August 30, 2012

Honorable Lisa Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Ave. NW
Washington, DC 20460

Subject: EPA Proposed Rule "National Ambient Air Quality Standards for Particulate Matter", 77 Federal Register 38890 to 39055 (June 30, 2012)
Docket ID No. EPA–HQ–OAR–2007–0492

Administrator Jackson:

Urban Air Initiative (UAI) appreciates this opportunity to comment on the Agency's proposal to address one of our most dangerous and costly health threats, urban fine particulate matter, known as PM2.5. Taking the proper steps to reduce fine and ultrafine particulates, as well as black carbon (BC), would also lead to significant reductions in related harmful constituents that coat or are absorbed by the particles, toxic compounds such as polycyclic aromatic hydrocarbons and quinones (PAHQs), and would produce substantial health and climate change benefits.[1] UAI is a non-profit 501(c) (4) corporation dedicated to the identification, research, and public education of cost effective methods of improving the quality of urban air. UAI's primary goal is to reduce harmful emissions from ubiquitous gasoline exhaust in our largest cities, which are responsible for billions of dollars in health costs each year, and are of great concern to tens of millions of Americans that belong to the most susceptible and vulnerable segments of our population.

SUMMARY OF COMMENTS. While UAI commends the Agency for addressing the issue of fine particle pollution, at 38899 of the rule, EPA notes that a great deal of new science on PM health effects has been published since mid-2009, the Integrated Science Assessment's cut-off date. UAI understands that the Agency will pay careful consideration to "studies that may be submitted during the comment period…in order to ensure that, before making a final decision, the Administrator is fully aware of the new science that has developed since 2009." Toward that end, UAI's comments will focus on several key areas where it believes EPA's analysis falls short of incorporating published studies and new science, and/or connecting the relationship between PM constituents and their human health effects. UAI believes that the primary areas in need of additional consideration prior to releasing the final rule are:

1. Particle size and composition are interconnected and have enormous impact on human health.
2. Gasoline exhaust is the primary source of urban primary and secondary PM, BC, and PAHQ toxics.
3. PAHQs are known toxics, have proven and serious health effects, and should require no additional epidemiological proof for EPA to act.
4. Ultrafine particles, PAHs, and BC are inextricably tied to gasoline composition, and their emissions will increase in urban areas if fuel quality improvements do not complement advanced engine designs.
5. Cost effective and technologically available methods of improving fuel quality exist.
6. EPA has clear statutory authority, and some experts say the legal obligation, to improve gasoline quality standards.

[1] See the glossary attached to these comments for a definition of terms.

SALIENT FACTS.

