Isothermal crystallization of polydimethylsiloxane–zeolite composites: ESR spin–probe and DSC studies

Srećko Valić
Ruđer Bošković Institute, Physical Chemistry Division, Zagreb, Croatia
Faculty of Medicine, University of Rijeka, Department of Medical Chemistry, Biochemistry and Clinical Chemistry, Rijeka Croatia
Centre for Micro- and Nanosciences, University of Rijeka, Rijeka, Croatia
valic@irb.hr; svalic@uniri.hr

The local segmental mobility of polymer chains plays an important role in determining the behaviour of polymeric materials. The presence of zeolite particles can modify the local dynamics, thereby affecting the overall performance of polymer composites with potential for various industrial applications. The aim of this study was to investigate the influence of zeolite addition on the local dynamic behaviour of polydimethylsiloxane (PDMS) chain segments during isothermal crystallization of PDMS–zeolite composites. The effect of PDMS molecular weight was also examined. Molecular dynamics was investigated using the electron spin resonance (ESR) spin-probe method, while thermal behaviour was analysed by differential scanning calorimetry (DSC).

ESR results show that zeolite addition accelerates isothermal crystallization, affecting segmental mobility in the amorphous phase at 188 K and suggesting that not only zeolite loading but also zeolite type plays an important role. At 203 K, three-component ESR spectra are observed, consistent with the presence of three dynamically distinct spin-probe environments. DSC measurements reveal no significant change in the glass transition temperature upon zeolite addition. However, shifts in cold crystallization and melting behaviour are observed, suggesting changes in crystal structure and crystal perfection. These findings demonstrate that zeolites act as heterogeneous nucleation agents and significantly influence the crystallization behaviour and local molecular dynamics of PDMS.

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