Particle Emissions from the Construction-Related Grinding of Metal and Carpet Glue

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INTRODUCTION

Grinding is a common industrial process in construction-related work. The emissions from grinding metal and other materials can potentially impact the air quality in the region of the work, and thus the health of people who perform the grinding or those nearby.

In this study, we measured the size and composition of particles emitted from the grinding of steel bolts and carpet glue in a construction site, as well as the controlled grinding of various metal samples in a machine shop.

METHODS

The steel bolts that were ground contained 95% Fe, with some C, Mn, Cr, V, and W. The bolts and the glue were ground with a grinder containing aluminum oxide, iron oxide, silicon oxide, cryolite, fiberglass, and silicon carbide. Solid samples of copper and stainless steel (type 309) were used in the machine shop. The glue was a standard carpet glue. Various instruments were used, as shown below:

Instrument	Size Range	Measured
ATOFMS (TSI 3800)	D_a = 150 - 3000 nm	Single-particle composition
DustTrak DRX (TSI 8534)	PM1, PM2.5, PMResp, PM10	Mass Concentration
PPC (TSI 9350)	D_p = 100 - 7000 nm	Number Concentration
APS (TSI 3321)	D_a = 320 - 20000 nm	Number Concentration
SMPS (TSI 3936L25)	D_m = 15 - 661 nm	Number Concentration

The five instruments were sampling at 29 meters from the site of emission, a lecture hall at Carleton College. Metal bolts were ground to remove approximately 250 chairs and carpet glue was ground off of concrete, as part of a room renovation.

RESULTS

Metal Grinding in Construction

Figure 1 shows normalized size distributions of particles sampled with the ATOFMS for each day that metal grinding was sampled. Included in the graph is the data from 6/30/2009, a day on which nothing was done, and which is used as a control. Most of the particles on grinding days are larger than those detected on the control day.

Figure 1

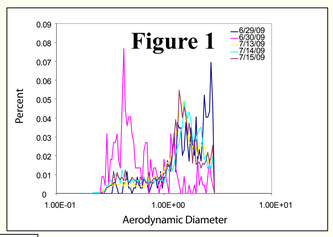


Figure 2

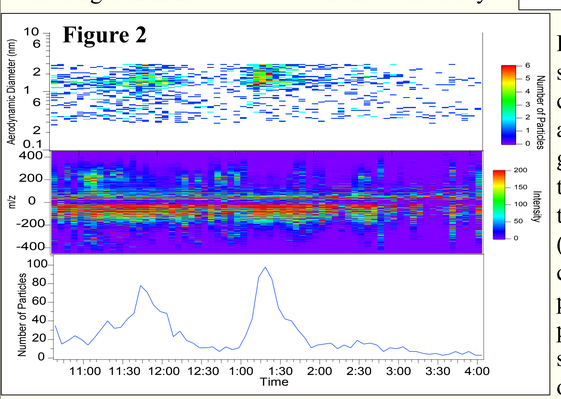
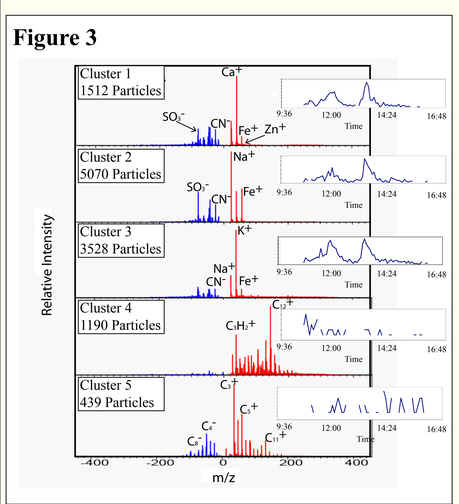


Figure 2 shows size, mass spectra and total particle count data from the ATOFMS as a function of time on one grinding day. You can see that during times of increased total particle concentration (bottom panel), the concentration of larger particles increases (top panel). The middle panel shows the temporal evolution of the mass spectrum

Figure 3



To investigate the composition of the particles emitted, wwe clustered the ATOFMS spectraby similarity, using the K-means algorithm in Enchilada. We found that the data was well represented by 5 clusters, as illustrated in Figure 3, which shows the averages of each of these clusters. The insets how their temporal trends. Note that clusters 1 ,2 and 3 correlate very well with the overall trend for that day, suggesting that they are due to grinding. The fourth and fifth clusters did not contain many particles and do not corelate as well, meaning that they are either background aerosol or are sufficiently small that they don't settle out as quickly. Their size distributions suggest that size may explain cluster 5, but not cluster 4.