1. In addition to size distinctions (e.g., PM2.5 = 2.5 micrometers (µm) or smaller in aerodynamic diameter), experts also distinguish between primary and secondary PM.
2. BC is a "significant fraction of **primary** PM".
3. EPA defines BC as an SLCF (Short-Lived Climate Forcer), and "the most strongly light-absorbing component of PM2.5"… This means that actions taken to reduce BC constituents in direct [primary] PM2.5 will have almost immediate effects on climate change". [EPA RIA, p. 6-34]
4. Mobile sources are responsible for 69% of all non-wildfire BC in the US. [EPA Draft Report to Congress].
5. Gasoline aromatic hydrocarbons are significant contributors to the formation of secondary organic aerosols in the atmosphere and resulting particulate formation. Researchers from the University of Colorado–Boulder and NOAA found that 80+% of the SOAs in Los Angeles, CA, came from gasoline exhaust. [March 2012]
6. "In urban areas, vehicular emissions constitute the majority of the primary particles in the atmosphere…Shortly after their emission from the tailpipe, highly concentrated gas vapors experience super-saturation due to rapid cooling in the atmosphere, which causes them to nucleate or condense onto the pre-existing particles, thereby creating a chemically complex aerosol…PAHs are semi-volatile organic compounds and they exist in both gas and particle phases. Given the increased toxicity of these semi-volatile species, efforts should be made to reduce their emissions from newer vehicles, including reductions in their gas-phase precursors formed during the combustion process." [Ning, Sioutas, University of Southern California, 2010]
7. PAHs are toxic, carcinogenic, and mutagenic. They coat the PM2.5 and ultrafine particles and are absorbed by the highly porous BC particles. The tiny particles then act as effective carriers of the PAHQs, and enable them to penetrate deeply into humans' lungs, enter the bloodstream, and get deposited into organs and cellular structures. PAHs cause a wide range of health disorders, including cancers, heart disease, and asthma and other respiratory conditions. PAHs are also one of the most omnipresent endocrine disruptor compounds. Experts have identified them as especially damaging to the fetus and young children, and other susceptible groups such as the elderly, asthmatics, and diabetics.
8. Congress gave EPA clear authority to reduce toxic emissions from gasoline in the 1990 Clean Air Act Amendments, including explicit instructions to reformulate gasoline by reducing and/or eliminating aromatics and other precursors of PM2.5 and PAHs.
9. Improving gasoline composition is one of the most cost effective means of reducing particle-borne toxics and BC emissions. For example, E30+ blends reduce particle number, particle mass, and BC by 30 – 45%, according to recent Ford Motor Company research. Recent studies show that ethanol's superior octane properties make mid-level ethanol blends a cost-effective substitute for hydrocarbon aromatics as gasoline octane enhancers.

PARTICLE SIZE AND COMPOSITION ARE INTERCONNECTED AND HAVE ENORMOUS IMPACT ON HUMAN HEALTH.

While the Agency hints at the connection, it fails in the proposed rule to close the loop on the potent linkage between particle sizes and their constituents or composition. At 38960, the Agency states that "chemical constituents present at higher levels in urban…areas, including byproducts of incomplete combustion, (i.e., polycyclic aromatic hydrocarbons, emitted as PM2.5 from motor vehicles)…can contaminate PM10-2.5." However, at 38922, the EPA states that the "information is still too limited to provide support for consideration of a distinct PM standard for ultrafine particles. In addressing the issue

of particle composition, the Integrated Science Assessment concludes that "[f]rom a mechanistic perspective, it is highly plausible that the chemical composition of PM would be a better predictor of health effects than particle size". The Agency goes on to cite several studies that show an association between mortality and morbidity effects and various PM2.5 constituents. Inexplicably however, it fails to mention the most potent, toxic, and pervasive of these constituents, the PAHs, along with the quinones, PAHQs, which are oxidative derivatives of gasoline aromatic compounds (see footnote 69 at 38922). EPA once again concludes that further study is needed.

UAI believes that, in reaching these conclusions, the Agency has failed to consider an extensive body of scientific literature, both pre- and post- the mid-2009 ISA review. A number of these studies were funded by none other than the EPA itself. Several are worthy of special mention here, and more detailed backup can be found in Attachment A.

The first study, "Particulate Matter (PM) Research Centers (1999 – 2005) and the Role of Interdisciplinary Center-Based Research", was published in *Environmental Health Perspectives* in February 2009[2], and presented a mid-term review of five academic centers' PM research work for the period 1999 - 2005. Experts from five prestigious universities (UCLA, Harvard School of Public Health, University of Rochester Medical Center, New York University of Medicine, and University of Washington) presented highlights of their first six years of research on PM, ultrafine particles, and traffic-related health effects. The study shows that the Agency has known for at least a decade now that traffic in urban areas poses serious health threats. The findings "suggest greater toxicity of traffic-related particles", "Ultrafine particles are unique in composition and toxicity", "the ability of PM to catalyze ROS (Reactive Oxygen Species) generation, an initial step in the induction of oxidative stress, was greater in the UFP fraction", and "mobile sources are highly relevant to the public health impacts of PM". In noting the policy implications of their research, the authors noted that "The PM NAAQS are based on mass concentration…a more sophisticated approach to standards will be needed. **Based on findings from the PM Centers and others, the potential efficacy of number and component-based standards should be assessed…the question of source-specific control strategies to maximize public health protection also needs to be considered."** (Emphasis supplied)

