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Microcellular Foaming – Art vs Science

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Cellular and microcellular plastics have significant market potentials in a wide spectrum of applications, ranging from daily household commodities to advanced engineering or biomedical applications.Although the foaming technology has been an art, extensive research has revealed its scientific aspects, and has led to its continuous development. Various studies have aimed to control cell morphology to achieve desirable foam properties such as acoustical and thermal insulation abilities, optical properties, as well as mechanical properties while reducing material costs. This is a non-trivial task because polymeric foaming processes involve delicate thermodynamic, kinetic, and rheological mechanisms. Furthermore, environmental concerns urge the replacement of ozone-depleting gases (e.g., CFCs or HCFCs) by non-ozone-depleting ones (e.g., CO2 and N2) for foaming. The uses of these viable alternatives pose additional challenges in foam fabrication because of their low solubility and high diffusivity in polymer melt. In this context, it is critical to elucidate the fundamental mechanisms that govern cell nucleation and growth processes during foaming in order to drive the development in this technology. This paper presents a series of theoretical investigations, simulations, and experimental studies to identify the mechanisms of cell formation, growth, coarsening, and coalescence of thermoplastics foams with the presence of inorganic fillers, organic dispersed phase, crystalline phase, or nanoparticles in the polymer matrices. This work also reveals the roles of various additives or dispersed phases to control cell formation and cell growth as well as to suppress cell ripening and coalescence.