ENVIRONMENTAL STRESS CRACKING RESISTANCE (ESCR) OF RECYCLED PP (rPP) FROM AND FOR YOGURT CUPS

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Abstract
Recycling of plastic packaging waste is a promising approach towards a circular economy due to the high amount used and the short application time. This paper uses the concept of environmental stress cracking resistance (ESCR) to investigate the fatigue behavior of recycled yogurt cup materials. As test environments air and oil where chosen, where the latter imitates the fatty structure of yogurt. Therefore, four fractions of manually sorted post-consumer polypropylene yogurt cup waste was shredded to flakes and washed with different temperatures and media. Additionally, one of these fractions was blended with varying amounts of virgin pipe material. Furthermore, the reference material, which is currently used for yogurt cups was tested for comparison. Various influences of the fatigue tests were detected, which are a more pronounced influence of oil than of air, especially for recyclates but also for virgin materials and a significant improvement of the recyclates which were blended with a pipe grade material.

1. Introduction
Mechanical recycling gained a lot of economic, legal and scientific attention in the past years. The goal is to close the loop which is for example already done in PET bottle recycling. However, a big amount of packaging products are made from polypropylene, e.g. yogurt cups. Products used for these applications do often come in contact with various different media which are based on fats and oils. Therefore environmental stress cracking (ESC) has to be considered as it is the most common cause of unexpected brittle failure. Our study deals with the recycling and reprocessing of thermoformed products like yogurt cups and focuses on the product performance.

2. Experimental
Thermoformed post-consumer polypropylene cups for dairy products from a separated collection in an Austrian waste collection center were manually separated for the purpose of this work. Decorations were removed so that only the pure plastic cup remains. The cups were shredded on an industrial-sized shredder. Afterwards three different washing programs were performed. For comparison an unwashed sample was prepared. Samples were prepared in pure form and one material was blended with a highly ESCR-resistent PP pipe grade. All samples in flake form were compounded using a filtration unit. Additionally, a standard thermoforming grade was used for comparison. All materials were compression molded to plates and cracked round bar (CRB) specimens were prepared and notched on a lathe. Cyclic tests in oil environment were performed at room temperature for the determination of the environmental stress cracking resistance (ESCR). Sunflower seed oil was chosen as representative oily environment, as dairy products have a certain amount of fatty and oily substances inside which could influence the material behavior during application. For some samples also tests in air were conducted. The used machine and environmental testing chamber is explained in [1]. Immersion tests for PP were performed prior testing to optimize testing time.

3. Results
For the reference material a certain difference of the fatigue behavior was derived for measurements in air and oil environment. As oil turned out to be more critical, the following experiments were continued only in oil. Afterwards, the samples from the recyclates with different pre-treatments were compared to the reference sample. Recycled materials achieved inferior results than the reference. Additionally, one recyclate fraction was also measured in air. The difference between the two media turned out to be much more present than for the virgin reference material. Therefore, this recyclate fraction was blended with 10,

20 and 30% of a pipe grade, to keep the recyclate content at a high level and to decrease the MFR which is important to maintain the performance of thermoforming materials. A significant improvement of the fatigue behavior could be detected for the diluted blends.

4. Conclusions

ESCR measurements were performed on manually sorted and differently pre-treated post-consumer thermoformed products. This approach successfully showed the applicability of fatigue experiments to gain insights on the material behavior compared to conventional mechanical characterization. For a comprehensive evaluation of material and product performance, it is of utmost importance to consider the medium to which the product is exposed. However, the influence is less compared to amorphous plastics, since less medium can penetrate into the crystalline areas.

Acknowledgements

The authors acknowledge financial support through the COMET Centre CHASE, funded within the COMET − Competence Centers for Excellent Technologies programme by the BMK, the BMDW and the Federal Provinces of Upper Austria and Vienna. The COMET programme is managed by the Austrian Research Promotion Agency (FFG).

References

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