Analysis of crack-tip fields and toughening mechanisms in ternary polymer blends

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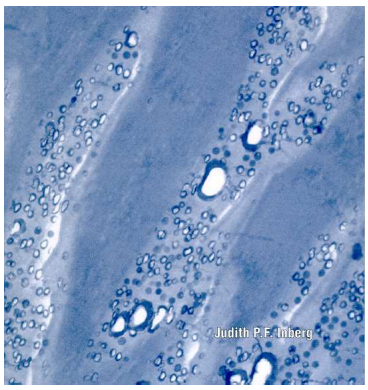
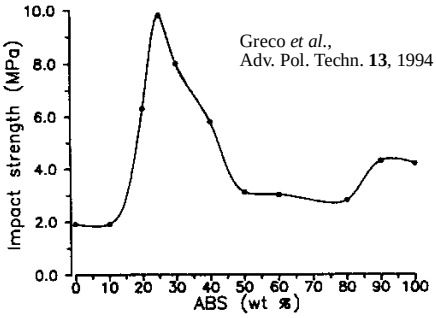
1. Introduction

Polycarbonate (PC) is notch sensitive. In order to improve the fracture toughness (especially under impact conditions), PC is blended with ABS (a blend of SAN and small rubber particles). Experiments show that it works, but the origin of dependence on ABS content and morphology are basically unclear.

The objective of this study is to gain basic understanding of the changes in the near crack-tip conditions due to addition of ABS: how does it affect dissipation by plastic flow and the propensity of crazing?

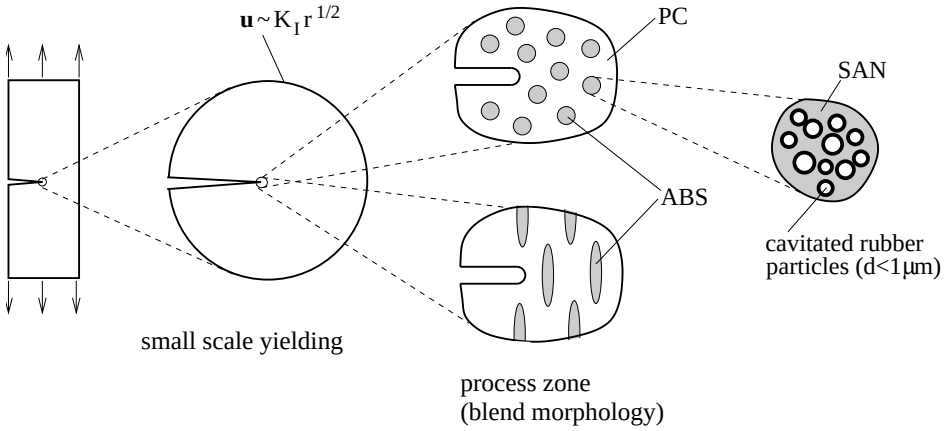


(from thesis J.P.F. Inberg)



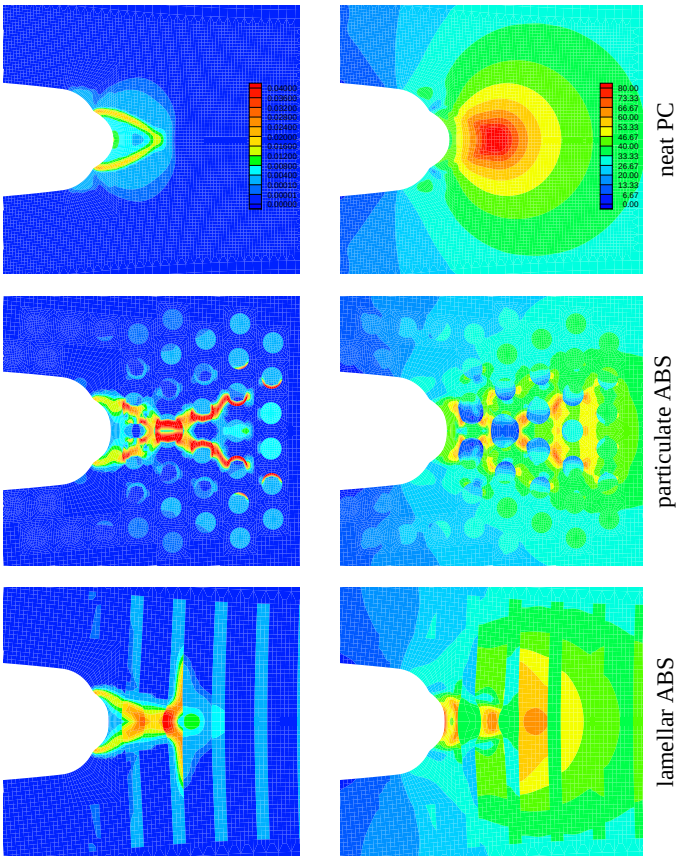
2. Modeling

We perform a numerical study of plastic deformation in a PC/ABS blend. The morphology is explicitly modeled (either particulate or lamellar ABS), but the ABS is modeled in a homogenized manner. Large strain, rate-, pressure- and temperature dependent yield of PC and SAN is accounted for, including softening and re-hardening. Once the rubber particles cavitate (upon reaching a critical hydrostatic stress), the ABS responds as porous SAN.



plastic strain rate (indicator for dissipation)

hydrostatic stress σ_m (indicator for craze initiation)



3. Results

Two morphologies are considered, both with 30% ABS (10% rubber).

The distributions of plastic strain rate show how the presence of ABS particles or lamellae tends to enlarge the plastic zone. As a consequence, the total dissipated energy $\overline{W}_{\text{diss}}$ near the crack tip is significantly larger in PC/ABS than in neat PC. This is an indication of an enhancement of the toughness due to the ABS. There is no significant dependence on morphology.

The nucleation of crazes depends sensitively on the local hydrostatic stress σ_m. The distribution of σ_m shows that the ABS dissolves the large stress peak ahead of the tip in neat PC, thereby reducing the tendency for crazing. However, high peaks are still found in between the individual ABS particles. The maximal value $\sigma_m^{\max}$ appears to be smaller in the lamellar ABS.