The study of the toughening mechanism of core-shell structure particles toughened polypropylene

21529043 Jia Erwen, Shangguan Yonggang, Zheng Qiang*

Department of Polymer Science and Engineering, Zhejiang University, Hangzhou 310027, China

Abstract: The mechanical properties show that PP/EPR/HDPE and PP/EPR/MDPE are tough enough while PP/EPR/LDPE is brittle. The contributions of the size of core-shell structure dispersed particles, crystallization properties and loss peak area of rubber phase were excluded. The high toughness of PP/EPR/HDPE and PP/EPR/MDPE can be ascribed to the lots of matrix's shear yielding deformation, and the stress can be transmitted to the core because of the good interfacial strength between EPR and HDPE or EPR and MDPE. In the meantime, the interfacial pressure stress can promote the shear yielding of the core. PP/EPR/HDPE/LDPE is brittle while PP/EPR/HDPE is tough, it is because HDPE and LDPE form complex core, and LDPE located in the outer, the interphase between the shell and the core is weakened, and the stress can't be transmitted to the core.

Introduction

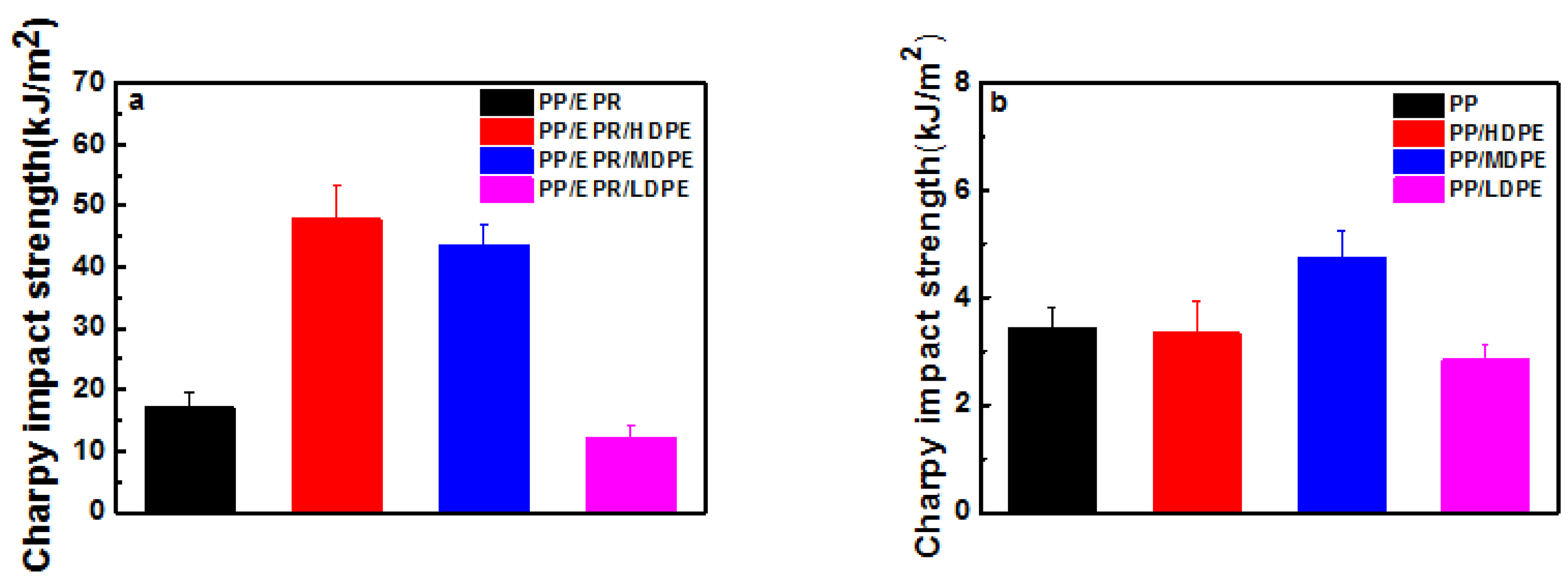

Fig. 1. Charpy impact strength at 23°C of (a) PP/EPR and PP/EPR/PE blends and (b) PP and PP/PE blends. The mass ratio of PP/EPR is 85/15, PP/EPR/PE is 85/15/10, and PP/PE is 85/10.

