Title

Bridging Model Estimates of Vehicular Emissions with Near-Roadway Ambient Measurements

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Publication Date

2020-02-01

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February 2020

A Research Report from the National Center for Sustainable Transportation

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National Center for Sustainable Transportation

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Acknowledgments

This study was funded, partially or entirely, by a grant from the National Center for Sustainable Transportation (NCST), supported by the U.S. Department of Transportation (USDOT) through the University Transportation Centers program. The authors would like to thank the NCST and the USDOT for their support of university-based research in transportation, and especially for the funding provided in support of this project.

Disclaimer

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Currently, vehicle emissions are measured using dynamometers and/or portable emissions measurement systems (PEMS); however, these systems operate at temperature and dilution ratios not representative of the ambient atmosphere. A majority of differences between the near-road studies and emission factors derived from PEMS and dynamometers could be due to the changes in PM that occur immediately after the emissions are emitted into the ambient atmosphere as they rapidly dilute and cool. This rapid dilution and cooling affects gas-particle partitioning of condensable organic aerosol (OA). As the exhaust is emitted the plume dilutes, which can lead to evaporation of existing OA into semi-volatile organic gases (VOC) (Figure 1); however, the plume also rapidly cools which leads to condensation and nucleation of evaporated and emitted VOCs into OA (Figure 1). The formation of additional OA through gas-particle partitioning could provide greater mass closure between vehicle emission factors and near roadway monitors. *This research will focus on developing a module that can be added into current emission simulators, such as the EPA's MOVES, that bridges the gap between PEMS/dynamometer measurements to account for gas-particle partitioning processes occurring on a timescale representative of near roadway monitors.*

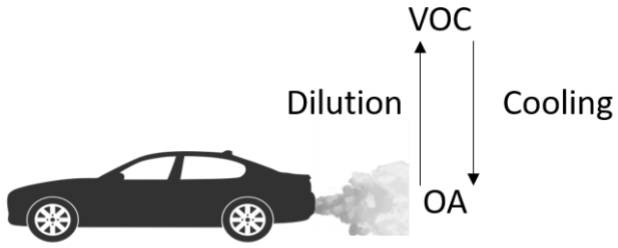

Figure 1. Schematic of exhaust after leaving vehicle

Utilizing an existing University of California, Riverside (UCR) dilution system built by Dr. Gysel (Figure 2), will allow me to dilute and cool vehicle exhaust, in order to examine the condensable PM from the engines in the dilution and timescale of near-roadway exhaust. Vehicle exhaust will be mixed with filtered clean air in the mixing chamber, to get the desired dilution and temperature then passed in to the residence chamber where the exhaust can age for up to 70 seconds before passing into a Scanning Mobility Particle Sizer (SMPS) to measure changes in OA mass.

