

Shell Thickness Controlled by Composition in HPP/EPR/EbP Blends: Influence on Core-Shell Structure and Thermal Behavior

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Introduction

Previous research shows that dispersed phases with a special core-shell structure, composed of ethylene-propylene random copolymer (EPR) and ethylene-propylene block copolymer (EbP), are dispersed in propylene homopolymer (HPP) matrix of Impact Polypropylene Copolymer (IPC). The special dispersed phase not only affects the crystallization behavior of HPP matrix, but also facilitates to improve the impact properties. However, it is difficult to regulate composition and structure by copolymerization method. Blending the three components extracted from IPC is proved to be a simple, effective and economic method controlling composition to model copolymers, and then the super structures as well as the corresponding material properties can be controlled. In this work, we try to explore whether the core-shell structure can be rebuilt by solution-mixing and how the morphology develops by changing composition ratio of EPR/EbP in ternary blends of HPP/EPR/EbP. Besides, the effect of phase structure controlled by composition on thermal behavior of HPP has also been investigated. Here, the HPP content keeps constant at 70 wt% in all blends while the rest 30 wt% dispersed phase consisted of EPR/EbP varies with different composition ratios. The ratios of EPR/EbP are 0/10, 3/7, 5/5, 7/3 and 10/0 separately for P70-0, P70-3, P70-5, P70-7 and P70-10.

