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

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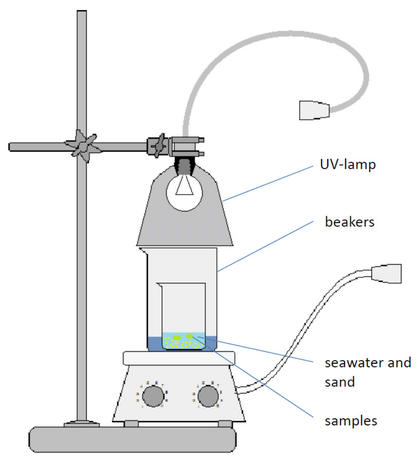
1. Introduction

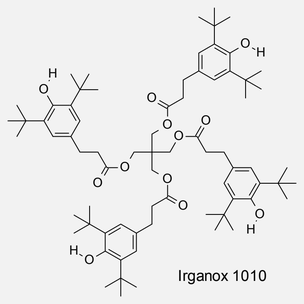
Microplastics in the oceans are a rising environmental problem. The presented project shows the development of an experimental set-up for the simulation of marine conditions for the artificial generation of microplastics. First trials with virgin and additivated polypropylene were performed.

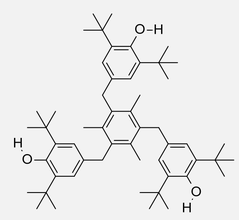
2. Materials and Methods



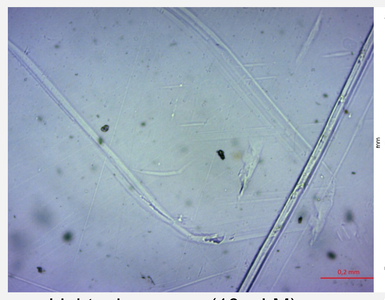
- Seawater, the solar radiation and the abrasion in the presence of sand and wave motions had to be transferred into a lab-scale set-up
- For the implementation the upper set-up was developed
- The temperature was increased up to 60 °C to accelerate the process of degradation.
- Comparison of the degraded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

3. Polymer recipes tested

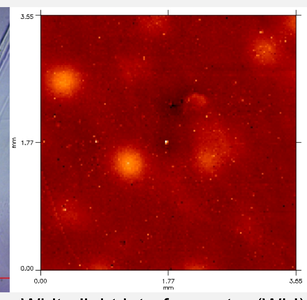




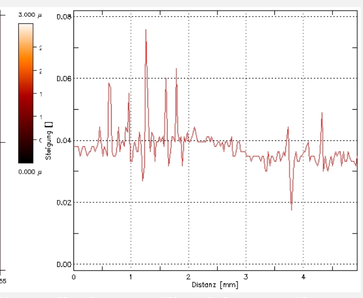
Comparison of virgin polypropylene with stabilized polypropylene (Irganox 1010 and Irganox 1330)



Light microscope (10x, LM)

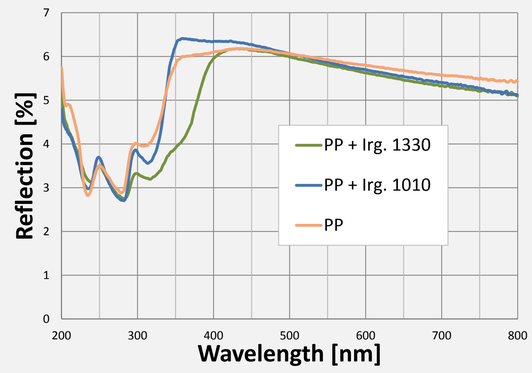


White light interferometry (WLI)



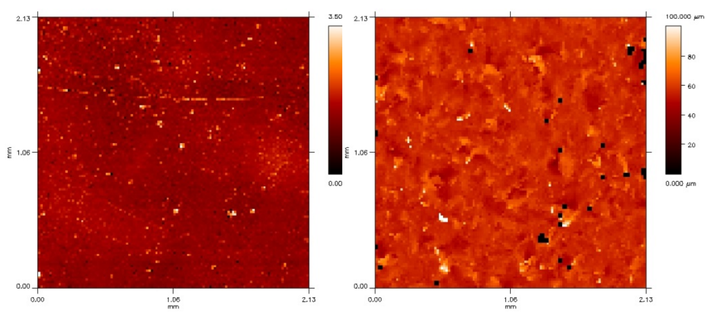
Surface profile of the sample

- 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.

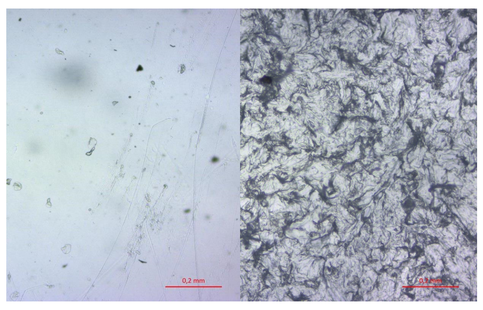


4.Results and Discussion

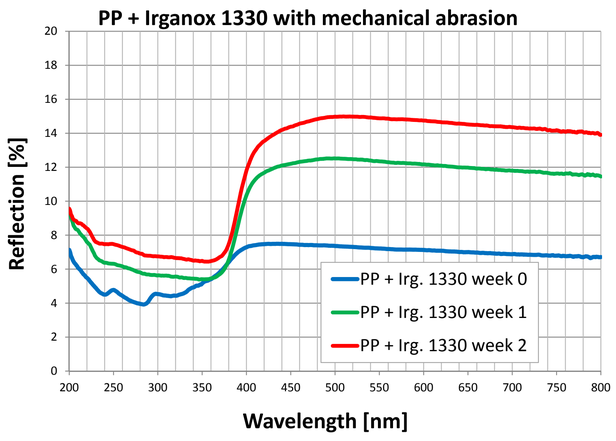
- After one week there are obvious changes in the UV-vis-spectra of all samples; hence also the color values changed, especially for the samples with Irganox 1330, changed significantly
- The change in reflection between ~380-500nm leads to the change in the yellowness index and the b*-value



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.

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