Development of photochemical chamber system for the laboratory characterization of primary and secondary vehicular exhaust from bio-ethanol

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A photochemical chamber was designed and built to study secondary gas and aerosol formation from ethanol blends in gasoline. The exhaust from two flex-fueled vehicles was irradiated in the chamber to simulate atmospheric aging of the emissions and formation of secondary organic aerosol. One vehicle and the fuel used were made in USA and the other was made in Brazil. Primary emissions of THC, CO, CO_2, NO_x and NMHC for both cars decreased as the amount of ethanol in gasoline increased. However, emissions of HC, CO and NO_x from the Brazilian car were markedly higher than the American car. Fuel efficiency remained approximately the same for both vehicles.

Results

The first vehicle was a 2012 flex-fueled Ford Focus 2.0 GDI. It was manufactured according to U.S. specifications. Pure gasoline (E0) and three standard ethanol blends were used: 10% (E10), 85% winter (E85W) and 85% summer (E85S).

The other vehicle was a Chevrolet Prisma 1.4 flex-fueled vehicle. It was manufactured according to Brazilian specifications for use with ethanol blends in gasoline. It was tested with 22% ethanol and 100% ethanol (E22 and E100, standard blends imported from Brazil).

The mean concentrations of the gases measured for urban and highway cycles and for cold and hot start show that the Chevrolet Prisma has larger emissions than the Ford Focus. This contrast is most likely due to the different technology of the cars and the formulation of the gasoline and ethanol. The Ford Focus was made in USA and the Chevrolet Prima was made in Brazil, the ethanol/gasoline mixtures for the two vehicles were imported from the US and Brazil, respectively. Another very clear observation for both cars is that as the amount of ethanol in gasoline increases, the emissions of THC, CO, CO_2, NO_x and NMHC decrease. The only gas with higher emissions with increasing ethanol content is CH_4 in the Ford Focus. Fuel efficiency remained the same for the Ford Focus at 15 km/l and increased slightly in the Chevrolet Prisma from 13.7 km/l with the E22 blend to 16.6 km/l with the E100.

After filling the chamber, the UV lamps were turned on. The maximum NO concentration measured inside the chamber was observed at this moment, because later, NO reacted rapidly into NO_2. For the US vehicle and fuel blends, the lowest NO concentrations were observed for the US E85. For the Chevrolet Prisma, NO concentration at the beginning of the experiment was much higher than the Ford Focus and this difference is most likely related to the difference in car technology. Figure 1 shows clearly the conversion from NO to [NOx–NO] because as the second increases, the first decreases. However, the concentration of [NOx–NO] relative to O_3 is much higher in the Ford Focus than in the Chevrolet Prisma. For the Ford Focus with the E10 blend, the maximum O_3 concentration is about 40% higher than the [NOx – NO] maximum concentration (for the E0 blend it is 17% lower, for E85W the maximums are similar, for E85S it is 40% lower). For the Chevrolet Prisma with the E22 blend, the maximum O3 concentration is 75% lower (for the E100 blend, O3 is 80% lower).

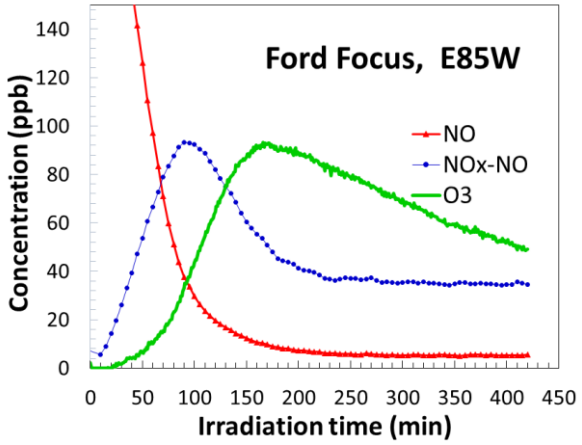

Figure 1. NO, NO_x – NO and O_3concentration inside the chamber for the E85W blend versus irradiation time.

For all fuel blends, secondary particle matter formation occurs with the initial nucleation of ultrafine particles, which then coagulate and grow with condensation of material into particle phase. For all blends, the maximum of the mass concentration is reached after the maximum in O_3.

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