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Polymers-grafted particles nanocomposites : dynamic contribution of grafted chains on dispersion mechanisms and mechanical properties

Nicolas Genevaz^{1,2*}, Denis Bertin², Didier Gigmes², Trang Phan², François Boué¹, Jacques Jestin¹

¹ Laboratoire Léon Brillouin, CEA Saclay 91191 Gif-sur-Yvette, France

² Aix-Marseille Université, CNRS, Institut de Chimie Radicalaire, UMR 7273, Av. Esc. Normandie Niemen, 13397 Marseille Cedex 20

nicolas.genevaz@cea.fr

Abstract

For most practical applications, the incorporation of nano-filler has been found to dramatically enhance the mechanical properties of polymeric materials. Understanding the reinforcement mechanism of nano-particles filled polymers matrix is of critically importance from industrial (for tire industry or food packaging) to fundamental point of view.

Reinforcement in nanocomposites depends of two major effects : fillers network contributions and chains – fillers interactions which can not be easily separated. We are interested in elucidating the mechanisms of mechanical reinforcements in model nanocomposites especially by dissociating the role of the filler from the one of the polymer chains dynamic. Thanks to controlled “grafting from” polymerization process, we can synthesis well defined grafted nanoparticles with a controlled length ($M_n=25000 \text{ g.mol}^{-1}$) that can be mixed with free polymer chains to form nanocomposites by solvent casting. The particle dispersion inside the polymer matrix can be easily tuned with the grafted to free chain ratio R that enables us to obtain different morphologies, from the individual particle dispersion for $R>0.24$ to the formation of dense large aggregates with intermediate interconnected particle networks for $R<0.24$ [1] (Figure 1). The grafted chain conformation is also depending of these different dispersion states, stretched for individual dispersion, the grafted brushes collapsed when particles forms aggregates [2]. With specific chain labelling, we recently show with mean square displacement (MSD) (Figure 2) measurements that a positive shift of the T_g of the grafted brushes is also associated with the formation of the aggregates meaning that the chain dynamic is modified by the particles organization. The reduction of the chain mobility with the particle dispersion is currently under validation with additional neutron spin echo measurements and can thus be discussed precisely as a function of the rheological behaviour of the nanocomposites.

References

- [1] Chevigny, C. et al., *Macromolecules*, **43 (11)**, (2010), 4833–4837.
 [2] Chevigny, C. et al., *Macromolecules*, **44 (1)**, (2011), 122–123.

Figures

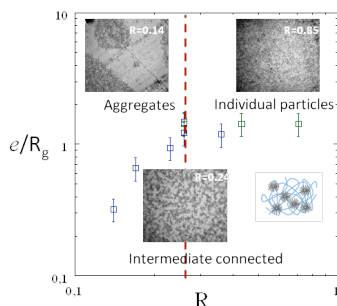


Fig. 1

Particle dispersion and grafted chain collapsed as function of the grafted to free chain mass ratio

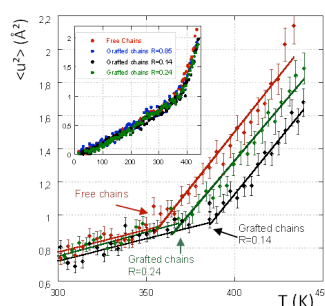


Fig. 2

MSD temperature dependence of free chains and of similar grafted chains for the different dispersion of particles, around the T_g and for the whole temperature range in insert.

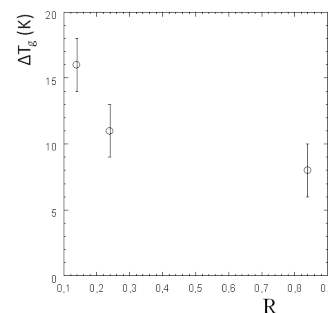


Fig. 3

Shift of T_g for grafted particles as function of R deduced from MSD experiments.