PROCESS BULLETIN

Carbon Black

Description

Carbon black has been called the king of pigments with good reason. It is the most permanent, has the smallest particle size, the greatest opacity and the greatest tinting strength. It is also the most difficult to disperse. Most carbon black is made by one of the following methods.

1. Channel Black - made by burning gas under controlled conditions; whereby, the combustion products and smoke impinge on the underside of steel channels from which it is continuously scraped. This method produces blacks featuring the smallest particle size.

2. Furnace Black - made by burning gas, oil or a mixture of these in a furnace under controlled conditions. The smoke (carbon) is removed from the stack gas by electric precipitation and is collected.

Carbon blacks are usually specified on the basis of average particle size, expressed as millimicrons (nanometers) or square meters per gram. These may vary from a minimum particle size of 10 millimicrons (560 square meters per gram) to as large as 500 millimicrons (6 square meters per gram). Usually, the smaller the particle, the more expensive the black and the more difficult it is to disperse. Actually, carbon black particles are better described as primary aggregates, because the particles are usually fused together in small aggregates.

Blacks of the same particle size may vary considerably in their ease of dispersion due to methods of manufacturing. Some blacks have a carbon-oxygen complex (volatile content) on the surface of the pigment, which improves the ease of dispersibility over a black lacking this complex. Other blacks may be treated with various surface-active agents to improve their dispersibility.

Blacks are sold as a fluffy, light powder or in the form of pellets made by moistening the black powder and pelletizing. The pelletized form may have a density twice that of the fluffy powder, reducing the storage volume and container size and tremendously improving the ease of handling. The disadvantage is that energy must be expended in breaking up the pellets, prior to the actual dispersion of the black.

In addition to its use in all types of paints, enamels, printing inks, etc., carbon black applications include such products as black nylon, where a special dispersion of black is added to nylon monomer prior to polymerization; gray-tint, plastic sunglasses, where a black dispersion in a plasticizer is added to the monomer prior to polymerization; precision resistors; coloring of gelatin and candy; television tube coating; carbon-black wax mixtures for crayons; carbon papers; special photographic coatings; cement (for concrete roads); paper coatings, paper stock and dope dying of synthetic fibers such as viscose, acetate, Dacron, Orlon, etc. Carbon black latex mixtures are used in master batching for rubber tires.

Equipment and Procedures

Dispersions of carbon black require high-energy equipment such as the Gaulin or Rannie homogenizer, ball mill, roller mill or Banbury mixer. High-shear dispersers and colloid mills may be used to wet out agglomerates and break up pellets, but they do not have sufficient energy to completely disperse the fine particle sizes found in black pigments. For aqueous dispersions the following equipment has been used: high-speed impeller mixers, pebble and ball mills, high-speed impingement mills, attritors and sand mills. Except for paints and some extremely high viscosity printing inks, many carbon black applications require a quality of dispersion that can only be achieved with the Gaulin and Rannie homogenizer.

The choice of high-energy equipment will depend, primarily, on the viscosity of the mixture. If it is an oil or resin vehicle with a viscosity of 10,000 cP or higher, the choice would probably be the roller mill. For viscosities between 300-10,000 cP in either aqueous or oil-resin vehicles, the colloid mill could be used. For viscosities from 1 to 1,000 cP the homogenizer would be the choice. The figures mentioned are all Newtonian viscosities.

In water-based vehicles the viscosity is usually thixotropic. This means that the apparent viscosities could be much higher and still have a low viscosity under shear. Although premixes must be prepared for both the roller mill and the homogenizer, the complete charge can be placed in a ball mill. Ball milling for fine-particle carbon blacks can be an extremely long process, perhaps as great as 48 hours, and exhibits the additional disadvantage of adding impurities from both the balls and the mill lining to the carbon black dispersion.

In using the homogenizer the continuous phase must be formulated for minimum viscosity, preferably below 200 cP. The premix should be processed with a high-shear disperser or colloid mill to reduce aggregates as far as possible, prior to processing in the homogenizer. It has been shown that one pass through a colloid mill at a relatively wide gap setting, plus one pass through the homogenizer, produced a better dispersion than three passes through the homogenizer alone.

One of the first questions asked in discussing carbon black dispersions is the percentage of carbon black that may be dispersed. It is impossible to furnish an exact answer, as it depends on the particle size of the carbon black. The smaller the particle size, the lower the percentage that may be incorporated in a formulation to form a stable dispersion. A second factor is the type of black, whether it has the oxygen/carbon complex on the surface or has other wetting assist pre-treatment. The efficiency of the vehicle or wetting agent in promoting dispersion is an important factor.