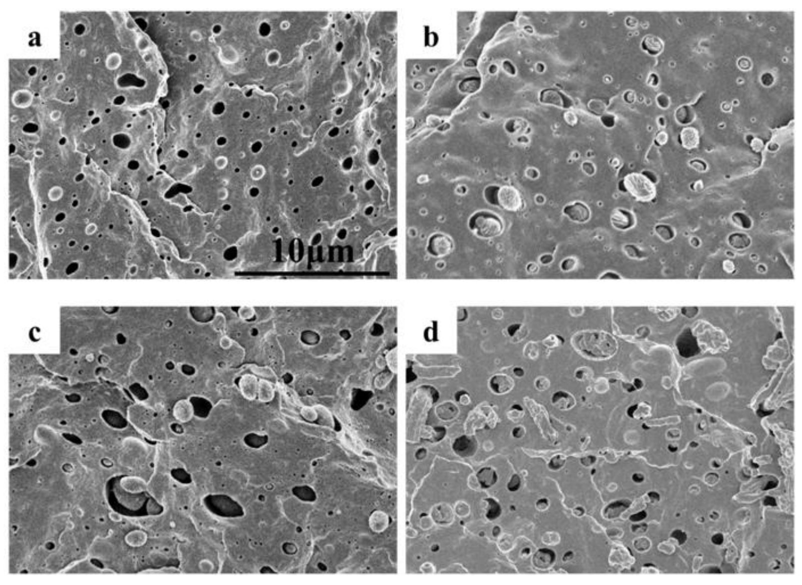

Fig.2 The morphology of PP/EPR and PP/EPR/PE blends. (a) PP/EPR, (b) PP/EPR/HDPE, (c) PP/EPR/MDPE, (d) PP/EPR/LDPE.