Core-Shell dispersed particles

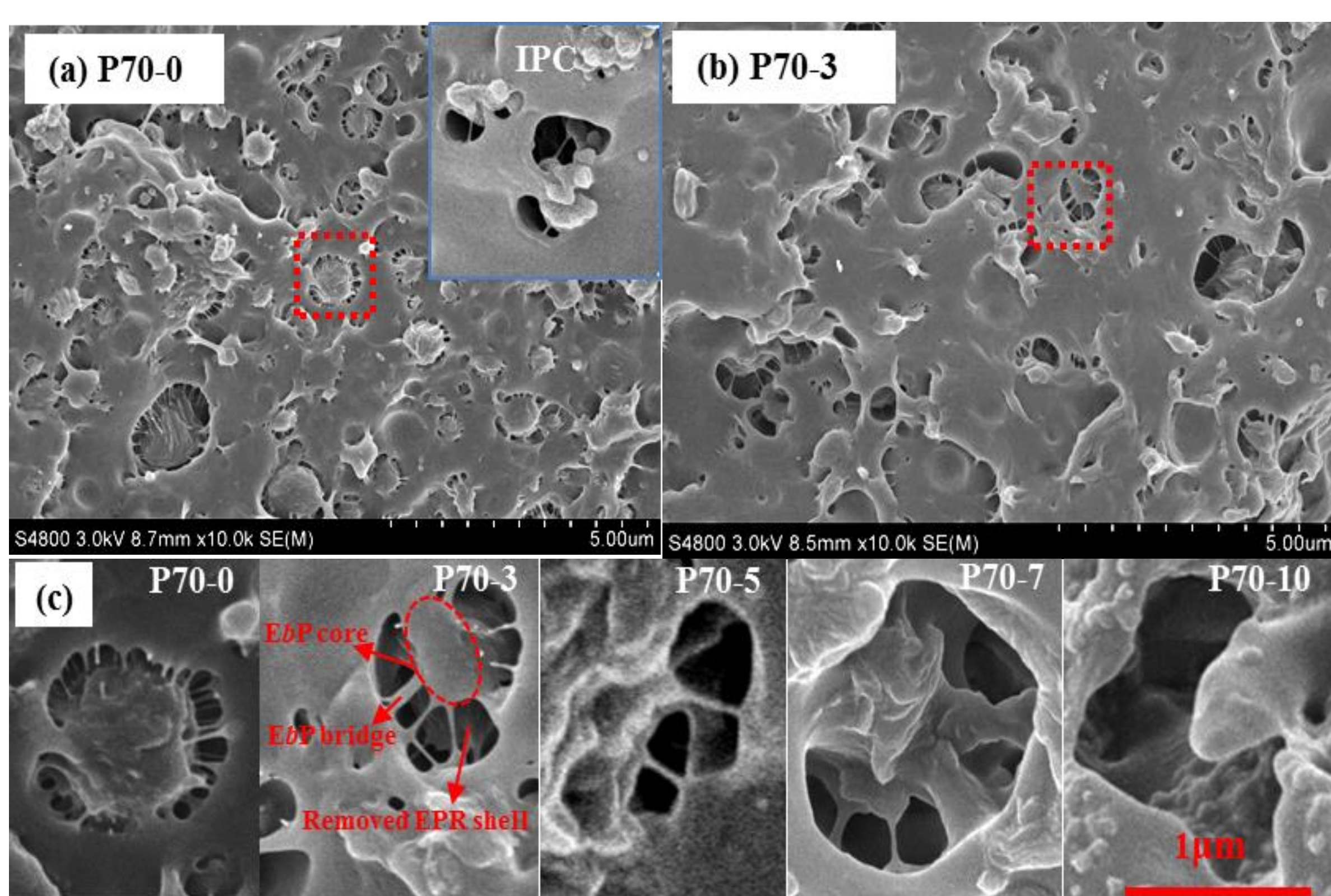


Fig.1 SEM images of HPP/EPR/EbP blends etched in xylene at 52 °C for P70-0 and 50 °C for others (4 h) with different composition ratios of blends. A few EbP component with short chains in P70-0 were etched in xylene while only EPR component was removed for others. The results show that the core-shell structure with bridges which is similar to that in IPC can be rebuilt by solution-mixing and the content of EbP greatly affects the morphology and size of core-shell dispersed phase.