To illustrate the ranges of concentration, we have prepared two curves. Graph 1 is for aqueous systems and shows the percentage of carbon black that may be incorporated, based on the surface area in square meters per gram. Since all manufacturers furnish the area in square meters per gram for various grades, it is simple to determine where the grade you are considering falls on this curve. For example, for a black having an area of 120 square meters per gram, one should be able to prepare an aqueous dispersion having between 20 and 38% solids black. The type of black, as well as the efficiency of the dispersing agent, cause the spread in concentration.

Graph 2 shows the same type of curve for a good wetting oil or resin vehicle. Selecting 120 meters per gram, the concentration would range between 9 and 13%. In the case of Graph 2 this percent solids represents the maximum black and minimum oil that will provide a stable dispersion. The actual viscosity will probably be far in excess of what may be processed on the homogenizer. It will, therefore, be necessary to dilute with a thinner or additional vehicle for dispersion purposes. However, one must have sufficient vehicle in order to prevent agglomeration after dispersion. The actual solids at the time of dispersion will depend upon the type of equipment used and the required viscosity. In the case of Graph 1 the actual percentage would normally be the concentration one could disperse in the mixture.has been used: high-speed impeller mixers, pebble and ball mills, high-speed impingement mills, attritors and sand mills. Except for paints and some extremely high viscosity printing inks, many carbon black applications require a quality of dispersion that can only be achieved with the Gaulin and Rannie homogenizer.

For aqueous dispersions the percent of dispersing agent is a function of both the fineness of the carbon black and the percent black in the dispersion, as well as the efficiency of the agent. Sodium lignosulfonates, sodium naphthalene sulfonates and sodium salts or carboxylated polyelectrolytes are very effective dispersants for aqueous carbon blacks. Some dispersing agents used for carbon black include: Marasperse® (Daishowa Chemicals, Inc.), Lomar® (Henkel Corp.), Tamol® (Rohm and Haas Co.), Daxad® (W. R. Grace, Inc.), Brij® (ICI Americas, Inc.) and Tergitol® (Dow). Sodium hydroxide is also used to raise the pH and improve the ease and stability of the dispersion. The pH should remain slightly above ten for any of the above mentioned dispersing agents.

In processing carbon black in the homogenizer, the best possible premix should be prepared using a high shear mixer, operating at the maximum allowable viscosity, and then diluting with more vehicle to the desired viscosity for the homogenizer. The premix should then be pumped to the homogenizer and processed for one to three passes at high pressure. The number of passes will depend upon the quality desired in the final dispersion and the particle size of the black being dispersed. The three passes may be made by pumping to a storage tank and then pumping back through the homogenizer to a second tank.

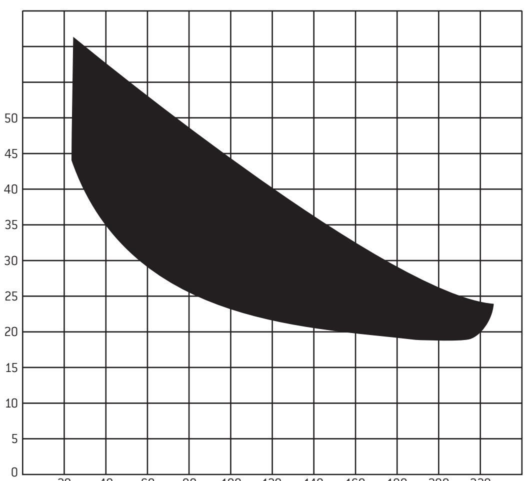
Testing

Carbon black dispersions may be tested by Hegman gauge readings (paints and enamels), by microscopic examination, by tinting strength or by a combination of all three. Microscopic examination should be made immediately after dispersion and, again, after the sample has been held for several days to determine if any agglomeration has taken place. In the event of age agglomeration, additional dispersing agent or vehicle must be used for shelf stability.

GRAPH 1

CARBON BLACK LOADINGS AQUEOUS SYSTEMS

% CARBON BLACK

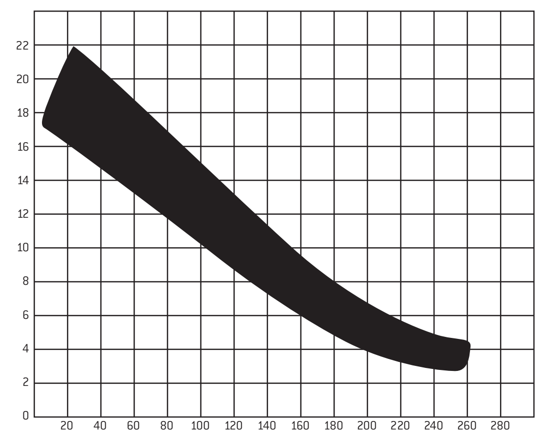


CARBON BLACK SURFACE AREA

GRAPH 2

CARBON BLACK LOADINGS OIL OR RESIN VEHICLES

% CARBON BLACK



CARBON BLACK SURFACE AREA

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