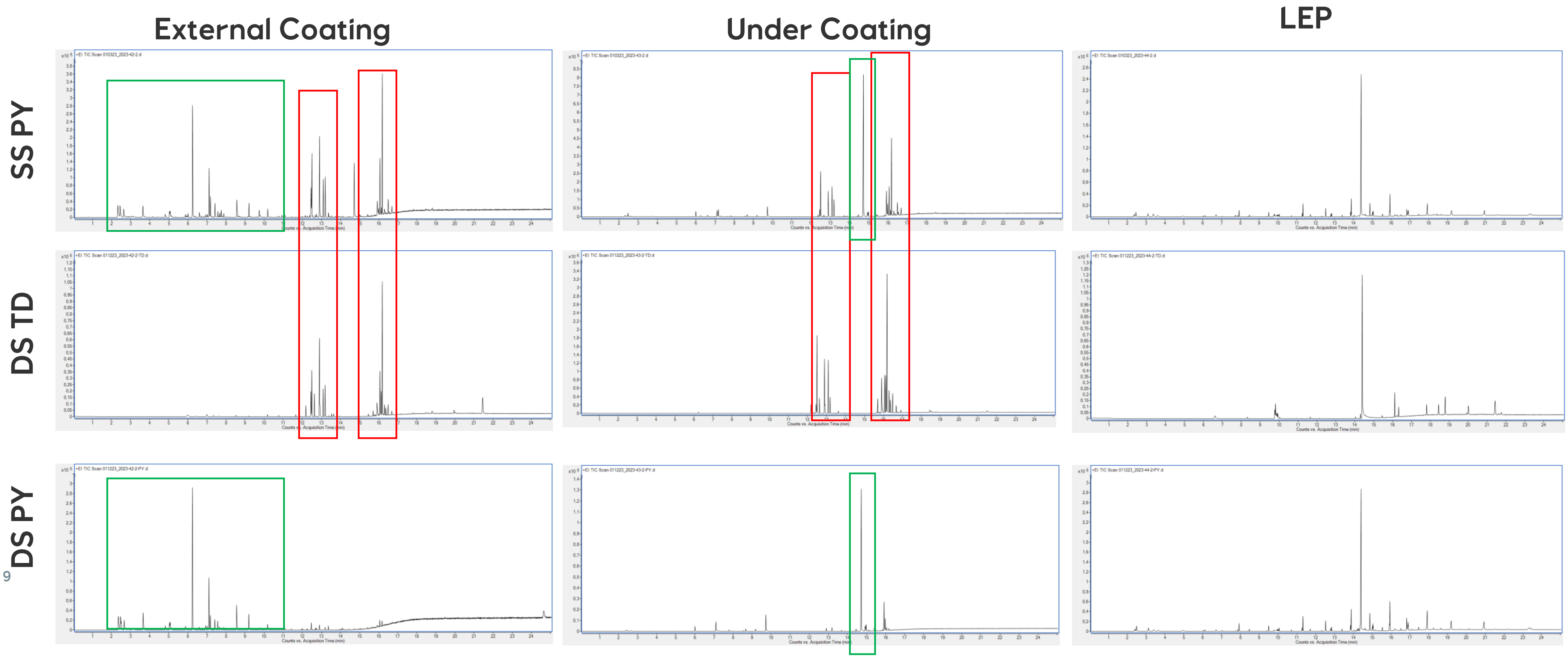




Residual $ZnCl_2$

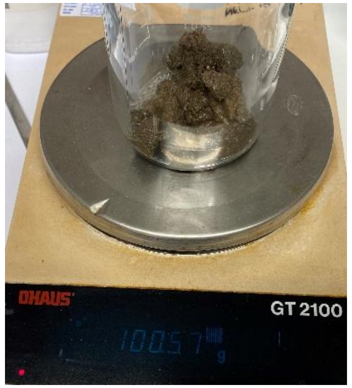


Characterization of coatings by pyrolysis and thermal desorption GC-MS

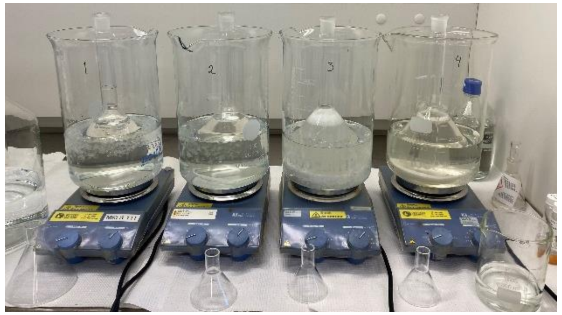


Extraction of synthetic particles (from coatings or background MP) from sediment samples

1. **Separation of potential synthetic particles from sediments (purification of the samples using density separation with $ZnCl_2$)**
2. Inspection of the purified samples using a stereomicroscope and selection of potential synthetic particles based on the physical characteristics
3. Physical characterisation of the potential synthetic particles (shape, size, colour)



N samples=15
N sub-samples= 45 (ca. 100 g ww each)
N blanks = 6
Total separated samples = 51