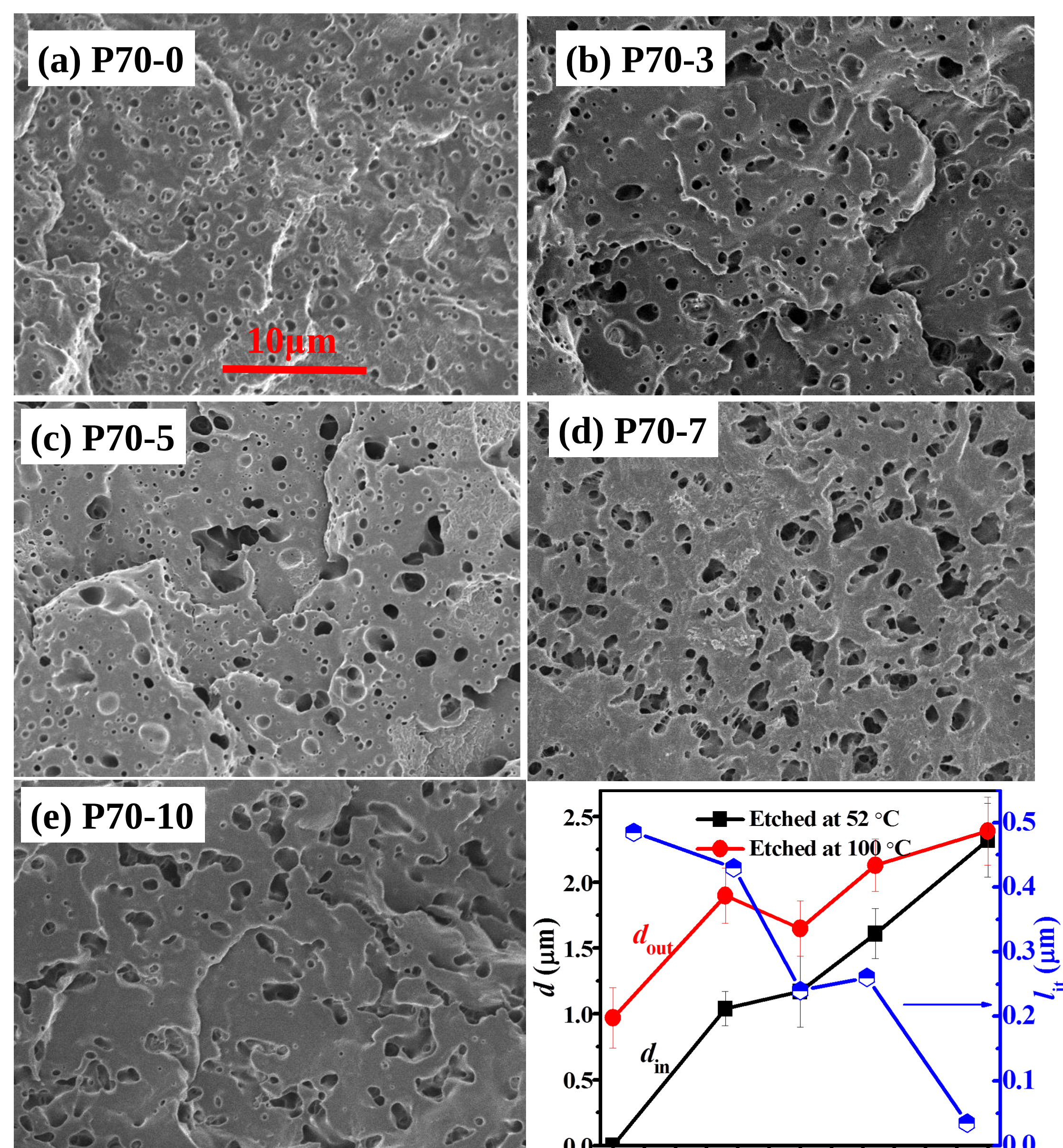


Fig.2 SEM images of HPP/EbP/EPR blends etched in xylene at 100 °C for 0.5h to remove the whole dispersed phase. The size of interior EPR shell and whole dispersed phase increases with increasing the EPR content. However, the size of external EbP shell located between HPP matrix and EPR shell tends to a reverse trend: the EbP interfacial thickness decreases with the increase of EPR content.

Crystallization and melting behavior

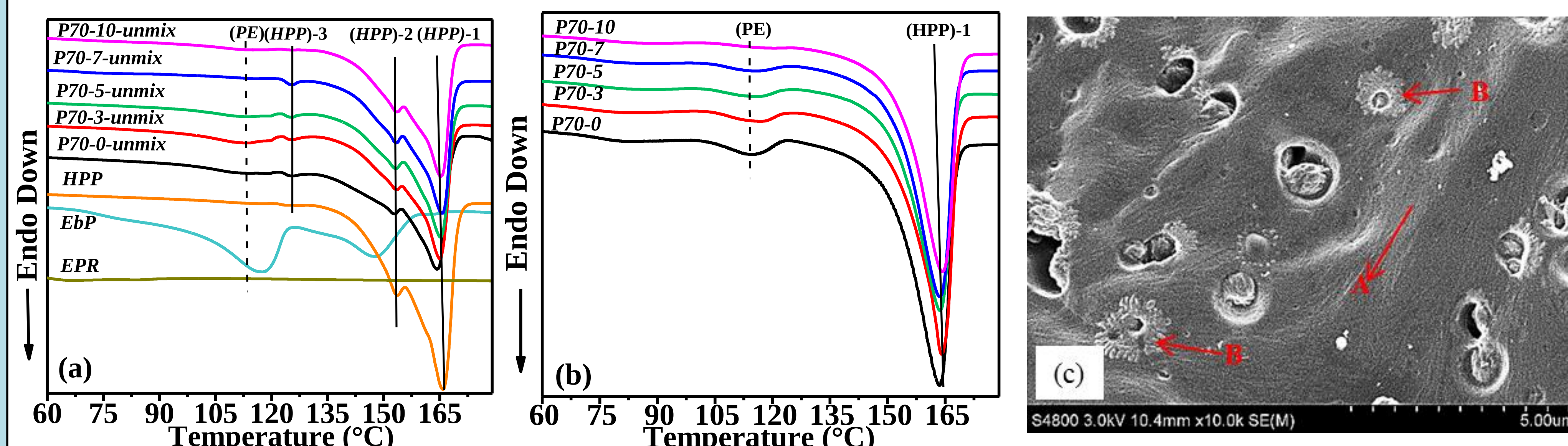


Fig.3 DSC melting traces for blends of HPP/EPR/EbP and each component at a heating rate of 10 °C/min for (a) unmixed and (b) solution mixed samples. The melting peaks at low temperature disappear after solution-mixing, indicating that co-crystallization may happen at interface between HPP and EbP phase. (c) shows different crystalline structure in HPP matrix and interface after removing amorphous EPR and PP phases.