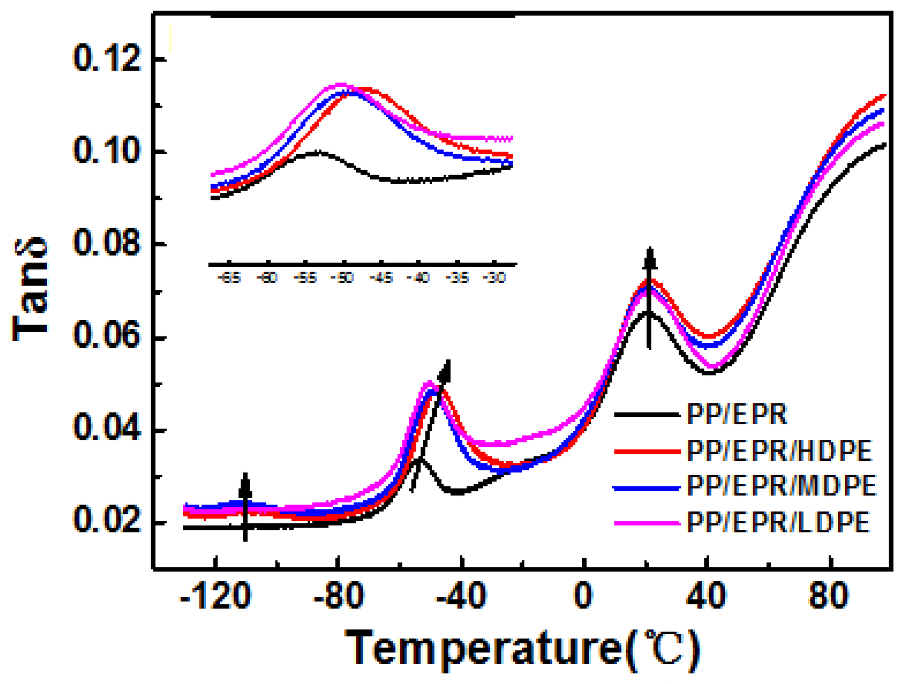

Fig.3 Dynamic mechanical properties of PP/EPR and PP/EPR/PE blends

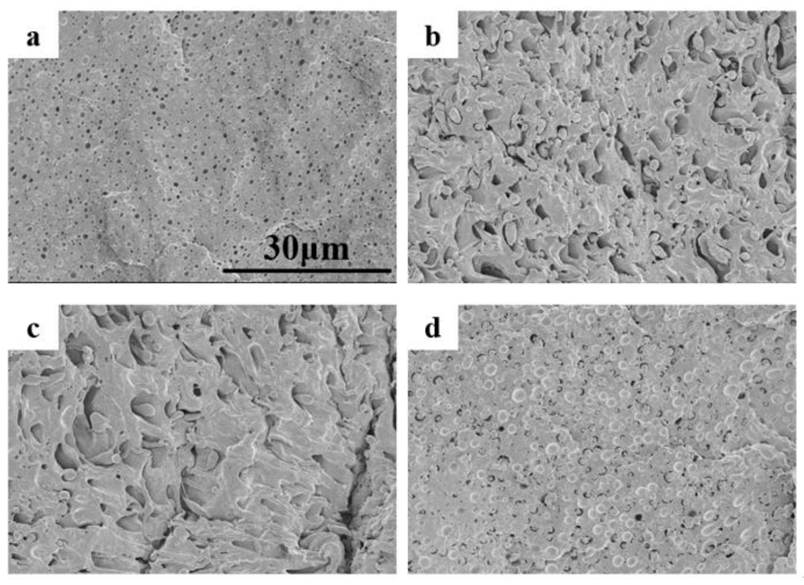

Fig. 5. The impact section morphology of PP/EPR and PP/EPR/PE blends. (a) PP/EPR, (b) PP/EPR/HDPE, (c) PP/EPR/MDPE, (d) PP/EPR/LDPE.

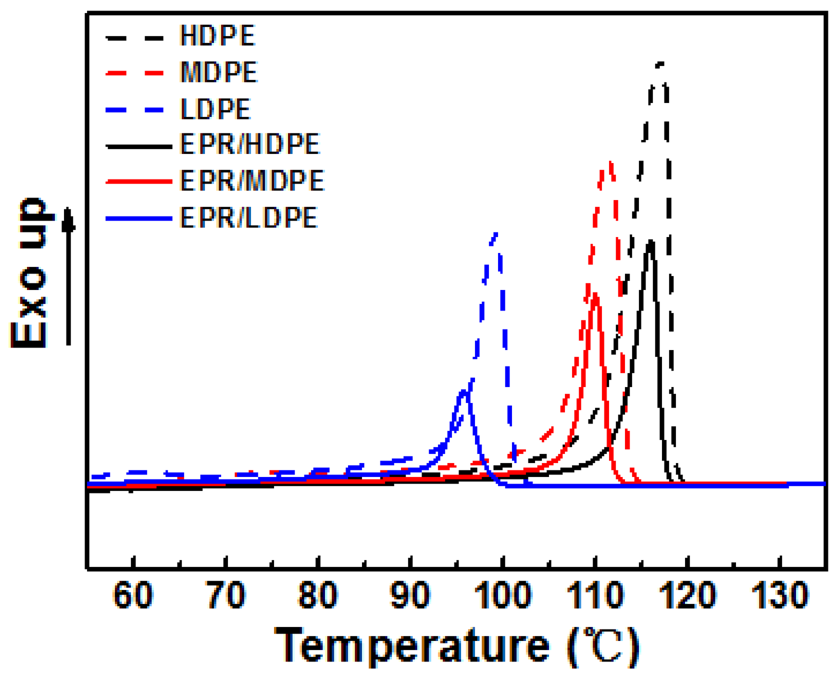

Fig. 6. The crystallization behavior of pure PE and EPR/PE .