Controlled Grinding in the Machine Shop

In order to investigate the particles emitted by grinding in a more controlled system, we measured when a variety of samples were ground with a similar grinding wheel, in a machine shop. One bolt ground (#1) was removed from the construction site, and is therefore an exact match. Figure 4 shows the average spectra of each sample that was ground. This was done by averaging the particles sampled during the time intervals that the specifieed bolts were ground.

Figure 4

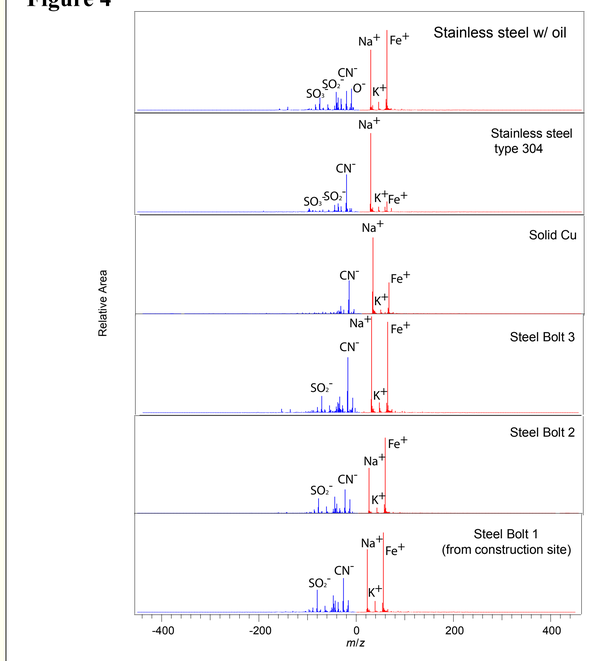
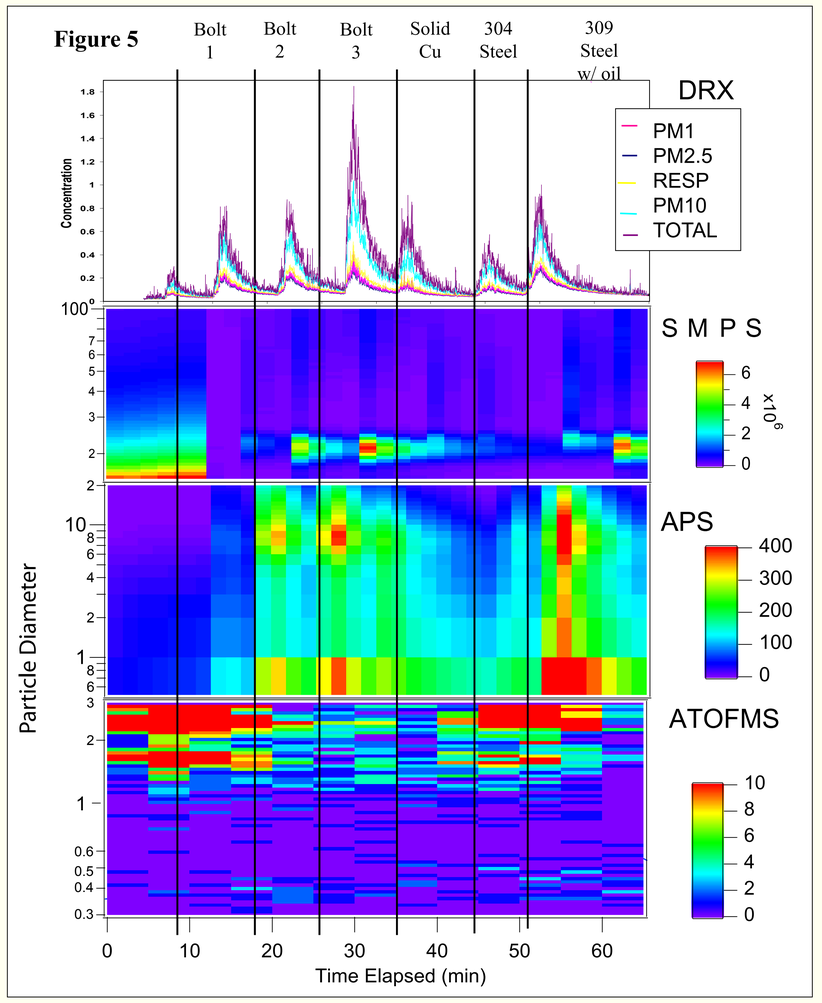


Figure 5 shows size concentration data as a function of time from the DRX, APS, and SMPS. The trial with lubricating oil showed particles in a wide size range as compared to the same bolt ground with no lubricating oil. The particles in the lubricating oil trial also stayed suspended for a longer time.

