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POSS® Nano-chemical additives for flow and dispersion in difficult to process high performance thermoplastics

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Statement of the Problem: High-performance aromatic polymers such as PEEK, PEKK, PPS, PPE, PEI etc., are well known to provide outstanding thermal and mechanical properties. They also require processing at high temperatures. In the case of PEEK and PEKK, processing temperatures can be in excess of 350 °C. Even more challenging is when these polymers are combined with filler or fiber reinforcements. Infilled systems, polymer viscosity increases further which results in increased extruder torque, temperatures, pressures that approach the processing limits of compounding equipment. A common solution to reducing viscosity is to decrease the molecular weight of the polymer or to use bimodal molecular weight distributions which, while allowable for some uses, can decreased mechanical performance. The high processing temperatures of aromatic thermoplastics also limit the use of traditional plasticizers due to their propensity to degrade and volatilize during compounding. For difficult to process polymers, POSS additives are uniquely well suited. In particular, POSS cages bearing all phenyl groups (such as dodecaphony) melt and are thermally stable in the 400°C temperature range. When phenyl POSS cages also contain silanols (such as the heptaphenyl trisilanol), they reduce viscosity and behave as high-temperature dispersants. POSS® chemical additives are a family of chemicals that melds the desirable thermal stability and modulus of inorganic additives ($SiO^{1.5}$) with organic (R) compatibility to render utility with heritage polymers, resins, monomers, and ingredients. The mechanism enabling POSS to provide flow enhancement in polymers have been postulated using Einstein sub-rheology. Additionally, the flow enhancement has been described to result from weak forces (Van der Waals, or London forces) between the POSS cages and polymer chain which causes deviation from classical hard-sphere theory. Perhaps a simpler explanation is that POSS cages melt during compounding. In the molten state, the cages act as a low viscosity liquid and thus provides a reduction in extrusion torque and viscosity of the polymers. Upon cooling both the POSS cages and the polymer re-solidify. The solidification of POSS is highly advantageous as it does not result in post-processing plasticization. At only 1.5 nm in diameter, POSS cages provide a large amount of surface area and volume when incorporated into formulations. Thus, in addition to flow enhancement, POSS cages can provide surface area and volume control around fillers and other additives. The dispersion of fillers is particularly well suited to POSS cages bearing silanol groups (such as trisilanol heptaphenyl POSS). Additionally, the high surface area of POSS can also aid in the nucleation and growth of polymer spherulites. In this light, POSS cages can be utilized to speed-up processing conditions and improve cycle times.

Biography

Joseph D. Lichtenhan, Ph.D. Dr. Lichtenhan is a pioneer and authority in the field of POSS® additives. POSS has been hailed as the first entirely new chemical class of monomers to be developed since 1955. His insights into their commercial utility launched the global sales for POSS® in 1998. Dr. Lichtenhan has excelled at technology transition and the establishment of a global footprint for POSS® via innovative sales and marketing techniques..

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