Carbon nanotubes can be described as sheets of graphene that are rolled to form a tube. Depending on the synthesis and reaction parameter, single-wall carbon nanotubes (SWCNT) as well as multi-wall (MWCNT) can be produced. In the case of MWCNTs, several concentric circular carbon nanotubes are grown in concentric circles. The diameter of carbon nanotubes can range in the range of 20nm, about 2.000 times thinner than a human hair. Their length can be several micrometers, and thus their aspect ratio can be in the range of a few hundreds to thousands.

Properties of Carbon Nanotubes

Due to the high aspect ratio of car- bon nanotubes and their low density, high surface areas and a few low densities, they are obtained. We can imagine one gram of mater- ials exhibiting a surface area similar to that of an average semidetached house. This is because of these parameters, carbon nanotubes seek to reduce their surface energy and tend to eas- ily agglomerate in the form of hun- dreds and thousands. This entanglement is already encouraged during their synthesis. To derive the full benefit from carbon nanotubes, one has to break off these agglomerates to achieve a good dispersion. We have already reported on how to disperse carbon nanotubes and have described the process in (CHEManager Europe 9/2009). Not only the amount of shear forces is important, but also optimized wetting and dis- persing additives are essential to stabilise the carbon nanotubes.

Dispersion Into Individual Tubes

Since most coating manufacturers do not want to spend several years and thousands of euros of research costs developing a process to disperse carbon nanotubes, they are focus- ing on already pre-dispersed carbon nanotubes in the form of aqueous or solvent-based dispersions. This not only offers comfortable access to carbon nanotubes, it also gives ad- vantages in respect of safety. Most concerns about the health hazards of carbon nanotubes are related to their form. In order to avoid the creation of carbon nanotube dust, dispersions using polymeric wetting and dispersing additives of high molecular weight are beneficial. If the dispersion dries to a solid film, a sticky film will be formed instead of a dusty powder.

Choosing the Right Carbon Nanotubes is Key

Depending on their diameter and length, carbon nanotubes are ex- pected to behave differently in hu- man bodies if inhaled. Most prod- ucers and users are focused on thin and flexible carbon nanotubes. This is due to the fact that thin and rigid carbon nanotubes are assumed to show some kind of adhesion-like behavior. In this case, human macrophages can- not digest the fibrillar particles and fail in phagocytosis. This would mean that the particles would not be removed from the human body and could cause inflammation. To avoid such problems, people should therefore focus on thin and flexible carbon nanotubes with diameters well below 10nm.

Price Considerations

While single-wall carbon nanotubes exhibit superior properties, their synthesis is still extremely compli- cated and yields are small. Because of this, single-wall carbon nanotubes are still much more expensive than multi-wall carbon nanotubes. Con- sequently, most companies focus on multi-wall carbon nanotubes for in- dustrial applications in coatings and plastics. But it is not only the differ- ence in price between single-wall and multi-wall carbon nanotubes one has to consider; it is also the comparison to other conductive ma- terials such as black or copper or silver particles that should be taken into consideration. If different prices of different conductive mate- rials, we can assume the following order of increased price: black copper + multi-wall carbon nanotubes + silver + conductive poly- meres + single-wall carbon nanotubes. Multi-wall carbon nanotubes can be considered as a medium-priced con- ductive material. This order can, of course, change depending on both quality and particle size, and given that copper or silver nanoparticles are much more expensive compared to the bulk material.

Surface resistivity of appecious and ohmic house clear can be determined by using carbon nanotubes.

Conductive Coatings Using Carbon Nanotubes

A fascinating material for the coating producer’s toolbox

Overview of the wetting conditions can be important.

The curing conditions and the cur- ring thickness of the coating deposits can also impact the carbon nanotube performance. For instance, a latex dispersion in which the carbon nanotubes are dispersed by a high shear action around the latex particles to form a 3-dimensional network. Compared to a 2-pack system where the curing results of coating is built up by monomers or oligomers, everyone would expect the latex dispersion to result in lower percolation thresholds. However, this is not true generally. Depending on the curing conditions and the mobility of the carbon nanotubes, very low results are also observ- able in 2-pack systems and in bak- ing enamels. Low concentrations of 0.5% to 1% carbon nanotubes result in anti-static properties, and even higher concentrations with contents of 2% to 4% phr in 2-pack systems and in coatings, 5% of carbon nanotubes show no effect at all in some coatings. It is really hard to give one a unique formula for this coating if necessary.

Beware of Purchasing a Wrong World

Carbon nanotubes are gaining in attractiveness because the growing demand from the market for func- tional materials is not limited to use as a coating material, but also to努力材料 as well as energy applications. In order to be in line with these developments, everyone has to consider their own special requirements and their performance, as well as the coating producer’s capability to use the carbon nanotubes. The quality and price of the carbon nanotubes can be very different. Therefore, they can be used in different coatings for different applications. The coating producer should choose the coating manufacturer carefully. As with any other new technology or new ma- terials, carbon nanotubes have to be considered as another interesting innovation in the coating world. They cannot perform miracles. People have to be realistic in their expectations, and more research and efforts have to be undertaken to develop and improve this fascinating material.

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