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Toughening of poly (lactic acid) by various polycaprolactone-copolymers with modulated crystallinity

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Poly(lactic acid) (PLA) is a commercially available biobased material with high strength and modulus. The major drawback of this polyester is its brittle nature. For applications such as thin films and foils, it is necessary to flexibilize PLA. Adding low molecular weight plasticizers or blending PLA with other polymeric components can help to increase the elongation of break of the resulting materials. However, due to complex (co-)crystallization aging and separation effects (migration) are described for these systems. Aim of this research was developing a non-migrating plasticizer for PLA. The idea is trapping oligomers within the PLA-matrix via crystallization to avoid migration and solubility problems. Blockcopolymers with a compatibilizing unit (poly-D-lactic acid) (PDLA) and a plasticizing unit polycaprolactone (PCL) were synthesized and blended with poly (L-lactic acid)-matrix (PLLA). Forming the so-called stereocomplex between PDLA-blocks and PLLA-matrix traps the PCL-blocks within the PLLA. Besides a lower migration tendency, stereocomplex bonding of the PCL-blocks improves the efficiency of the plasticizer. In comparison to polymer blends with the same amount of PCL-oligomers, blockcopolymers with PDLA and PCL shift the glass transition temperature to lower values. This effect can be explained by the modulated crystallization of the PCL-blocks trapped within the matrix. The mobility of the bound PCL-blocks is lower, so that their ability to crystallize is lower and a higher effective amount of PCL can interact with the PLLA-matrix. This effect is even more pronounced using branched PCL-blocks. The crystallinity of branched PCLs was significantly lower than of linear PCLs. Adding small amounts of DL-lactide units to these branched structures results in completely amorphous oligomers. PLLA blends with blockcopolymers containing these branched PCL-blocks show a tremendous increase in elongation at break from 1 % for neat PLLA up to 213 %.

Biography

Philip Mörbitz holds a Master of Science in Polymer Science from the Technical University of Dortmund. He has been working for Fraunhofer UMSICHT since 2014 as a doctoral fellow. He successfully defended his PhD Thesis in February 2018 and is now working as a post doc researcher in the department “Bio-based Plastics”. His main fields are macromolecular chemistry and structure properties relationships in terms of polymer physics.

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