# An experimental set-up for the generation of microplastics: Degradation of polypropylene in the presence of different antioxidants

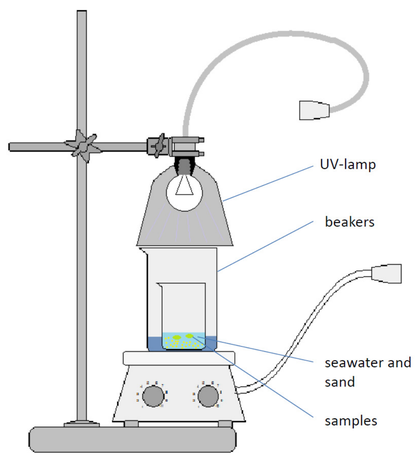
N. Hemker[a], D. Walper[a], J. Meyer[a], U. Braun[b], S. Fuchs[a],

HOCHSCHULE HAMM-LIPPSTADT

## 1. Introduction

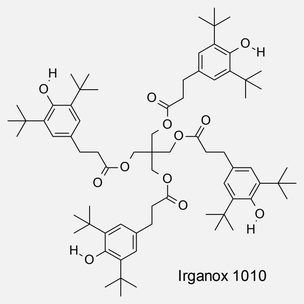
Microplastics in the oceans are a rising environmental problem. The presented project shows the development of an experimental set-up for the simulation of marine conditions for the artificial generation of microplastics. First trials with virgin and additivated polypropylene were performed.

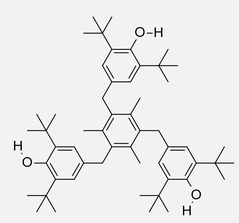
## 2. Materials and Methods



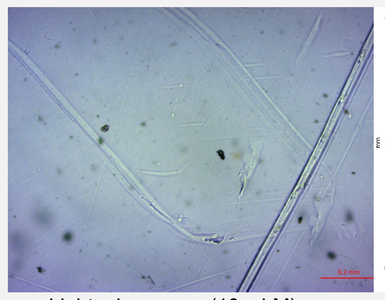

- Seawater, the solar radiation and the abrasion in the presence of sand and wave motions had to be transferred into a lab-scale set-up
- For the implementation the upper set-up was developed
- The temperature was increased up to 60 °C to accelerate the process of degradation.
- Comparison of the degraded plastics with and without mechanical abrasion was performed

## 3. Polymer recipes tested

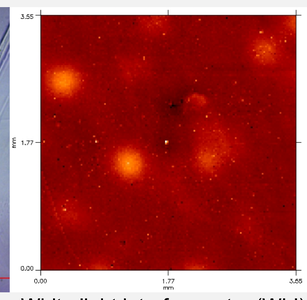


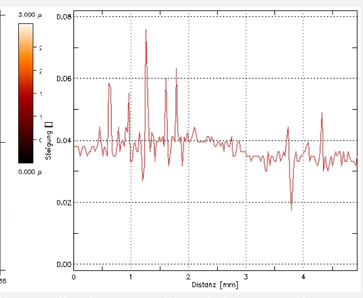

Comparison of virgin polypropylene with stabilized polypropylene (Irganox 1010 and Irganox 1330)



Light microscope (10x, LM)

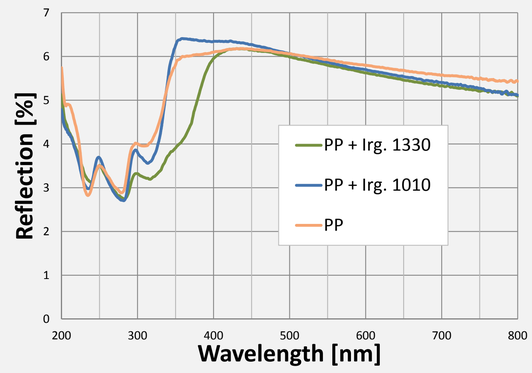


White light interferometry (WLI)



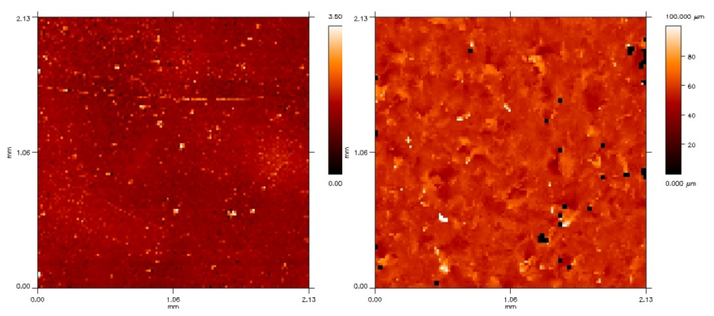

Surface profile of the sample

- Light microscopy (LM), white light interferometry (WLI) and the surface profiles show no differences between the three samples (PP, PP+Irg.1010 and PP +Irg. 1330) before the degradation treatment. Here virgin PP is shown.
- The UV-vis-spectra and color-indices show small, but insignificant changes between the additivated and the virgin PP before degradation.