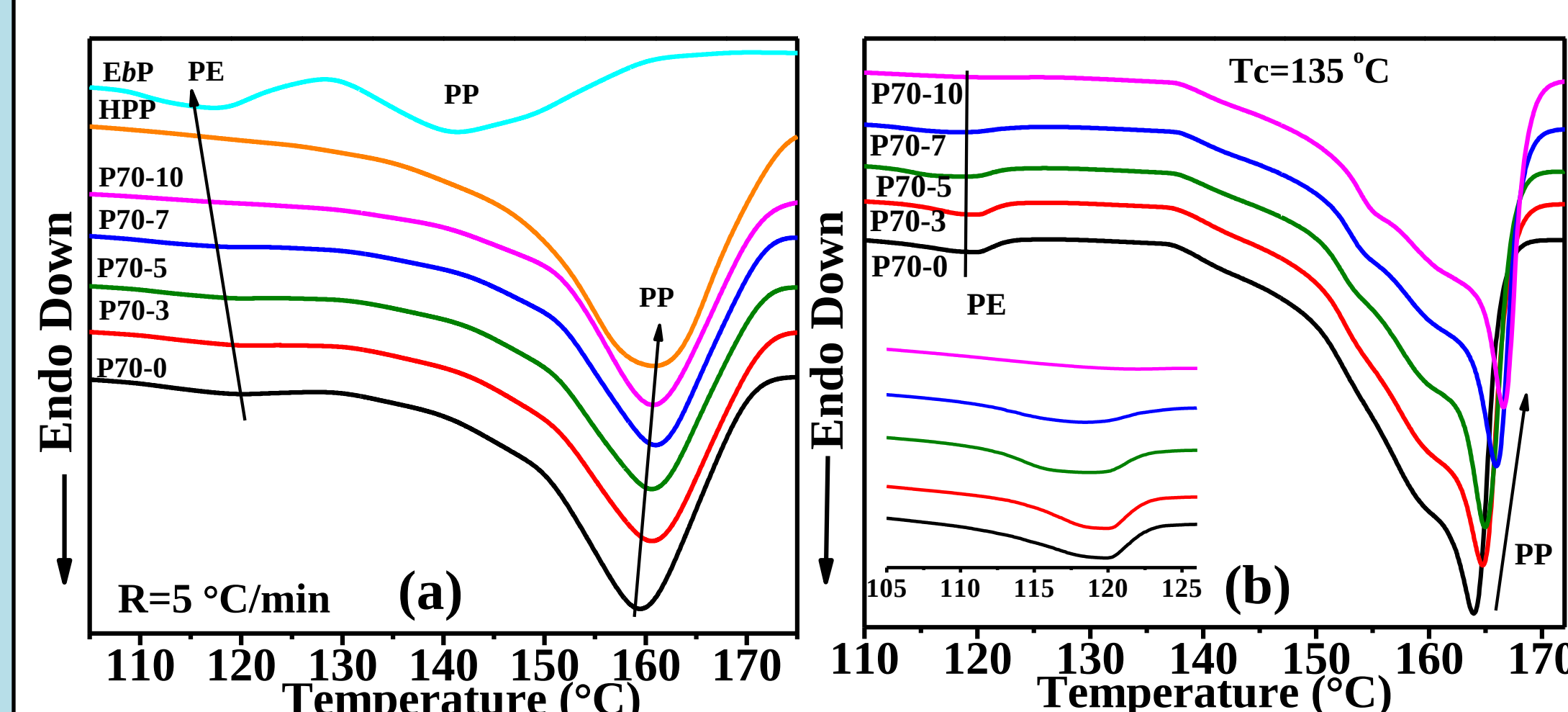


Fig. 4 DSC heating traces after non-isothermal (R=5 °C/min) and isothermal crystallization ($T_c=135$ °C). The melting peak tends to higher temperature with increasing the content of EPR for all crystallization conditions.

