EFFECTS OF POLYMER-COATED JANUS GOLD NANOPARTICLES ON THE COALESCENCE STABILITY OF IMMISCIBLE POLYMER BLENDS

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Polymer-coated Janus gold nanoparticles (PJGNPs) can be used as stabilizers in polymeric blends. However, despite their high surface activity and amphiphilicity, recent flow-induced head-on coalescence experiments [1] of two polybutadiene (PBd) drops in a polydimethylsiloxane (PDMS) matrix showed that surprisingly this type of nanoparticles reduced the drainage time by 60% with respect to a similar system stabilized by block-copolymer surfactants, while increasing the drainage time by one order of magnitude with respect to the clean interface system as expected. These findings may be attributed to the nanoparticle metallic cores, which increase the magnitude of van der Waals (VDW) interactions between the drop interfaces, favoring coalescence. However, similar effects might be consequence of other mechanisms. To design effective nanoparticle stabilizers for advanced multiphase materials it is necessary to discern the importance of the different mechanisms due to the presence of PJGNPs on blends stability. To do so, we used a boundary integral code [2] to simulate flow-induced coalescence and incorporated in it a new derived analytical expression, based on a hybrid Hamaker-Lifshitz method, which evaluates the disjoining pressure (DP), i.e. the VDW interactions per unit area, in the presence of metallic nanoparticle cores as a function of the particle dimensions and core materials. These simulations were also compared to those for a system governed by the same dimensionless numbers and the clean interface DP expression. In these simulations the effects of the interfacial Peclet number (Pe_s) and the Marangoni number (Ma) on the drainage process were also considered, since amphiphilic nanoparticles affects both dimensionless numbers. Coalescence was very sensitive to all these three parameters, whose exact determination was found to be essential in discerning the main stabilization mechanisms in blends with interfacial nanoparticles. The gold cores in PJGNP stabilized blends can reduce dramatically the drainage time (see Figure 1), however the soft corona, which keeps the gold cores apart, thus reducing the maximum interfacial concentration of the cores, softens this effect.

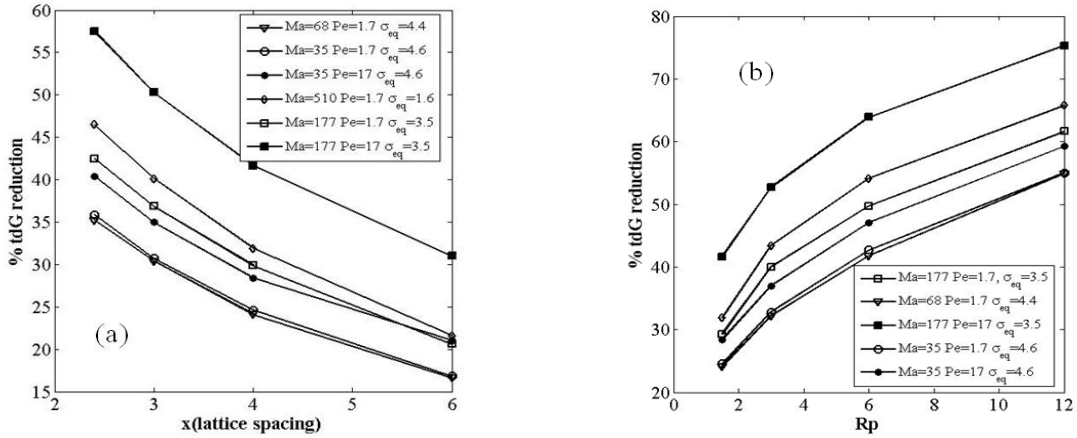

Figure 1. Reduction of drainage time for a system with PJGNP compared to a system stabilized by block-copolymers with the same Pes and Ma (a) Effect of dimensionless lattice spacing x scaled by the particle radius Rp. (b) Effect of Rp(nm).

[1] Borrell, M.; Leal, L. G., Interfacial activity of polymer-coated gold nanoparticles. Langmuir 2007, 23.
[2] Dai, B. and Leal, L.G., The Mechanisms of surfactant effects in drop coalescence. Phys. Fluids. 2008, 20.