The second study is a February 2010 article by two USC researchers, Ning and Sioutas, which posited that "Combustion-generated aerosols, especially emissions of heavy and light duty vehicles, are the dominant contributors of ambient particulate matter (PM) in urban environments."[3] The authors emphasize the importance of both particle size and toxicity. They note that "Polar organic compounds such as quinones can act as catalysts to produce ROS directly, whereas polycyclic aromatic hydrocarbons (PAHs) can induce oxidative stress indirectly, through biotransformation to generate redox active quinones." The paper provides an excellent treatment of how primary and secondary PM, ultrafine, and aerosols from mobile sources are formed and transported. Table 1 confirms that the predominant fraction of ambient PM originates from gasoline-powered light duty vehicles in California, which will also be the case in the largest U.S. cities, due to the fact that approximately 96% of vehicles are gasoline-powered.

Ning and Sioutas note that "PAHs are semi-volatile organic compounds and they exist in both gas and particle phases…PAH concentrations were consistently higher when the nearby freeway was busy with traffic during morning rush hours." (p. 50). They also note that an alarming trend is developing absent fuel composition changes. "Advanced vehicle emission control technologies are effective in reducing solid, non-labile PM emissions by means of filtration. However, recent investigations have shown substantial increases (by one order of magnitude and often more) of particle number emissions from

[2] *Environmental Health Perspectives*, Fanning et al., Volume 117, Number 2, February 2009.
[3] http://aaqr.org/VOL10_No1_February2010/6_AAQR-09-05-IR-0036_43-58.pdf

retrofitted vehicles due to the formation of nucleation mode particles from organic vapors in the exhaust. The emission of these smaller particles in the atmosphere pose a greater threat to public health, since they deposit deeper in the human respiratory systems and their chemical composition appears to be intrinsically more toxic than the non-labile PM…**Given the increased toxicity of these semi-volatile species [e.g., PAHQs], efforts should be made to reduce their emissions from newer vehicles, including reductions in their gas-phase precursors formed during the combustion process."**

A third important study is the 2009 Araujo/Nel UCLA research which found that UFPs are much more pathogenic than other PM, due to their smaller size and larger particle numbers; larger content of redox active compounds (ROS catalysts); greater bioavailability; and greater lung retention.[4]

Finally, the CARB December 2011 LEV III PM Technical Support Document (also referenced below) concluded that "it is likely that the inclusion of a strict SPN (solid particle number) standard would lead to reductions in EC (i.e. BC) emissions."[5]

GASOLINE EXHAUST IS THE PREDOMINANT SOURCE OF URBAN PRIMARY AND SECONDARY PM, ULTRAFINE PARTICLES, BC, AND PAHQ TOXICS.

UAI believes that EPA's regulatory approach is in urgent need of rebalancing, as it has disproportionately relied upon stationary and diesel emissions controls[6], and has largely overlooked the significant role played by gasoline exhaust in our largest cities, which is where the vast majority of Americans live and work. In addition to its important role as a source of the powerful warming agent BC, gasoline exhaust represents the highest volume, most ubiquitous, and pervasive source of ambient PM, UFPs, and the PAHQ toxics in the urban environment. UAI experts' analysis of the scientific literature has confirmed that the gasoline aromatic compounds, which by virtue of their physical and chemical properties are extremely difficult to combust, are the primary source of both the toxic PAHQs, and the particles which carry them to humans' lungs in urban environments, and responsible for billions of dollars of premature mortality and morbidity costs. The incomplete combustion of aromatics sets in motion a virtually inseparable chain reaction of semi-volatile organic compounds, UFPs, PAHQs, PM2.5, and BC emissions that makes urban air so dangerous for tens of millions of Americans. Consequently, UAI believes that the single most important action the EPA can take to protect the public health and welfare is to set higher standards for gasoline quality.

