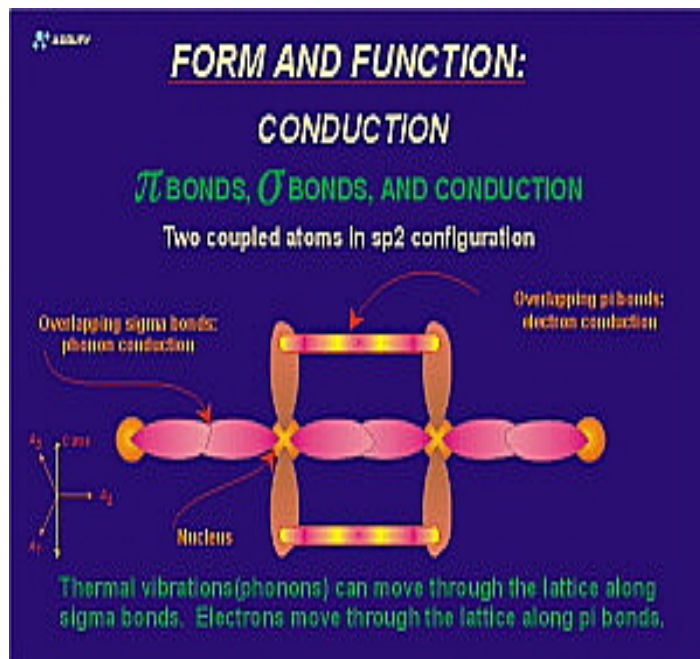


Enhancing Conductivity in Polymers with Graphite and Carbon

Introduction: Plastics and polymers are inherently low in thermal and electrical conductivity. For this reason applications that require conductive properties, which could also benefit from the use of polymer components because of their light weight, high strength/weight ratio, easy moldability, etc, cannot take advantage of this desirable material. Research is in progress on inherently conductive polymers, and some polymers with reasonable conductivity values are commercially available. However, at the present time admixing inert, conductive fillers into non-conductive polymers remains a very effective and economical way to produce an electrically or thermally conductive polymer component.

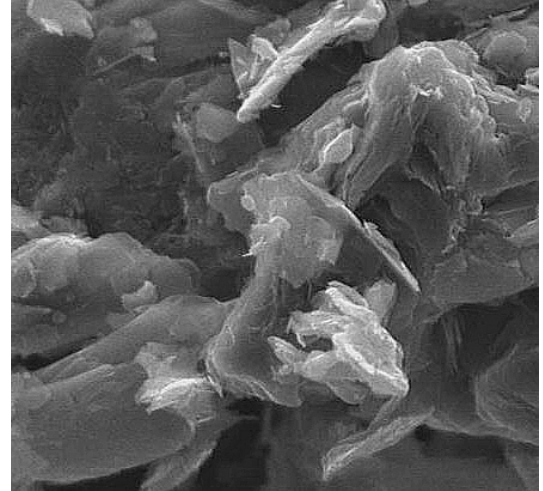
Carbon and Graphite as Conductive Fillers: Graphite and carbon offer the benefit of low density and cost when compared to metallic substances used for the same function. Graphite and carbon also have an advantage in that they are typically inert and compatible with most if not all polymer systems. Carbon materials provide electrical conduction through the pi bonding system that exists between adjacent carbon atoms in the carbon/graphite structure. Thermal conduction is affected by overlapping sigma bonds which are part of the same molecular bonding system. Regardless of whether or not the conduction is thermal or electrical, electrons provide the pathway for energy transfer.





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Many carbons, and especially graphite, have thermal and electrical conductivities many orders of magnitude higher than most polymers or plastics. However it is not necessarily an easy task to significantly increase the conductivity of plastic by a simple addition of conductive carbon. The problem becomes one of “dispersion”, “pathway development”, or “continuity” using the conductor as the energy conduit through the polymer. If a conductor is dispersed through a non-conductive medium one possible configuration is a composite of conductive particles wrapped in an insulative polymer. This configuration would result in an article that is no more conductive than the pure polymer. The key to creating a conductive polymer is the development of a continuous pathway of interconnected conductive particles through the polymer.