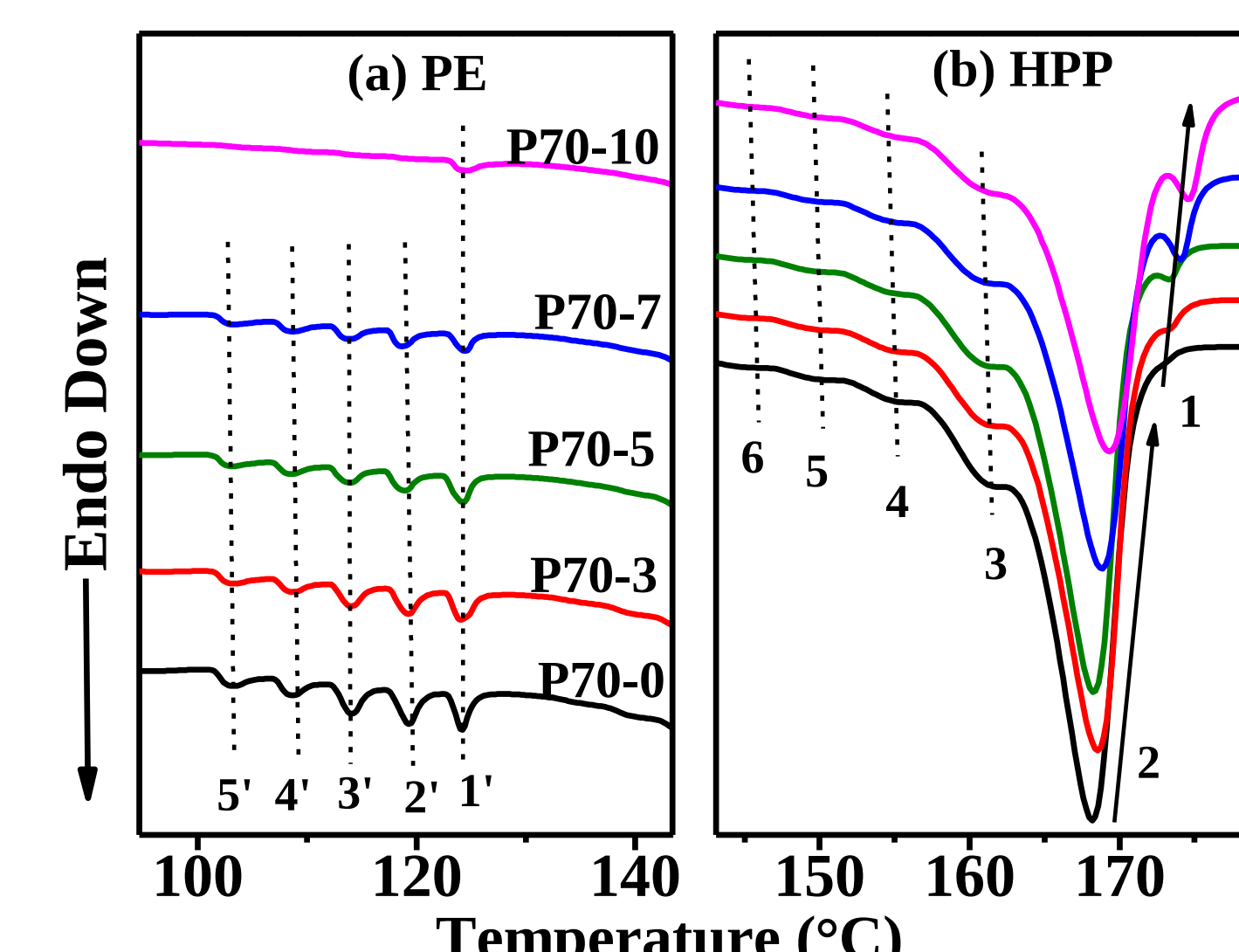


Fig. 5 DSC melting curves of PE (a) and HPP (b) for blends after being treated by SSA technique. The enhanced nucleation is regarded as the cause of elevated melting point.