Table 1. The crystallization information of pure PE and EPR/PE.

	HDPE	MDPE	LDPE
The crystallization enthalpy of pure PE (J/g)	193.6	151.9	121.4
The crystallization enthalpy loss of PE in EPR/PE compared to pure PE (J/g)	12.7	12.9	9.4
The percentage of crystallization enthalpy loss (%)	6.55	8.51	7.78
The decrease of crystallization peak (℃)	1.0	1.3	3.3

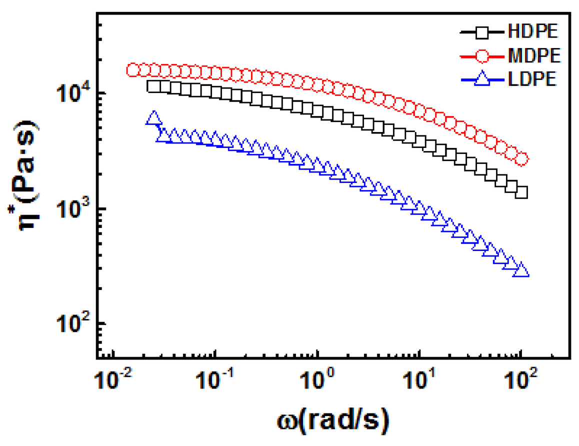

Fig. 7. the complex viscosity of PE.

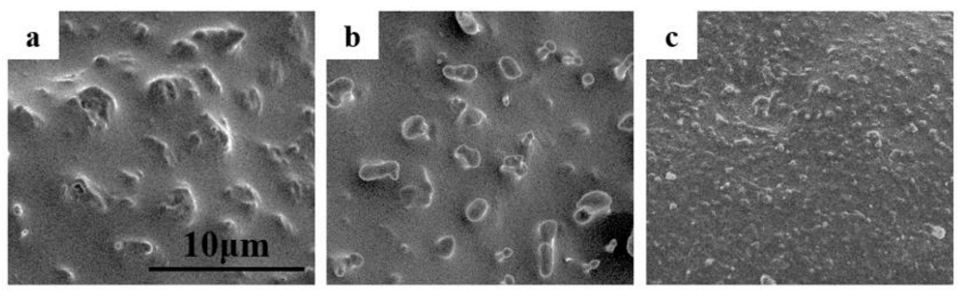

Fig. 8. The morphology of (a) EPR/HDPE (b) EPR/MDPE and (c) EPR/LDPE.

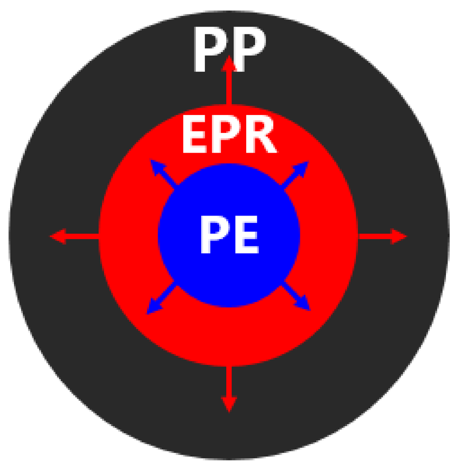

Fig. 4. Stress model of PP/EPR/PE ternary blend.

