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## Hierarchical organization in biodegradable polymer films by SAXS, USAXS and synchrotron FTIR imaging

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Poly(lactic) acid (PLA) is a biodegradable biopolymer which suffers from poor mechanical properties and high cost. The addition of polyethylene (PE) introduces a toughening effect which dramatically improves these material properties. Here we report on initial characterization of films produced by blown film extrusion and the re-organization of films as static loads are applied. The measurements utilized are synchrotron based FTIR microspectroscopy and the polarization analysis capability of the MIRAS beamline at ALBA together with a combination of synchrotron (ALBA, NCD-SWEET and Advanced Photon Source, 9ID) and lab based X-ray scattering. The extended range of scattering vectors of our X-ray scattering measurements characterizes length scales typifying molecular scale packing of polymer chains but also the organization around the micron scale phase separation of PE and PLA. While X-ray scattering is able to provide insight into organization of craze formation in films, orientation of PE semi-crystalline lamellae and their phase separation it is ill suited to provide information on the poorly ordered PLA. As the films were stretched, visually dark bands appeared in the films. X-ray scattering provided evidence of a reinforcing effects of the phase separated PE. The poor performance of the pure PLA films is associated with the crystallization of PLA as evidenced from the appearance of broad SAXS peak typical of semicrystalline lamellae in the pure PLA films. This feature was poorly visible or absent in the blend films. These bands were associated with chemical and orientational heterogeneity. Polarized FTIR microspectroscopy measurements showed a dichroic behavior for the PLA/PE blend films in the fractured regions, indicating an alignment of PLA and PE with respect to the stretching direction in the presence of PE. The dichroic signal is much weaker for the PLA films. The results show that the presence of PE supports an alignment of the PLA chains without crystallization.

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