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RESEARCH ARTICLE

Measurement of Dispersion Stability of Surface-Modified Nanosized Carbon Black in Various Liquids

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The dispersion stability of nano-sized carbon black produced by a thermal plasma process was investigated using a novel multiple light scattering method. The effect of surface modification of carbon black on the dispersion stability was monitored in various polar and non-polar liquids including water, methanol, styrene, and toluene. The results show that carbon black functionalized with carboxylic anion groups has much improved colloidal stability in a polar solvent and the degree of dispersion stability is strongly related to the solubility parameter value of liquids. In addition, the carbon black with carboxylic anions has a long-term stability without any auxiliary dispersion agent such as a surfactant due to electrostatic repulsion.

Keywords: Carbon Black, Plasma, Modification, Dispersion Stability.

1. INTRODUCTION

Carbon black has excellent properties such as heat and chemical resistance, and electroconductivity.[1] When carbon black is incorporated in various matrices for desired purposes, the improvement of dispersion is crucial for the products to have uniform isotropic properties throughout the materials. Due to their small particle size, thereby large surface area, carbon black easily aggregates in the matrix caused by great inter-particles interaction.[2] When the particle size of carbon black becomes smaller, it becomes more important to disperse carbon black aggregates to use in various applications.[3]

Recently, a novel grade of carbon black has emerged, often referred as plasma black. Plasma black is produced as a by-product in the thermal plasma decomposition process of methane or natural gas.[4,5] One of the unique properties of plasma black is a reduced particle size. Therefore, the uniform dispersion of plasma black becomes more important due to their enlarged surface area. In this work, carbon black produced by decomposition of methane by thermal plasma process is chemically oxidized and the dispersion stability of the modified plasma black in various polar and non-polar solvents is studied employing a novel multiple light scattering method.

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2. EXPERIMENTAL DETAILS

The carbon black used in this study was produced by direct thermal decomposition of methane using D. C. plasma jet. It has an average aggregate size of 80 nm and the specific surface area of 190 m^2/g. A well-established chemical oxidation process[6] was utilized in order to introduce carboxylic acid and carboxylic anion groups onto carbon black surface. 2 g of plasma black, 22 ml nitric acid, and 8 ml sulfuric acid were added into a 100 ml flat bottom flask with a magnetic stirrer. The flask was sonicated for 15 min with a horn-type ultrasonic apparatus (200 watt power). The chemical oxidation reaction was carried out at 110 °C for 24 h. After acid treatment, the plasma black is functionalized with carboxylic acid groups (COOH) on the surface. For substitution of the carboxylic acid groups with the carboxyl anion groups (COO^-), the obtained carboxylated plasma black was mixed with 50 ml of 10 wt% aqueous NaOH solution three times. Filtering, washing with DDI water, and redispersion were repeated at least 10 times until the pH of the filtrate reached near 7.0.

3. RESULTS AND DISCUSSION

Figure 1 represents the degree of modification of carbon black by chemical oxidation using nitric acid and sulfuric acid. The constant weight is maintained up to 600 °C for pristine carbon black, and decomposition of carbon black continuously progresses above 600 °C. For the carboxylated carbon black, the grafted carboxylic acid groups

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