Attachment B provides more background and links to support this contention, but several of them are worth mentioning here.

1. Funded by CARB, NOAA, and the National Science Foundation, University of Colorado-Boulder researchers recently determined (March 2012) that 80+% of the secondary organic aerosols (SOAs, or secondary PM) in the Los Angeles basin were attributable to gasoline, not diesel,

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[4] http://www.particleandfibretoxicology.com/content/6/1/24/ref, , pp. 6 - 7

[5] http://www.arb.ca.gov/regact/2012/leviiighg2012/levappp.pdf, p. 126

[6] For example, see the February 18, 2012 *New York Times* article by Felicity Barringer, "Scientists Find New Dangers in Tiny Pervasive Particles in Air Pollution". Barringer noted: "Taken together, the findings of the new study and of a handful of others published in the last two years could mean that two decades' worth of pollution control strategies—focused on keeping tiny particles from escaping into the atmosphere—have addressed only part of the problem." A Carnegie Mellon researcher said current policy is flawed: "We haven't been trying to control a lot of the organics". The article concluded by noting that "Emissions of coal-fired power plants do not play a role in the formation of these organic particles, several scientists said…".

exhaust. http://www.colorado.edu/news/releases/2012/03/02/gasoline-worse-diesel-when-it-comes-some-types-air-pollution

2. A February 2009 MIT study by Chan et al., "Understanding Secondary Organic Aerosol (SOA) Formation from Lower-Volatility Precursors: Photooxidation of Naphthalene and Alkyl-naphthalenes", stated that " After 3 h of photooxidation, PAHs and *n*-alkanes can account for up to 86% of the SOA, or all of the "unexplained" SOA". (Slide 12)
3. In October 2010, Honda Motors research scientists found that a substantial amount of PM emissions are produced by gasoline engines, and that "all of the additional PN (particle number) is considered a PAH, with a high boiling point or soot. The higher the boiling point hydrocarbon added, the more the PN increases. This trend is particularly notable with aromatic substances." Honda concluded that since PM is a risk to both human health and global warming, "PM emissions from gasoline engines can be significantly reduced by improving the quality of fuels around the world." [SAE-2010-01-2115]
4. In its December 2011 Appendix P to the LEV III ruling, CARB stated that "Although diesel engines are known major contributors to PM emissions, recent studies show that gasoline engines also play a key role", and cited a 2010 Iizuka, et al. study. This study cited aromatics content as an even more important factor than distillation, and recommended replacement of aromatics with ethanol (slide 32). Supra, p. 88
5. In the same document, on p. 123, CARB states: "The results of this analysis indicate that EC [elemental carbon, used interchangeably with BC] accounts for approximately 70 percent of the PM mass emissions from gasoline-powered LDV. This result is in stark contrast to lower EC/PM ratios reported by others (U.S. EPA 2008). The rising EC/PM ratio observed in the newer vehicles tested in this study indicates that the reductions in EC emissions may not follow PM mass reductions…the ARB is still maintaining the importance of the particle counting alternative and is pursuing an active study program on particle number measurement as an alternative to the filter-based method".
6. A May 2009 UCLA/CARB study found "peak levels of ultrafine particles (UFP) immediately adjacent to the freeway, but we found high concentrations persisted for up to 1.5 miles downwind of the freeway during the pre-sunrise hours." Other pollutants, including "particle-bound polycyclic aromatic hydrocarbons, also extended far from the freeway during the pre-sunrise hours," a time when most people are in their homes. http://www.ph.ucla..edu/pr/newsitem061009.html

The sixth study referenced above seems to contradict the Agency's statement at 38921-38922: "Internal combustion engines and, therefore, roadways are a notable source of ultrafine particles, so concentrations of these particles near roadways are generally expected to be elevated. Concentrations of ultrafine particles have been reported to drop off much more quickly with distance from roadways than fine particles (U.S. EPA, 2009a, p. 3-84)."