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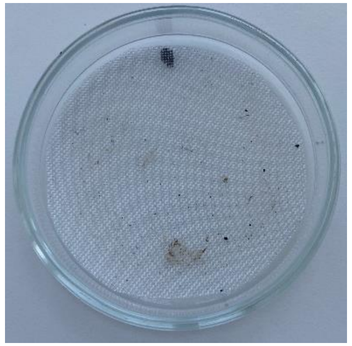
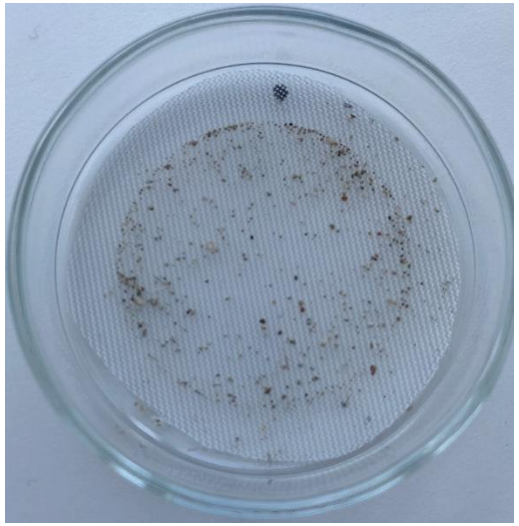
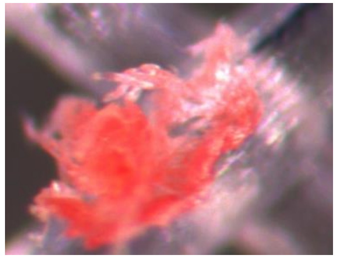
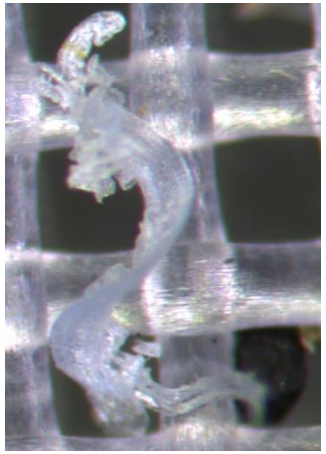
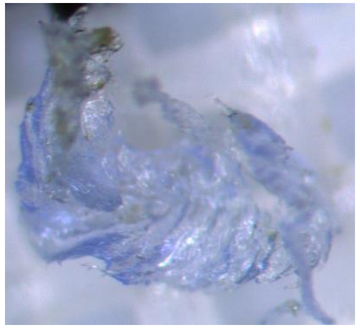
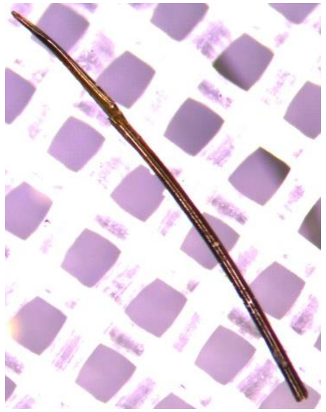












Potential synthetic particles
N = 30
Shapes = fragments, filaments, films
Dimension = 300 µm to 25 mm *(measured at the two largest cross-sections)*

No obvious coating particles from the physical features

Microplastic in OWF sediment samples

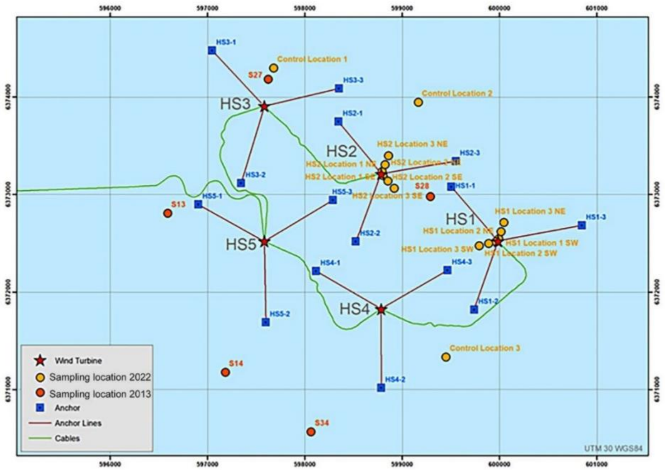
Original sample ID	No. Selected particles	No. confirmed MP	MP shape	MP polymeric composition
HS1-NE-1	2	2	Flake	PBT
HS1-NE-2	2	2	Flake, Fragment	PBT
HS1-NE-3	0	0		
HS1-SW-1	1	1	Flake	PA
HS1-SW-2	0	0		
HS2-SE-1	0	0		
HS2-SE-2	2	2	Thick filament	PS, PE-PP
HS2-SE-3	6	5	Film, flake	PE-PP, PA
HS2-NE1	2	2	Flake	PE
HS2-NE-2	3	0		
HS2-NE-3	6	4	Fragment, Film	PE, PS-DVB
HS-2022-ref-1	4	1	Flake	PE-PP
HS-2022-ref-2	2	1	Thick filament	PE-PP
Hyw-ref-3	0	0		
Hyw-SW-extra	0	0		
Totals	**30**	**20**		

- 60% (n = 9) of sample sites contained MP >300 µm.
- In most cases, 1-2 of the subsample did not contain MP.
- 30 particles selected for FTIR analysis, 20 identified as MP.
- No evidence of OWF turbine coating particles.
- Most common polymer types were PE-PP (n = 5), PE (n = 3), PBT & PA (n = 2).

* Sample sites are sum of triplicates sub-samples (n = 3)

Summary

- Sediment samples collected from Hywind Scotland Windfarm.
- Material fingerprinting approach developed and used to identify OWF-derived particles.
- No OWF-derived particles >300 μm found in any sediment sample studied.
- Pre-testing showed fragmentation could occur during sample processing – should investigate particles <300 μm in future.
- Low amounts of other MP (flakes, fragments films, filaments) found across all sediment samples.
- These data can be used as a background/baseline for future monitoring.



Thank You

Any questions?

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