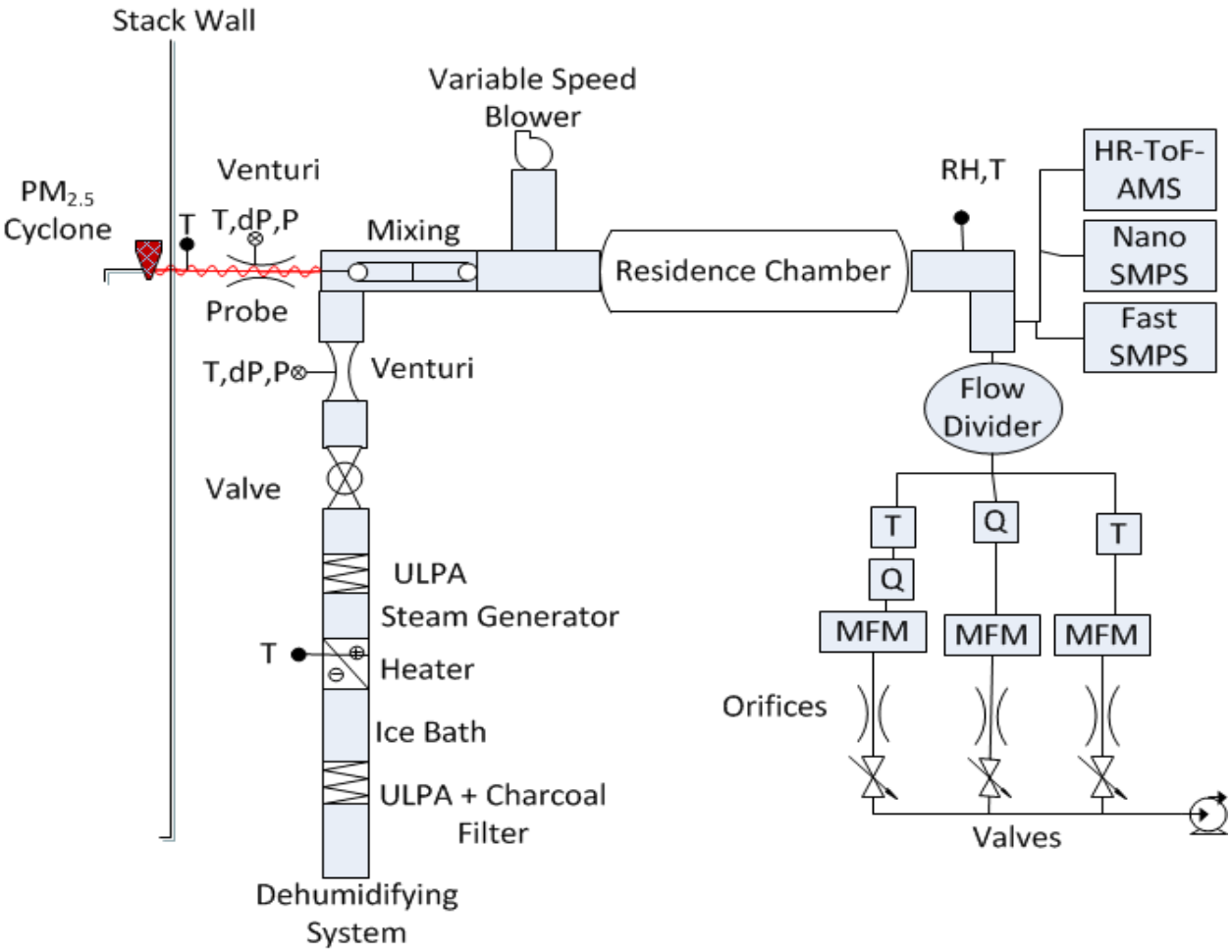

Figure 2. UCR PM Measurement System [1]

Table 1 shows a comparison study done between the UCR system and other PM measurement systems [1]. The UCR system is comparable to other systems, with one difference being the extended range of time for the aging section residence (5-70 seconds). The aging section was extended for the UCR system in order to study nucleation and PM mass growth [1]; the aging section will allow me to study how vehicle emitted PM changes within the first 5-70 seconds after being emitted.

Table 1. Comparison of UCR and other designs [1]

Parameter	Units	DRI	CDS	CE-CERT
Raw Sample Flow Rate	L/min	25	25	25
Dilution Ratio (nominal)	--	40	20	20
Dilution Ratio (range)	--	25-50	10.0-40	10.0-40
Aging section diameter	m	0.46	0.2	0.35
Aging section flow rate (nominal)	L/min	226	113	113
Aging section length (nominal)	m	1.83	6	5
Aging section length (range)	m	n/a	1.2	0.02-0.98
Aging section residence time (nominal)	sec	80	10	10
Aging section residence time (range)	sec	n/a	0-10	5.0-70
Aging section reynolds number	--	1000	800	500
Bypass flow rate (nominal)	L/min	799	412	417
Bypass flow rate (range)	L/min	424-1049	49-912	167-1167
Mixing section diameter	m	0.15	0.2	0.2
Mixing length	diameters	18	1.4	1.4
Mixing section type	--	single parallel jets	multiple parallel jets	multiple parallel jets
Mixing section Reynolds number	--	9000	6000	6000
Dilution Air Conditioning	--	HEPA+activated charcoal	HEPA+activated charcoal	ULPA+activated charcoal
Sample flowmeter	--	venturi	venturi	venturi

England *et al.* studied the effects of dilution ratio on total number concentration and particle diameter from a natural gas combustion. England *et al.* concluded that, for natural gas combustion the particle number concentration and particle diameter decreases with increasing dilution ratio when holding temperature and residence time constant (Figure 3) [2].