The photomicrograph to the right is an epoxy resin containing 200-mesh synthetic graphite. Although the individual graphite particles are highly conductive it is doubtful that any improvement in the bulk conductivity of the polymer will be realized. Close examination of the micrograph shows that the particles show only limited interconnectivity. Compounding with addition of finer graphite particles would help provide pathways between the larger particles resulting in better conductive continuity of the filler. The micrograph to the right illustrates the improved interconnectivity realized when using 20-micrometer graphite with the same epoxy. The closer proximity of the conductive particles is apparent.



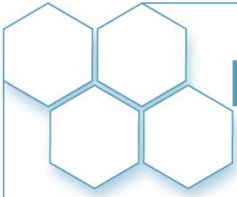
Generally, conductive continuity can be improved by reducing the particle size of the graphite powder. In applications where coarser particles are a requirement the addition of a small percentage of finer particles to the mix will significantly improved electrical and thermal continuity by providing conductive pathways between the coarser filler particles.



ASBURY GRAPHITE MILLS, INC.
405 Old Main Street • PO Box 144 • Asbury, New Jersey 08802
Phone: 908.537.2155 • Fax: 908.537.2908

KBolesta@asbury.com www.asbury.com

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Some Considerations...

Viscosity Effects: The job of the polymer formulator is to optimize the required properties of a polymer system while minimizing any negative properties. This optimization includes both performance as well as process parameters. A significant problem encountered when adding any solid filler to a fluid polymer system is the effect the additive has on viscosity. The viscosity of the polymer will have a profound effect on pumping, molding and other properties that depend on the ability of the system to flow. As with most other additives the particle size of carbon or graphite is inversely proportional to surface area, therefore if particles of a smaller size are added to a polymer system there will be a corresponding increase in viscosity. For example, the addition of 10% coarse flake graphite (>100 micrometers) may have little effect on viscosity, whereas the addition of 10% of 5-micrometer flake graphite could turn a free flowing system into thick paste. A formulator must balance the addition of both coarse and fine graphite/carbon with the goal of maximizing conductivity and other desired properties, while minimizing the effect this addition may have on viscosity-related problems.

Mechanical Properties: The same general rules of thumb that apply to the addition of other non-reinforcing fillers to plastic also apply to carbon and graphite. For example, the mechanical properties of polymers and plastics are typically not improved by the addition of graphite particles (not true for carbons and carbon fibers) so the properties which are enhanced by their addition i.e., conductivity, thermal-mass, density, etc., must be balanced with requirements such as tensile strength, elongation, creep, etc. In cases where the application of carbon and graphite are required the benefits realized by their addition far outweigh any negative impact.

Friction and Wear: Addition of Carbon and graphite materials to polymers and plastics for electrical and thermal property enhancement may also simultaneously enhance the friction and wear properties of the system. Conventional petroleum coke and synthetic graphite are the typical candidates for this application although flake graphite, pitch coke, needle coke and other carbons and graphite have also been used successfully. PTFE, polystyrene, nylon, polyethylene, are a few of the many polymers systems that are routinely doped with carbon and graphite to improve their behavior in conductive and friction applications.

The addition of graphite to polymers can improve the friction characteristics in both processing and application. Due to the low coefficient of friction inherent to graphite, its addition to a polymer can significantly reduce the shear forces required in vigorous blending operations. This is especially apparent in rubber compounding where graphite is routinely added as a process aid. In application the same low coefficient of friction is helpful in reducing surface rubbing friction between the polymers and mating surfaces.

The addition of carbon to polymers, i.e., petroleum coke, etc., can help improve wear properties. Petroleum coke is harder than most polymer compounds, but soft enough to not be considered an abrasive. By adding 5-20% calcined petroleum coke to plastic the wear properties of the compound can be significantly improved without the use of true abrasives.

Contact Us: Asbury Carbons can provide plastics manufactures with a full line of graphite and carbon products for use as conductive filler. Particle sizes from “millimeter to micrometer” are available as off-the-shelf products. Let our experienced technical and sales staff help you with selection of the conductive filler that puts your product “in the black”.



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