International Carbon Black Association

Factsheet:

Particle properties of Carbon Black

Introduction

Carbon Black, CAS No. 1333-86-4 / EINECS No. 215-609-9, is a form of virtually pure elemental carbon that is intentionally manufactured. Carbon Black has been produced and marketed for more than a century without significant changes to its physicochemical properties. More than 10 million tonnes of carbon black are produced every year worldwide. Carbon Black is placed on the market as a black powder or as pellets. Over 90% of carbon black is used in rubber applications, approximately 9% as a pigment, and the remaining percentage as an essential ingredient in a multitude of diverse applications. All historic physicochemical and toxicology data remain valid for Carbon Black manufactured today.

It is important to note that many articles in the scientific literature and a number of authoritative bodies erroneously use the terms soot and black carbon as synonyms for Carbon Black. Carbon Black is physically and chemically distinct from soot or black carbon. Soot and black carbon are terms applied to various unwanted carbonaceous by-products resulting from the incomplete combustion of carbon-containing materials, such as oil, fuel oils or gasoline, coal, paper, rubber, plastics, and waste material. While most types of Carbon Black will contain over 97% elemental carbon arranged as aciniform (grape-like cluster) particulate, the total particle mass of soot or black carbon typically contains less than 60% carbon, depending on the source and characteristics of the particles (shape, size, and heterogeneity).

Two other commercial carbonaceous products often confused with carbon black are activated carbon and bone black. Each is produced by processes different from commercial Carbon Black and possesses unique physical and chemical properties.

Due to its particle structure Carbon Black is affected by the current nanotechnology/nanomaterial discussions between many stakeholders, including researchers, regulators, Non-Governmental Organizations and industry. This factsheet has been developed to provide an overview of carbon black – its morphology, particle size, exposure potential, and health effects – demonstrating that it is a substance of low toxicity.

Particle structure - morphology

Carbon Black is produced in a closed reactor by incomplete combustion or thermal decomposition of liquid or gaseous hydrocarbons under controlled conditions. The ASTM D3053 Standard on *Terminology Relating to Carbon Black* defines carbon black as follows:

> Carbon black exhibits aciniform morphology composed of spheroidal "primary particles" strongly fused together to form discrete entities called aggregates[1]. The primary particles are conceptual in nature, in that once the aggregate is formed the "primary particle" no longer exists, they are no longer discrete and have no physical boundaries amongst them. The aggregates are loosely held together by weaker forces forming larger entities called agglomerates. The agglomerates will break down into aggregates if adequate force is applied (e.g., shear force). Aggregates are the smallest dispersible unit[1]. Carbon black is placed on the market in the form of agglomerates.
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> ***[1] The one exception to this general characteristic of manufactured carbon black involves thermal black, where "primary particles" can exist as discrete entities. However, "primary particles" produced via the thermal black process have characteristic diameters in the range of 150-500 nm, meaning that primary thermal black particles are of sizes that fall outside the nanoscale region.***

Following the ASTM D3053 definition and applying the terminology of the International Organization for Standardization's (ISO) Technical Specification 80004-1 of 2010, carbon black is considered a nanostructured material (a material having internal or surface structure in the nanoscale).

Particle Size Information for Carbon Black

The size of the conceptual primary particle is in the nanoscale range. However, typically primary particles do not exist in isolation in Carbon Black powder. As primary particles are fused/covalently bonded together, the primary particle size distribution is not relevant to Carbon Black. As described above, the spheroidal primary particles strongly bond/fuse together to form discrete entities called aggregates (Fig. 1b). Aggregates are robust structures, able to withstand shear forces; they are the smallest dispersible units measuring ~80 to ~800 nm. Agglomerates are difficult to measure as they break apart when shear forces are applied. Typically, Carbon Black is shipped/placed on the market in the form of pellets (i.e., compressed agglomerates) to facilitate the ease of handling and to reduce the creation of dust (Fig. 1a). The size of pellets generally falls between 0.1 and several micrometers.