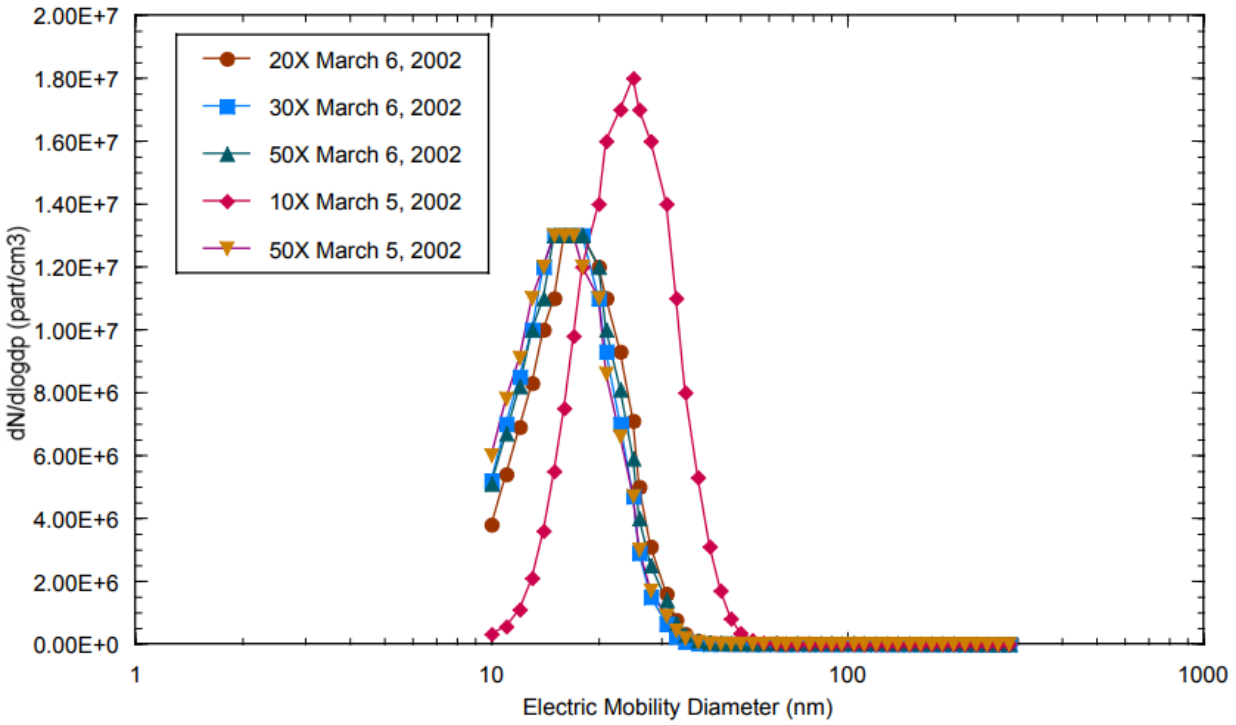

Figure 3. Comparison of particle size distribution as a function of different dilution ratios from natural gas combustion [2]

The goal of this research is to first measure OA formation on the timescale of near roadway emissions and then build a module for the EPA MOVES model that accounts for the additional OA formation during the dilution and cooling process. This research is critical in understanding how vehicle emissions interact with the ambient air, immediately after being emitted, which can greatly improve our understanding of how vehicle emissions affect human health, air quality, and the environment.

References

1. Gysel, N., Cocker, D., Miller, W. Evaluation & Improvement of Particulate Matter Measurement from NG Power Plants
2. England, G., Chang, O., & Wien, S. (2004) Development of Fine Particulate Emission Factors and SPeciation Profiles for Oil- and Gas-Fired Combustion Systems. Final Report.