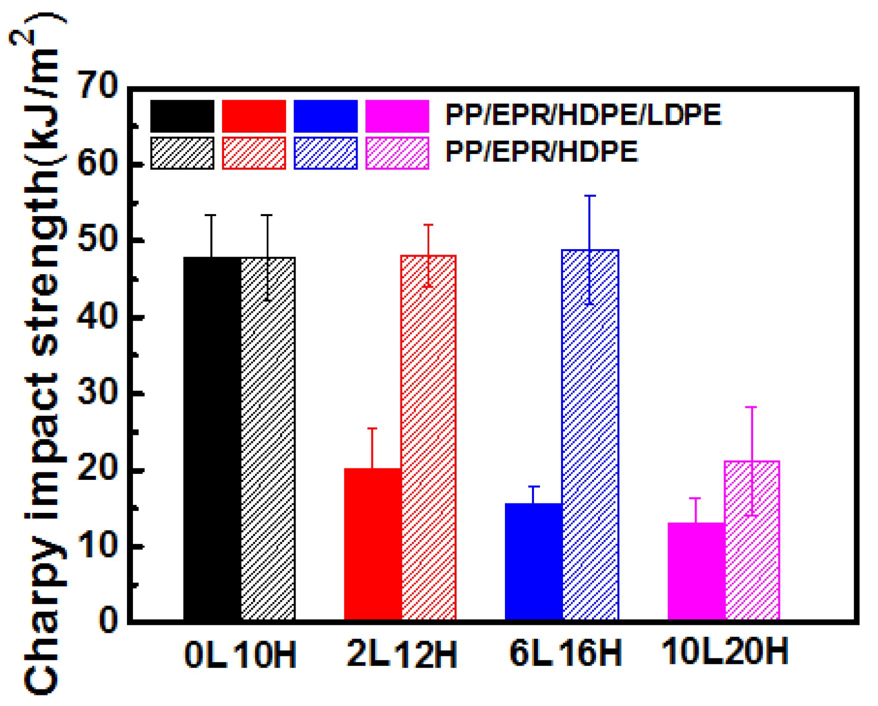

Fig 9. Charpy impact strength at 23°C of PP/EPR/HDPE with different HDPE content and PP/EPR /HDPE/LDPE with different LDPE content.

