Lecture 14. Physical Properties of Carbon Black. Surface Area, Porosity, and Adsorption Properties of Carbon Black. Applications of Carbon Black

The purpose of the lecture: to provide information about physical properties and applications of carbon black.

Expected results: to master physical properties and applications of carbon black.

The key to understanding the nature of carbon blacks is the recognition of their fundamental properties. The four fundamental properties of carbon black are particle size, structure (aggregate and shape), porosity, and surface functionality. Electron microscopy of carbon black particles shows that they have a complicated structure, with some spherical particles fused together. As shown schematically in Figure 1, the size of these particles is called “particle size” and the size of the particle chain is called its “structure.” Various functional groups such as the hydroxyl(-OH) or carboxyl(-COOH) group are found on the surface of carbon black, and their amount or composition is sometimes referred to as “surface chemistry.” The three main properties have a large effect on practical properties such as blackness and dispersibility when they are mixed with inks, paints, or resins.

Particle Size

The diameter of spherical particles is the fundamental property that largely affects blackness and its ability to disperse when carbon black is mixed with resins or as reinforcement in elastomers. In general, the smaller the particle size, the higher the blackness of carbon black becomes. Dispersion, however, becomes difficult due to an increase in coagulation/van der Waals force. The measurement of carbon black particle size is complex and very much dependent on the technique used.

Microstructure of Carbon Black

Like particle size, the size of the structure also affects the blackness and dispersability of carbon black. Generally, the increase of structure size improves dispersability but lowers blackness. Carbon black with a larger structure in particular shows an excellent conductive property.

Normally carbon black has been considered to be polycrystalline solids. The highresolution electron microscopy has made it possible to extend our knowledge of the internal organization of carbon black particles. The first x-ray diffraction studies of carbon black and soot particles were carried out by Warren in the 1930s and 1940s who demonstrated the presence of layer planes of graphite-like carbon. The first x-ray diffraction patterns of carbon black shows two or three diffused rings at about the same position as the most intense graphitic diffraction peak. The results show that carbon black consists of bundles of parallel-oriented graphitic planes at distances of 3.5 to 3.8 A. However, no evidence of the three-dimensional graphite structure was detected.

For carbon blacks, the crystallize size La usually falls in the range 1–3 nm, whereas Lc is usually of the order of 1.5 nm. A typical powder diffraction pattern of a particular grade of carbon black (N774) as produced and graphitized is shown in Figure 2. It can be seen that after heat treatment at 2700°C the peak profile becomes sharper. The diffractogram shows strong overlap of the peaks for both samples.

The microstructural model derived from x-ray diffraction analysis of carbon black postulates that the crystallites in the bulk of the particles are connected to one another by single planes or poorly organized carbons, as shown in the schematic model of Figure 3.