Figure 1a: Representative picture of Carbon Black as typically placed on the market

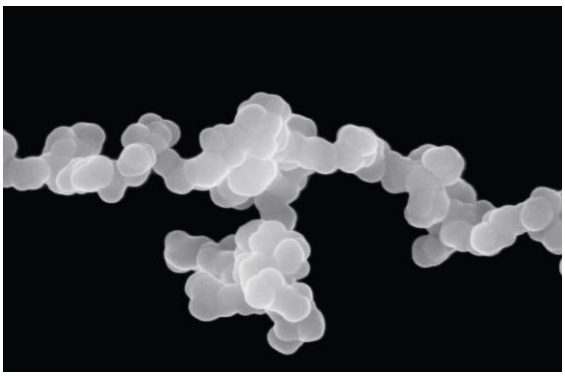

Figure 1b: Scanning electron microscope view of a typical carbon Black aggregate consisting of fused primary particles (magnification: x 120,000)

Applications and Exposure Potential

Carbon Black has been used safely in a wide variety of industrial and consumer applications for many decades.

Carbon Black is mainly used as reinforcing agent in rubber products and tyres; as UV stabilizer or black pigment in plastics, inks and coatings; as electrical conductive agent in batteries, plastics and in rubber, and in other applications like catalysts, concrete, paper, and other carbon preparations.

In all of these products the carbon black is bound into a matrix. A recent study (in press) has shown that Carbon Black is not released from different plastics under conditions representative of typical food contact applications. Thus, it has been concluded by the International Agency for Research on Cancer (IARC) and other organizations that consumer exposures to carbon black in the use of these products is negligible (IARC, 2010). Potential exposure to carbon black could occur in the workplace. However, workplace exposures are appropriately managed with engineering controls and personal protective equipment to ensure compliance with country-specific occupational exposure limits. Kuhlbusch et. al. (2006) conducted physical and chemical characterization of airborne particles near the reactor, bagging and pelletizing areas during carbon black production and concluded from these measurements, that no carbon black is released under normal operating conditions as ultrafine particles (< 100 nanometers).

Health Information

Carbon black has been the subject of extensive scientific health studies during the past several decades. Carbon black is classified by the International Agency for Research on Cancer (IARC) as a Group 2B carcinogen (possibly carcinogenic to humans) based on “sufficient evidence” in animals and “inadequate evidence” in humans (IARC, 2010). Studies of carbon black manufacturing workers show no causative link between carbon black exposure and cancer risk in humans. However, results of carbon black production workers health studies suggest that cumulative exposure to carbon black may result in small decrements in lung function.

Carbon black is not a chemical irritant, but may cause mechanical irritation of the throat, eyes, and skin. It is not a skin sensitizer. Carbon black is not considered to be mutagenic.

Carbon Black has been investigated thoroughly in numerous toxicological and epidemiological studies, which demonstrate it is a substance of low toxicity. Following the CLP (EU regulation for Classification, Labelling and Packaging) criteria for identifying hazardous substances, Carbon Black has been determined to be non-hazardous under the EU REACH regulation by the CB4REACH Consortium.

Literature References

Numerous papers have been published on Carbon Black. We recommend the following which provide comprehensive information:

- “*Carbon Black*”, Second Edition, Revised and Expanded, Donnet, JB., Bansal, RC., Wang, MJ., Marcel Dekker, Inc., New York, 1993.
- “*Carbon black vs. black carbon and other airborne materials containing elemental carbon: Physical and chemical distinctions*”, Long Ch.M., Nascarella M.A. and Valberg P.A., Environmental Pollution Volume 181, October 2013, Pages 271–286
- “*ICBA Carbon Black User’s Guide – Safety, Health, & Environmental Information*”, International Carbon Black Association, June 2004.
- ”*Particle characteristics in the reactor and pelletizing areas of carbon black production*”, Kuhlbusch T.A.J. and Fissan H., 2006, 3(10), 558 - 567.

- IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 93, 2010, Lyon, France.
- "*Carbon Black*", McCunney et al. 2012, *Patty's Toxicology, Sixth Edition. Volume 5,* Chapter 89
- International Carbon Black Association, US EPA Nanoscale Materials Stewardship Program Voluntary Submittal Package Carbon Black – CAS # 1333-86-4 at http://www.epa.gov/oppt/nano/icba.pdf

Overall Conclusion

The members of the International Carbon Black Association (ICBA) have been conducting comprehensive safety and health studies on Carbon Black over many years. Based on these data, Carbon Black products are safe for use in their different applications. A comprehensive dossier on carbon black has been filed with the EU Chemical Agency (ECHA) in accordance with the EU REACH requirements. See the ECHA website for dissemination information. In addition, the International Carbon Black Association participated in the 2006 US Environmental Protection Agency (EPA) voluntary Nanoscale Materials Stewardship Program.