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The Role of Ionic Nucleation in the Formation of Nucleation Mode Particles Associated with Diesel Engine Exhaust

Tiny volatile particles, in the nanoparticle diameter range (Dp<50 nm), are often formed as engine exhaust dilutes and cools in the atmosphere. Although the environmental impact of these particles is poorly understood, concerns have been raised about possible adverse health effects. Thus there is considerable interest in understanding the mechanisms that lead to the formation of these particles. There are two main theories that attempt to explain nucleation mode formation during exhaust dilution; homogeneous nucleation and ion-induced nucleation. In this study we have examined the possible role of ionic nucleation. Measurements were made of the electrical charge on the nucleation mode particles formed during dilution of the exhaust of a medium-duty Diesel engine by measuring particle size distributions upstream and downstream of an electrostatic collector designed to remove all charged particles in the ultrafine range. Charge levels of particles in the nucleation mode were found to be too low to be consistent with ionic nucleation, even when the possibility of partial neutralization due to charge enhanced coagulation was taken in account.
We also examined the role of possible ion-induced nucleation using an ion trap to remove essentially all ions from an exhaust stream before the dilution and cooling process that normally forms nucleation mode particles. The ion trap had no significant influence on the nucleation mode. This provided further evidence that ionic nucleation did not play an important role.
These results were supported by calculations of likely ion concentration histories during Diesel engine combustion. These calculations accounted for recombination and attachment during the engine expansion stroke for typical Diesel conditions and suggest that even if very high ion concentrations are initially formed during combustion, recombination and attachment would reduce the concentrations to levels much lower than typical nucleation mode number concentrations. Thus both our experimental results and these calculations suggest that ionic nucleation is unlikely to play a significant role in the formation of nucleation mode particles associated with Diesel engine exhaust

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