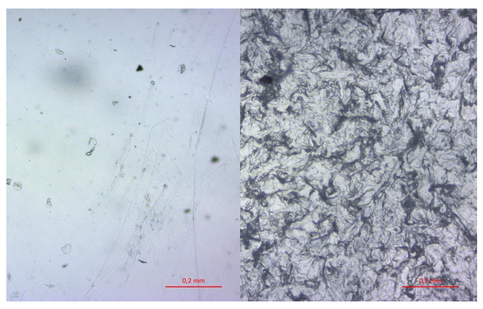



## 4.Results and Discussion

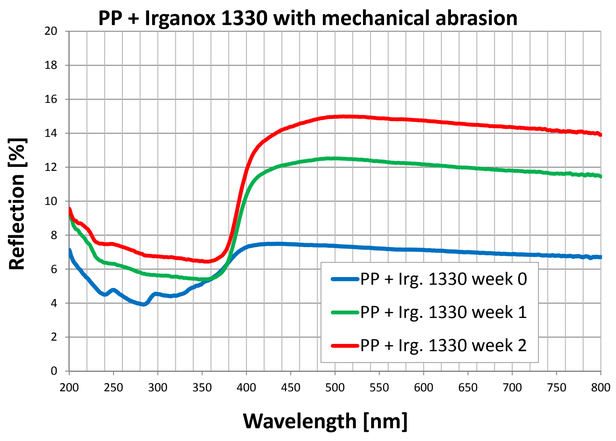
- After one week there are obvious changes in the UV-vis-spectra of all samples; hence also the color values changed, especially for the samples with Irganox 1330, changed significantly
- The change in reflection between ~380-500nm leads to the change in the yellowness index and the b*-value



WLI after 1 week: left without, right with mechanical abrasion



LM after 1 week: left without, right with mechanical abrasion




| | mechanical abrasion | Week | L* | a* | b* | YI |
|---|---|---|---|---|---|---|
| PP | no | 0 | 32,33 | -0,13 | -0,99 | -4,56 |
| | no | 1 | 33,04 | -0,09 | -0,90 | -4,01 |
| | yes | 0 | 25,92 | -0,39 | -1,51 | -8,63 |
| | yes | 1 | 48,04 | -0,49 | -1,33 | -5,04 |
| PP + Irg. 1010 | no | 0 | 29,02 | -0,24 | -1,71 | -8,70 |
| | no | 1 | 33,75 | -0,08 | -0,80 | -3,45 |
| | yes | 0 | 25,39 | -0,32 | -1,95 | -11,04 |
| | yes | 1 | 42,09 | -0,32 | -1,75 | -6,96 |
| PP + Irg. 1330 | no | 0 | 26,59 | -0,42 | -1,62 | -9,10 |
| | no | 1 | 28,99 | -0,61 | -0,19 | -1,91 |
| | yes | 0 | 25,59 | -0,50 | -1,41 | -8,40 |
| | yes | 1 | 41,81 | -0,88 | 0,09 | -0,80 |

- The polymer surfaces which were treated with sand show already significant changes in the surface roughness after one week
- It (Ra, average roughness value) increases from ~ 0,24 µm to ~3,20 µm
- In contrast, the surfaces of the untreated samples did not change noticeably
- After two weeks no further change in roughness could be detected

## 5. Conclusion & Outlook

- The presented experimental set-up proved to be suitable to examine of the artificial generation of microplastics under simulated marine conditions.
- Results show significant changes especially in the UV-vis-spectra of the treated polymers already after one week of exposure. Also the surface damages due to the mechanical abrasion by sand motion are remarkable.
- For more reliable results longer degradation times have to be applied. The actual examinations are designed to run over 4 weeks.
- The next step should be the examination of different polymers and different antioxidants.
- Furthermore, the determination of the molar weight of the degraded polymer is a fundamental point of interest.

## 6. References

**(1)** Andrady, A. L.: "*Microplastics in the marine environment.*" Marine pollution bulletin 62.8 (**2011**), 1596-1605. **(2)** UNEP, Kershaw, P.J.: "*Marine plastic debris and microplastics–Global lessons and research to inspire action and guide policy change*." United Nations Environment Programme, Nairobi, (**2016**). **(3)** Celina, M. C.: "Review of polymer oxidation and its relationship with materials performance and lifetime prediction." Polymer degradation and stability 98.12 (**2013**): 2419-2429. **(4)** Carlsson, D. J., et. al.: "*Initiation of polypropylene photooxidation. 2. Potential processes and their relevance to stability*." Macromolecules 9.5 (**1976**): 695-70. **(5)** Kester, Dana R., et al. "*Preparation of artificial seawater*." Limnology and oceanography 12.1 (1967): 176-179.

[b] Ulrike Braun
Federal Institute of Materials Research and Testing (BAM),
Berlin, Germany

Sabine Fuchs
sabine.fuchs@hshl.de

[a] University of Applied Science
Hamm-Lippstadt
Marker Allee 76-78
59063 Hamm, Germany.