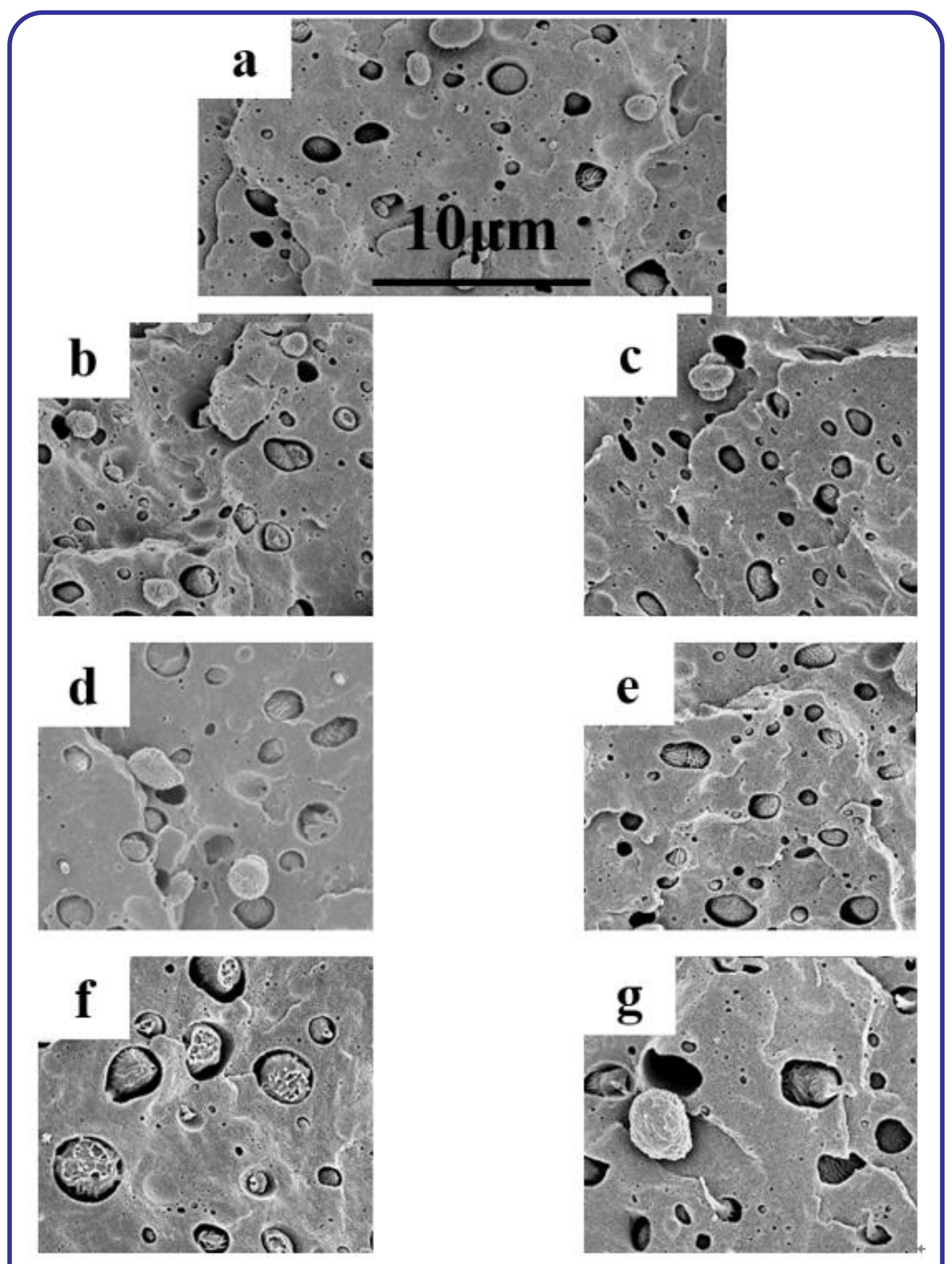

Fig 10. The morphology of PP/EPR/HDPE and PP/EPR/HDPE/LDPE blends. (a) 10H/0L, (b) 2L, (c) 12H, (d) 6L, (e) 16H, (f) 10L, (g) 20H. The total content of PE for (b) and (c), (d) and (e), (f) and (g) are the same.

