Polymer
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Innovation, Application, Evaluation

Plasticization

A polymer is similar to a plateful of uncut spaghetti. The points at which the spaghetti strands contact each other are “sticky”, similar to the attractive forces between molecules. Because of their long lengths, many of the molecules are entangled, among themselves and with other molecules. There is a significant amount of free volume around the molecules.

As one begins to pull on one or more of the molecules, there is an interaction with the others --- pull on one and the others will tend to move. Some of the short molecules or those with less entanglement will slip and move more easily, while others will begin to tighten and restrict movement.

A plasticizer is a material, generally gaseous or liquid, which is compatible with the polymer and can be absorbed into its interstices --- the space around the polymer chains. Effectively, a solvent is a plasticizer --- but generally with low permanence, i.e., a solvent is generally volatile and evaporates from the polymer fairly rapidly. A plasticizer, therefore, may be considered as a solvent with low volatility.

Plasticizers, due to their compatibility with the polymer, are able to permeate into the free volume around the polymer chains. This interaction results in a few things. First, it reduces the effects of secondary bonding forces which tend to keep the polymer “stuck” together. Secondly, it increases intermolecular distance which results in some swelling and increased free volume. Finally, as a result of the increased free volume and decreased secondary bonding forces, the plasticizer acts as a lubricant which enhances chain mobility --- the polymer molecules are more easily able to move and slip past each other in response to an applied load.

The introduction of a plasticizer reduces the glass transition temperature, T_g, of the material which permits the polymer to remain more ductile at lower temperatures. This enhances the material’s low-temperature toughness and impact resistance.

Conversely, the modulus and strength of the material decline. Under an applied load, the polymer chains can more easily slip and pull out of the polymer mass, therein reducing the stiffness of the material as well as the amount of load it can achieve at any given deformation.

Many compound additives, by virtue of the fact that they are generally compatible with the resin, and are well dispersed in the interstices of the polymer mass, are virtual plasticizers. Although their introduction into a compound may be for some other reason (lubricant, colorant, dispersion aid, etc.), they also facilitate all the functions of a plasticizer with the resultant ramifications on properties. Other unintentional "additives" can also play the role of additional plasticizer. Water or absorbed water vapor plasticizes nylon as well as many other polymers. Also, gases such as nitrogen, helium, argon, carbon dioxide, to name a few can be absorbed into polymers and act as a plasticizer for the polymer.

Be cautious and aware of the intentional, as well as unintentional, effects additives may have on the ultimate properties of a compound. Don't assume that a small addition of an additive will only affect the intended property enhancement. Whenever there is an improvement in one property, there will always be a change in one or more other properties. Make sure the negative effects do not counteract the positive benefits you are seeking.

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