Thermal mechanical properties

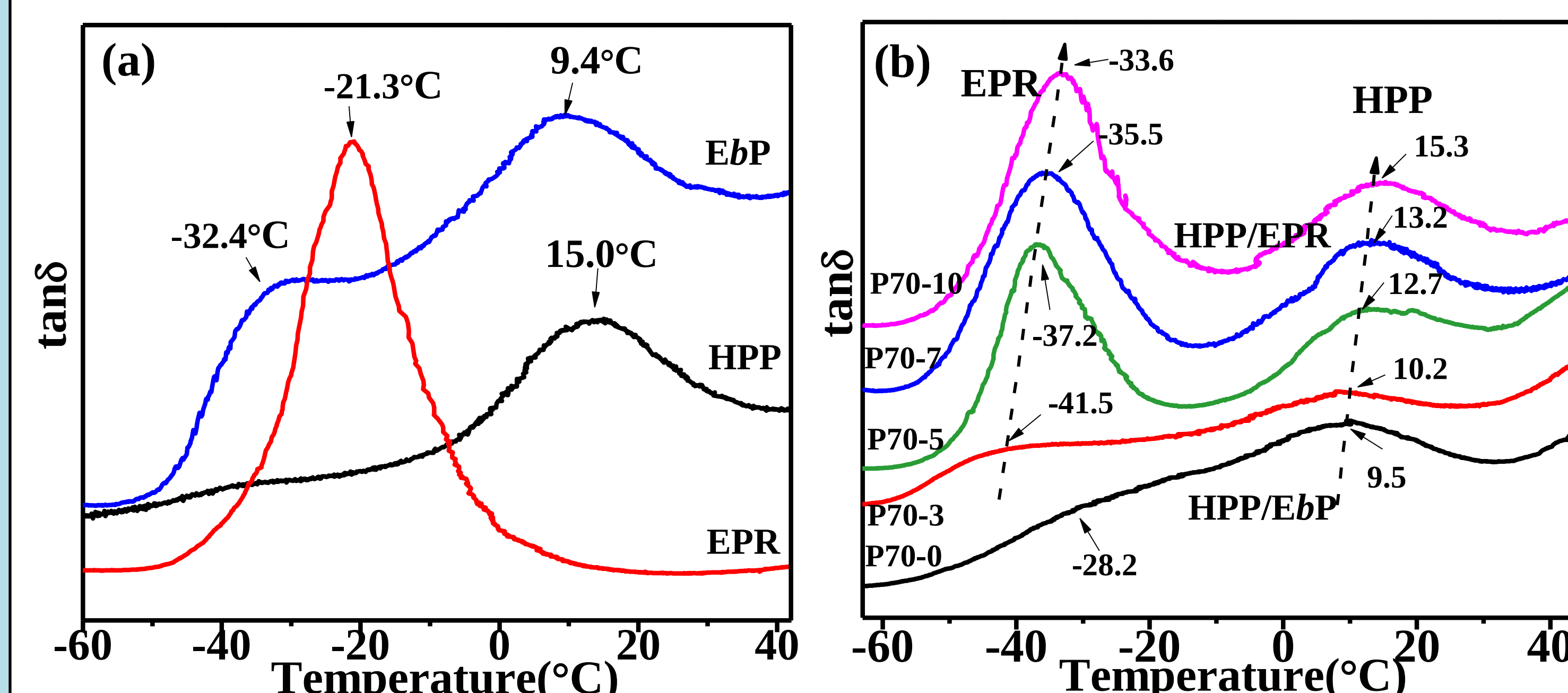


Fig. 6 Mechanical loss factor ($\tan\delta$) versus temperature of each component (a) and blends (b). Two depressed T_g s of HPP and EPR suggest that EbP chains penetrate into adjacent phases and promotes segmental mobility.

Conclusions

Similar multilayered core-shell structure as in IPC was rebuilt in ternary blends of HPP/EPR/EbP and the thickness of layers could be regulated by changing composition of EPR/EbP. The content of EbP determined the interfacial thickness and greatly affected the morphology and number of core-shell dispersed phase. With the decreasing content of EbP, the ratio of dispersed phase with core-shell structure reduces and sole EPR particles increases. Crystallization and melting behavior suggested that nucleation behavior is enhanced and melting points increased with the decrease of EbP interfacial thickness. The molecular dynamics results reflect interfacial penetration state of chains and confirm the existence of core-shell structure indirectly.

References

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