Figure 5



Glue Grinding in Construction

In addition to bolt grinding at the construction site, grinding was used to remove old carpet glue from the concrete floor. Sampling of thse particles was carried out in the same way as the metal grinding particles. Figure 6 shows size data from three instruments: the DRX, SMPS, and the APS. They not only show a good corelation but in times of higher total concentration the larger particles (size range from 4 to 6 μm) increases as well.

Figure 6

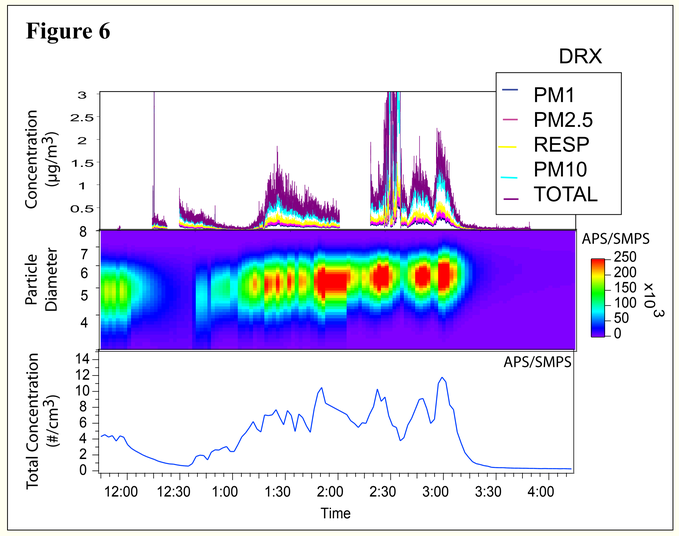
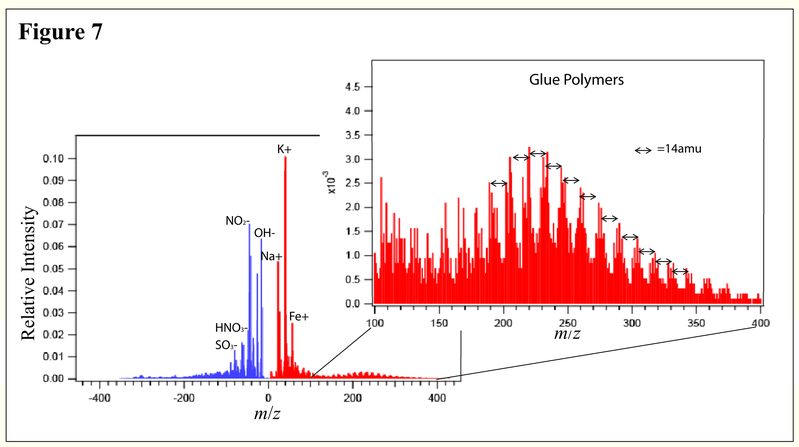


Figure 7 shows the average mass spectrum of the particles sampled during the glue grinding episodes. Clustering was performed on the particles, with the majority of the particles being placed into one cluster or several mimilar clusters, so it can be assumed that athe majority of the particles are identical. For this reason, an average spectrum is shown here instead of cluster centers. Note the prominent peaks due to high mass polymeric ions, presumably fragments of the glue itself, which is visible in these particles.

Figure 7



CONCLUSIONS

From the various experiments shown here, we can see that the instruments tend to agree about times of increased total particle concentration. We can also see as a general trend that during grinding times the concentration of larger particles increases. The addition of the ATOFMS to the experiments gives us valuable information about the composition of the particles emitted in various grinding activities, including:

- Grinding particles contain strong signals from metals such as Ca, Fe, Na, K and weaker signals from Zn and V. They also contain many organic carbon and elemental carbon particles.
- Addition of machine oil to a sample bolt ground in the machine shop significantly broadens the size distribution and those particles tend to stay in the air longer.
- Polymers are visible in particles from grinding glue.

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