REPROCESSING OF HIGH DENSITY POLYETHYLENE

Hoai Maria Nguyen Thu, Michael Preschl, Thomas Koch, Vasiliki-Maria Archodoulaki

E308-02-1- Institute of Material Science and Technology- Research Group Structural Polymers
TU Wien

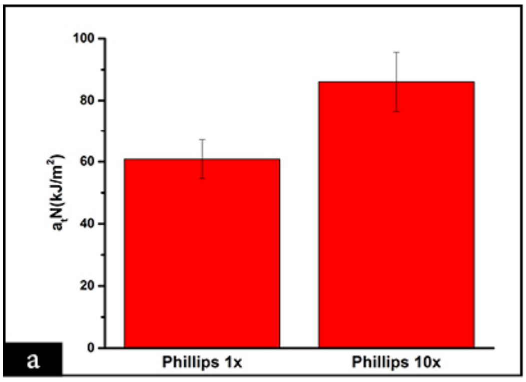
INTRODUCTION

Plastics have made modern life possible and have become an integral part of our everyday life. In 2017 the worldwide plastic manufacturing reached about 350 million tonnes[1]. Plastic disposal has become a global problem since plastic scraps are released into the environment during its production and as waste after usage. Mechanical recycling is a common way to re-process waste materials. However, the mechanical properties of the material are maybe affected, which can lead to a reduction of the quality of the manufacture. 92% of the worldwide plastic production is allocated among 7 different types of plastic. With 36% polyethylene leads the world market [2].

This work deals with the simulation of mechanical recycling of high density polyethylene (PE-HD). In literature the data are incomplete concerning an industrial upscaling, since the processing temperatures used in research are too low[3] which comes along with a low extruder throughput and therefore low profit. Besides, little attention was payed which catalyst system was used to produce PE-HD[3],[4]. Ziegler Natta leads to chain scission and further degradation. Whereas Phillips can cause crosslinking, and the thermoplastic becomes a thermoset, which excludes the re-processing through film blowing[5]. The influence of the pre-treatment method (pelletising or grinding) is also a point of interest, since additional mechanical degradation can occur.

EXPERIMENTS / FUNDAMENTAL OF THE PROBLEM / EXAMINATIONS

To simulate mechanical recycling 10 extrusion cycles were done on the single screw extruder Ex-18-26 with a screw rotating speed of 75 rpm and two different processing temperature sets from the first zone to the third zone were applied. The first one with 130°C-180°C-200°C follows the approach in literature and the second one with 130°C-240°C-240°C represents processing temperatures from industry. Two PE-HD types were investigated. One made through a Ziegler Natta catalyst named Hostalen GF 4750 purchased from LyondellBasell and the Phillips type Marlex 5502BN provided by Chevron Phillips Chemical. Moreover, the manufacturing processes of pelletizing and grinding were simulated. Pelletizing was conducted through cutting and grinding was done with the universal cutting mill Pulverisette 19 (Fritsch). After 1 and 10 extrusion cycles tensile tests (Zwick 050) according to DIN ISO 527-2 and tensile impact strength tests (Instron Ceast 9050) according to DIN ISO 8256 were done. The influence of the processing of the specimens (injection moulded and compression moulded) is also investigated. To determine the crosslinking content, the samples were heated at 140°C for 24h in xylene according to ASTM D2765-01.



RESULTS AND DISCUSSION

At 180°C and by pre-treating the material via cutting, in comparison to the first cycle extruded samples, the 10 times extruded PE-HD had higher impact tensile strength. This was found for both catalyst systems (Figure 1). No changes in strain at break were observed between the single extruded samples and the 10 times extruded Phillips PE-HD. For the 10 times extruded injection moulded Ziegler Natta PE-HD samples the strain at break doubled (Figure 2b). Due to chain scission of the longest chains, the new medium sized chains have a higher mobility, which causes a weakening of the polymer network. Therefore, the rigidity decreases and the elasticity rises[6].

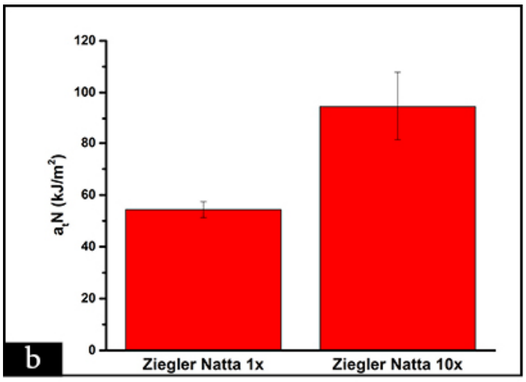


Figure 1: a) tensile-impact strength for Phillips PE-HD, b) tensile-impact strength for Ziegler Natta PE-HD

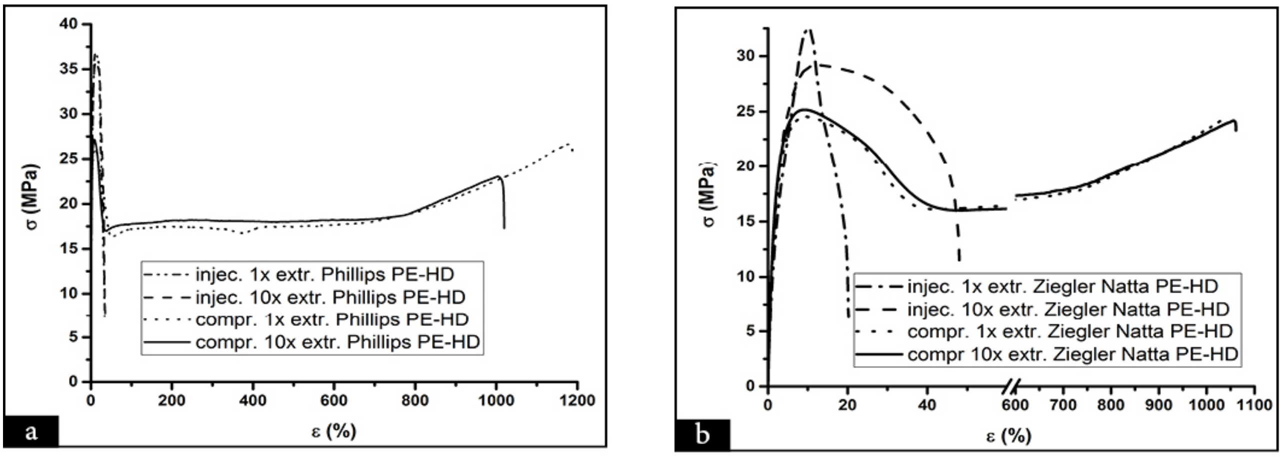


Figure 2: a) stress- strain diagram for Phillips PE-HD, b) stress- strain diagram for Ziegler Natta PE-HD

CONCLUSION

The obtained results show a strong dependence on the processing parameters and the used PE-HD type. The gentlest re-treatment process for each polymer must be identified. Further PE-HD types with other melt flow index values and PE-HD from post-consumer waste must be investigated, in order to ensure a proper recycling method.

REFERENCES

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