Nanoparticle generations from the brake friction of subway train

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In this study, we measured the size distribution of brake-wear nanoparticles (5.6 to 560 nm) emitted between brake disks and pads with a brake dynamometer for railway vehicles using the fast mobility particle sizer (FMPS, TSI 3091). We observed the changes in particle size distribution over braking time at an interval of one second. In addition, airborne wear particles were collected and analyzed for shape and element composition of each particle in order to identify the mechanism of nanoparticle generation during braking. Experimental conditions of braking tests (12 cases of different rotating speeds and normal pressures) were selected based on the operation conditions of real train.

The change in size distribution over braking time can be described in more detail with size distribution curves over braking time. Figure 1 shows the size distribution in 2, 3, 4 and 6 seconds after braking commenced (t=0) and has characteristics similar to those of a log normal distribution with a peak at around 200 nm (test case of 100 km/h with 12 kN of braking force). It was also found that the size distribution properties of the peak did not change over time, with the exception of one phenomenon where the number concentration at the peak decreased. The number concentration in a 200 nm range was observed in all braking conditions and varied according to speed and braking force increases. However, the generation of particles in a 10 nm range was observed only when the speed and brake force were above certain levels and intensified only when speed and brake force further increased, a wider size distribution was found due to the coagulation of particles.

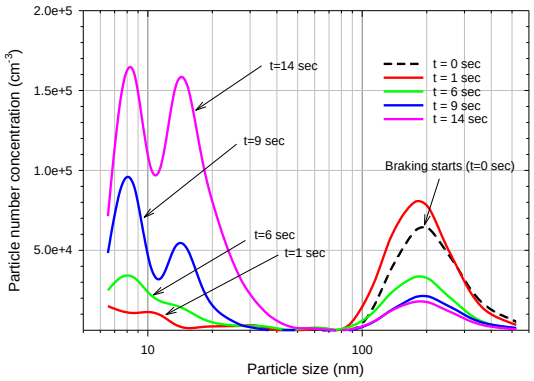

Figure 1. Change of nanoparticles concentration over the braking time

The single nanoparticle of agglomerated particles in Figure 2 consisted of C, O, Cu, Fe, Si, Sb, Al and Ba in that order. It was found that Si, Fe, S, Ba and Cu are common elements detected in wear particles. These elements are found mostly in the established analysis studies of brake wear dusts and Ba, in particular, is widely used as a filler for brake pads. Therefore, it is highly probable that the wear particles analyzed in this study were released in braking testing (Namgung et al., 2016).

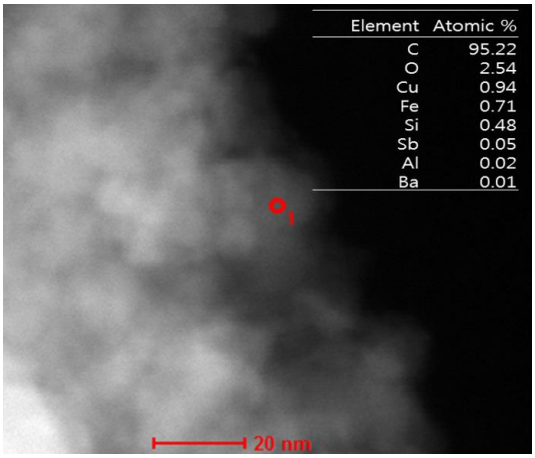

Figure 2. Elemental analysis of wear nanoparticles by TEM-EDX

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