Characteristics of Carbon Nanoparticle Oxidation by NO_2

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Abstract

The oxidation rates of carbon nanoparticle by nitrogen dioxide were measured over the temperature range 17-700℃ and the concentration range of 0-552 ppm at two different reaction times. A tandem differential mobility analyzer (TDMA) technique is used for the oxidation of the monodisperse particles. The size-decrease rate of the particles shows a modified Arrhenius equation form, which describes the rate of reaction.

1. INTRODUCTION

NO_2 may be formed in diesel exhaust gas as the oxidation of NO in gas stream by catalyst or nonthermal plasma technique. The small amounts of NO_2, in the range of a few hundreds ppm by vol. will promote the oxidation of the carbon particulates in the temperature range 200-700℃. However, the soot oxidation by O_2 requires the temperature of 700℃ or above. Thus, by NO_2 a continuous regeneration of the soot is possible. But as the size of nanoparticles and NO_2 concentration, the rate of reaction and the time of removal is different. Therefore It is required quantitative data for the oxidation.

2. METHODS

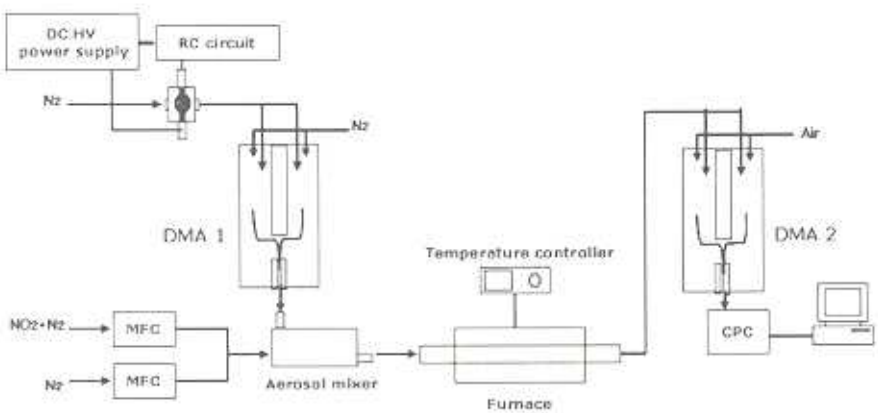
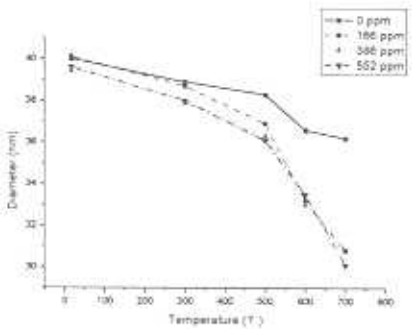


Figure 1. Experimental setup for the carbon nanoparticle oxidation

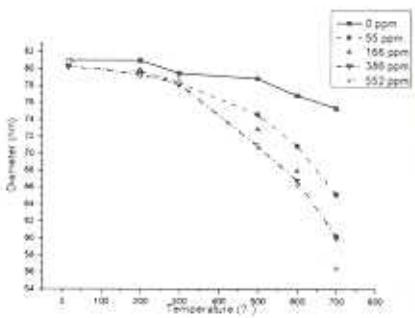
The carbon particulates are generated by a graphite spark discharger using nitrogen as a carrier gas. The NO2 concentrations are controlled by MFC (mass flow controller). The particles generated are sent to the first differential mobility analyzer (DMA) to extract monodisperse particles and the second differential mobility analyzer measured its distribution after the oxidation by nitrogen dioxide. The carbon particles between 40 and 80nm are selected from the first differential mobility analyzer. The temperature of reaction is controlled by a electrical furnace.

3. RESULTS

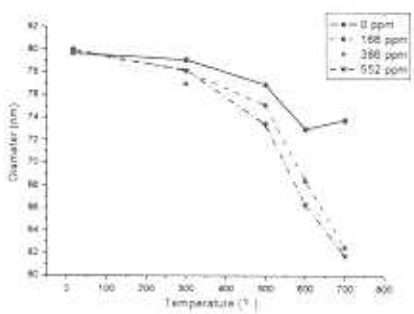
The experimental result of this study is shown in Figure 2. The GMD of carbon nanoparticles decreased as temperature or NO_2 concentration or reaction time increasing. If the reaction time is same, regardless of the initial diameter of nanoparticle, the reduction rates are nearly same. During 17s and 34s, the size decreases each 16.5% and 25% at 700℃. As the reaction time is double, the size-decrease rate increases about 50%. But at NO_2 concentration more than 166ppm, the difference of size-decrease rate is not large. The size-decrease is subject to Arrhenius equation form, which describes the rate of reaction. The reduction rate exponentially increases.



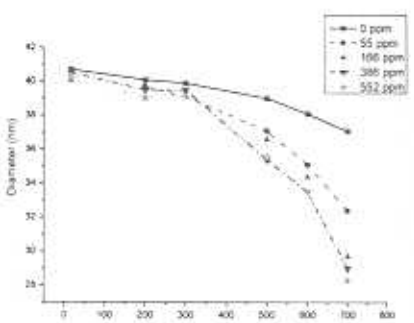
a) reaction time: 17s, initial diameter: 40nm



b) reaction time: 34s, initial diameter: 40nm



c) reaction time: 17s, initial diameter: 80nm



d) reaction time: 34s, initial diameter: 80nm

Figure 2. Variation of GMD with temperature and NO_2 concentration

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