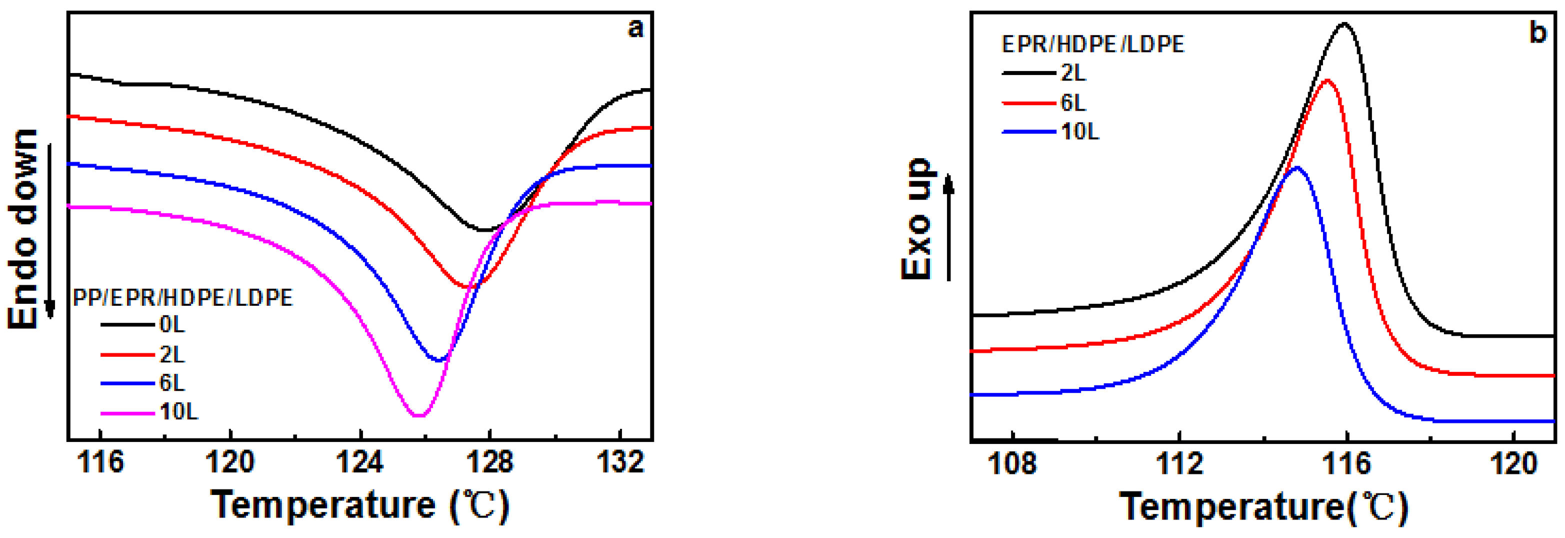

Fig. 11. (a) The melting behavior of PP/EPR/HDPE/LDPE and (b) the crystallization of EPR/HDPE/LDPE. xL means the relative mass ratio of EPR/HDPE/LDPE in PP/EPR/HDPE/LDPE is the same as that of EPR/HDPE/LDPE.

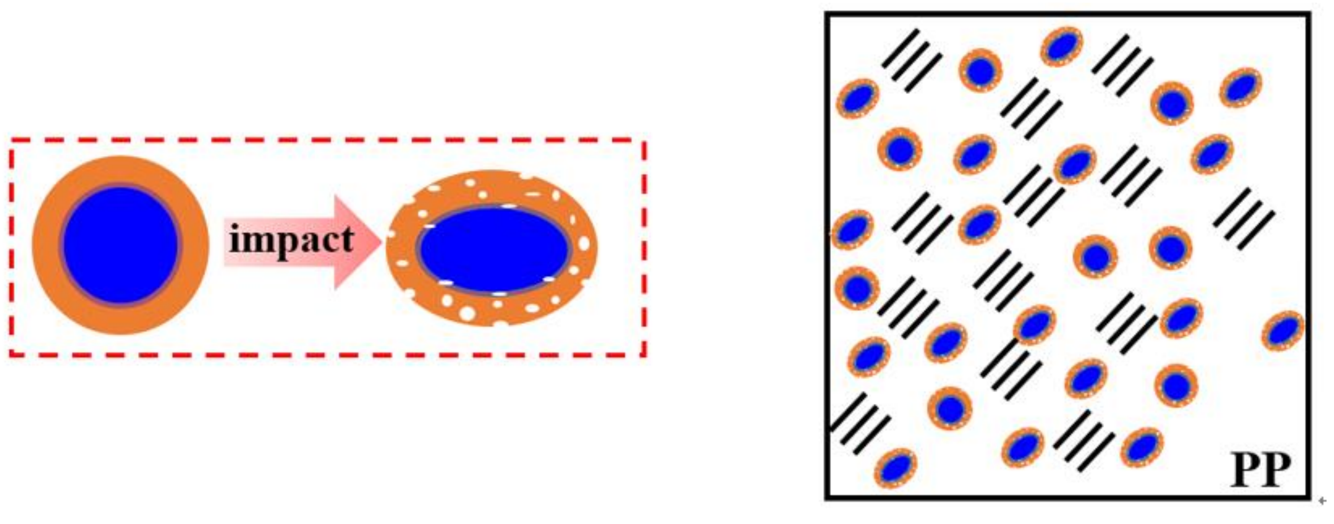

Fig. 12. Schematic model depicting the toughening mechanism of core-shell structure dispersed phase toughened polypropylene.

Conclusions: An enough interfacial strength between the shell and core is needed to transmit the stress from shell to core, and the pressure stress that the shell put on the core is beneficial to the shear yielding of the core, and the shear yielding of the core can also dissipate the energy. Finally the shear yielding of the core, the debonding of the interphase of the shell and the core and the cavitations of rubber shell release the triaxial stress, thus planar shear stress is formed to promote the shear yielding of the matrix, and when the shear yielding band can percolate across the whole matrix, then the matrix can dissipate large amounts of energy, and it turns out to be tough enough.

Acknowledgement

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References

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