SO268/3*: ON-BOARD SYSTEMATIC POLYMER WEATHERING IN MESOCOSMS

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INTRODUCTION

- Transit SO268/3 of the research vessel SONNE from Vancouver, Canada to Singapore between May 30 and July 5, 2019
- Project MICRO-FATE - Characterizing the fate and effects of microplastic particles between hotspots and remote regions in the Pacific Ocean
- Construction of mesocosms on the research vessel for natural weathering of polymers under controlled conditions (monitoring of UVB light and seawater properties)
- Analysis of the change in chemical and physical surface properties of polymers during the weathering period

NATURAL WEATHERING UNDER CONTROLLED CONDITIONS

Samples

Figure 1: Samples of different polymers (Low density polyethylene (LDPE), Polystyrene (PS), and Polyethylene terephthalate (PET)) were used as sheets (A), granulates (B), and bottle fragments (consumer product, C).

- Polymers: Low density polyethylene (LDPE), Polystyrene (PS), Polyethylene terephthalate (PET)
- Sampling after different weathering times (up to 28 days) → progress

Mesocosms

Figure 2: View of one of the mesocosms installed on board the ship (left) and position of the samples at different water depths: Sheets and PET bottle fragments in the foreground, granules in nets in the background (right).

- Imitation of different solar irradiances:
  - UV up → directly under water surface
  - UV down → at approx. 0.3 m water depth
  - Dark up und dark down → without UV light

MONITORING OF LIGHT AND SEAWATER PROPERTIES

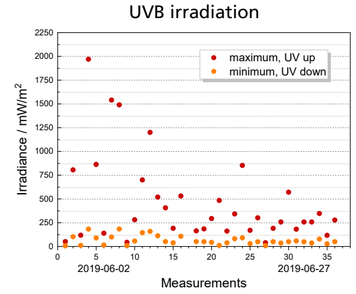

Figure 3: Monitoring UVB irradiation (spectral range of 280–315 nm) in sample positions. Irradiance fluctuated a lot due to position of the sun, attenuation by clouds and dissolved organic substances in the seawater, rolling of the ship. Average values are approx. 400 mW/m², peak values up to 1970 mW/m².

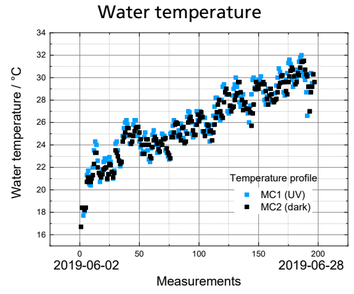

Figure 4: Water temperature in mesocosms rises from 16.7 °C to 31.6 °C from Vancouver to Singapore.

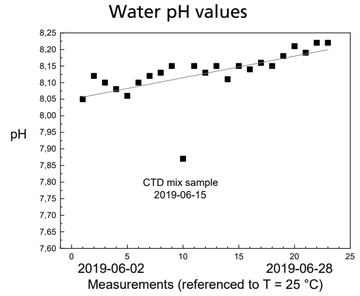

Figure 5: PH values increase towards Singapore from 8.05 to 8.23.

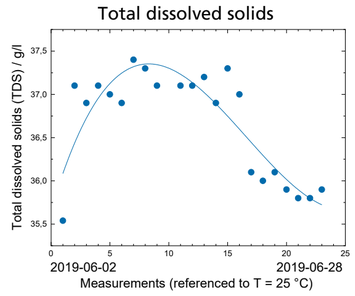

Figure 6: Total dissolved solids show lower values near the coast and higher values in the pacific center.

WEATHERING ANALYSIS METHODS

- Contact angle measurement → assessing wettability with water
- FTIR spectroscopy → analyzing breaking and formation of chemical bonds due to weathering progress
- Light microscopy and scanning electron microscopy → visualizing biofilms and roughness
- UV/VIS spectroscopy → color measurement to quantify yellowing
- Computer tomography → analyzing of weathering phenomena in the bulk
- For granules: density analysis by floating tests → biofilm on the surface?

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SELECTED RESULTS OF WEATHERING

Contact angle – wetting

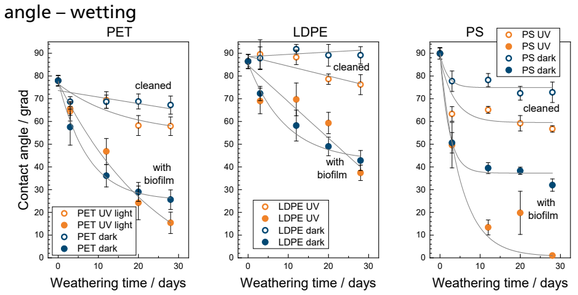

Figure 7: Temporal development of the contact angles of sheet samples weathered under controlled natural conditions in two mesocosms either with (UV light) or without (dark) light irradiation on the Pacific Ocean.

FTIR spectroscopy – chemical surface changes

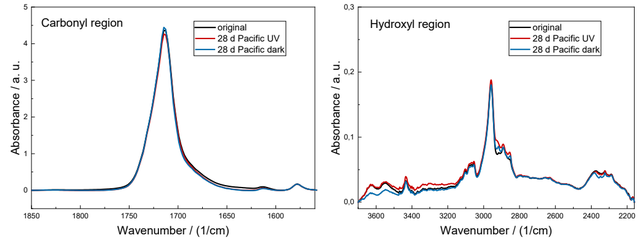

Figure 8: Carbonyl and hydroxyl region from FTIR spectra of Pacific weathered PET samples in comparison with a not weathered sample.

Scanning electron microscopy – biofilm growth

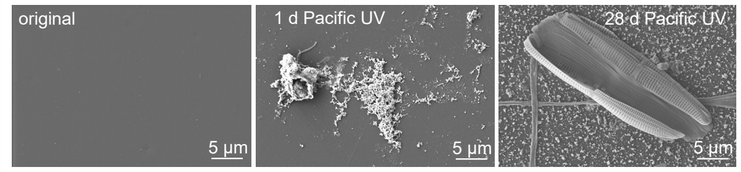

Figure 9: SEM images of PS sheets with growing biofilm over time during weathering in the mesocosm.

Summary

- Various methods were used to analyze changes in chemical and physical surface properties
- Water contact angle decreases with weathering time
  - Wetting increases for all samples
  - Contact angle depends on biofilm growth, on UV light irradiation, and on polymer material: complete wettability for PS for UV position, LDPE wets worst
  - Cleaned samples without biofilm: eco-corona layer influences the contact angle (cannot be completely removed with our cleaning method)
- None or only minimal chemical changes on the surface detectable

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