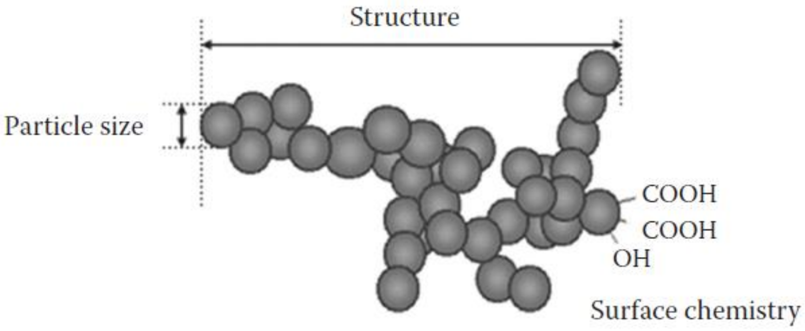

FIGURE 1. Micrograph of carbon black aggregate

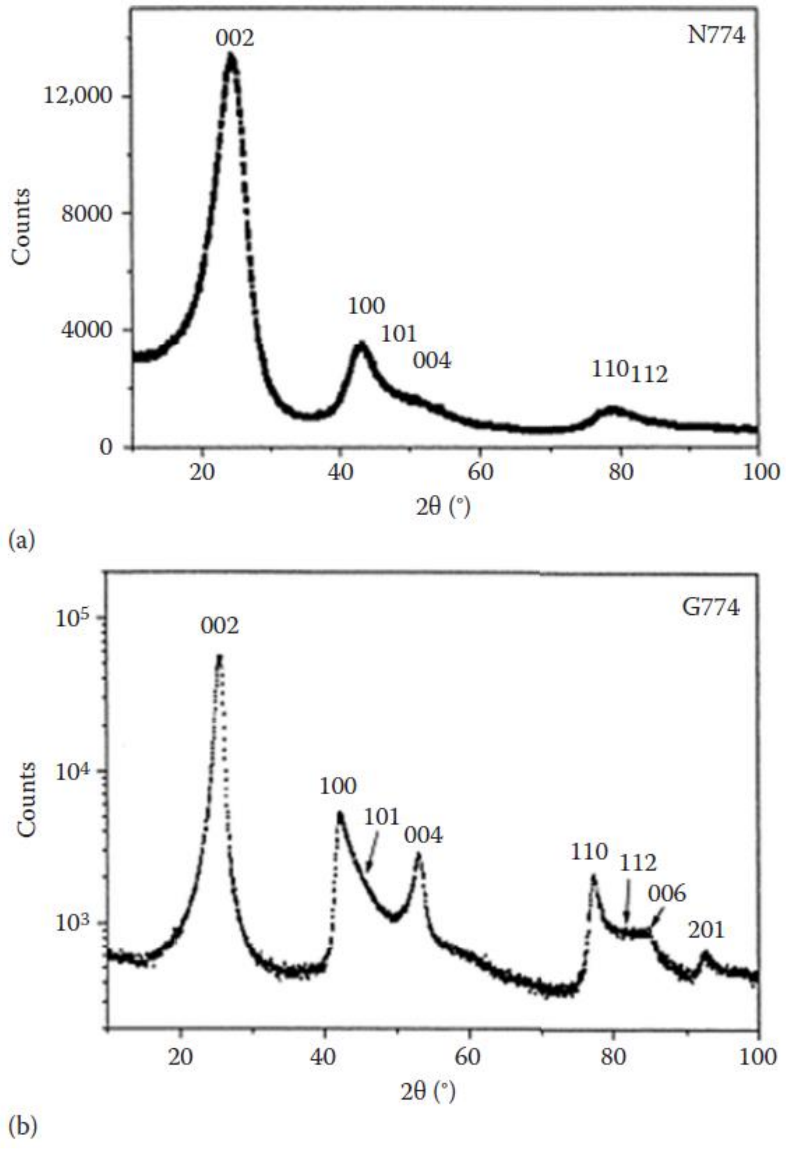

FIGURE 2. Powder diffraction pattern of N774 carbon black: (a) as-produced and (b) after HTT at 2700°C

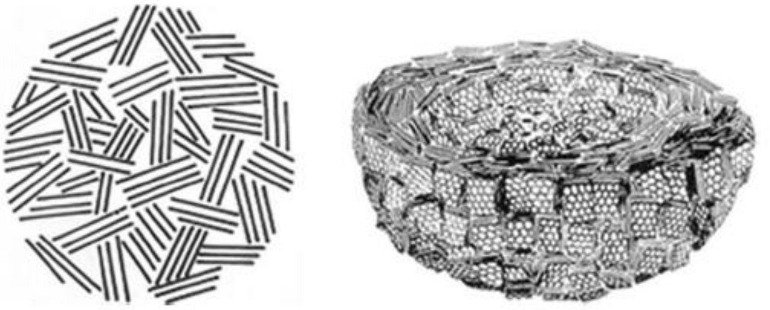

FIGURE 3. Schematic model of carbon black microstructure