Black Carbon, Mobile Sources, and PAHs. In a 2010 *Sustainability* article, Sierra Nevada Research Institute, et al. published "Black Carbon's Properties and Role in the Environment: A Comprehensive Review."[7] The paper does an excellent job of elaborating on BC's relationship with PAHs, and its subsequent impact on both global warming and health effects. The authors note that "The emission and transport of BC in the environment is also associated with the fate of other organic substances, particularly polycyclic aromatic hydrocarbons (PAHs), whose isomers can be utilized to trace the sources of BC in soils and sediments." Fossil fuel BC is fully depleted in radiocarbons (^{14}C), whereas biomass BC is not. This makes BC a useful tool to measure fossil fuel combustion

[7] http://www.nrs.fs.fed.us/pubs/jrnl/2010/nrs_2010_shrestha_001.pdf

emissions. In addition, scientists can reliably use PAH isomers to identify the source of the BC, which in most U.S. cities is predominantly gasoline exhaust.

"Black carbon has been reported as a better marker of total PM sources than standard mass concentration measurements because of its longer lifetime (40 hours to a month) in aerosol form, a dry deposition rate… and the fact that BC is hydrophobic and chemically inert." Table 1 lists several leading sources of PAH isomers, including automobiles. (P. 298)

UAI believes that the Agency should give serious consideration to BC's ability to serve as a marker for both sources and constituents of fine and ultrafine particles, reference the discussion at 38922 of the proposed rule on the relative value of source apportionment methods. In order to maximize the investment of protecting public health and welfare, the highest priority attention should clearly be paid to the nation's largest cities, which is where the vast majority of Americans are most exposed, including tens of millions of those most susceptible to particle-bound PAHQs.

Near-Roadway Monitoring. UAI notes that at 39009 in the proposed rule, the Agency proposes addition of a near-roadway monitoring component to PM2.5 design criteria. Once again, EPA unfortunately displays its misguided bias prioritizing diesel over gasoline emissions. "The EPA believes that there are gradients in near-roadway PM2.5 that are most likely to be associated with heavily travelled roads, **particularly those with significant heavy duty diesel activity**." (Emphasis supplied). Notwithstanding EPA's failure to recognize the significant role gasoline exhaust plays, UAI agrees with EPA that such near-road sites could provide valuable understanding of emissions "such as BC, ultrafine particles, and particle size distribution." EPA proposes to install these monitors at one location within each CBSA with a population of one million persons or greater, which will require approximately 52 monitors across the country. The Agency seems to confirm UAI's position on the importance of prioritizing gasoline exhaust-driven pollutants in our largest cities, when it states that "…the largest CBSAs are likely to have greater numbers of exposed populations, a higher likelihood of elevated near-road PM2.5 concentrations, and a wide range of diverse situations". [39010]

UAI is confident that these monitors will provide further reinforcement for what is already known about particle-borne toxics in our largest cities. However, EPA must not delay acting until the monitors have been installed, for reasons set out at the end of these comments.

POLYCYCLIC AROMATIC HYDROCARBONS/QUINONES (PAHQs) ARE KNOWN CARCINOGENIC TOXICS, HAVE PROVEN AND SERIOUS HEALTH EFFECTS, AND SHOULD REQUIRE NO ADDITIONAL EPIDEMIOLOGICAL PROOF FOR EPA TO ACT.

Attachment C provides more support for this contention. It in part relies upon epidemiological evidence developed during the HHS/Surgeon General's anti-smoking campaign. Many of the same PAHQs found in gasoline exhaust are the same as, or similar to, those found in cigarette smoke, both direct and secondhand (ETS). UAI believes there is no reason for EPA to have to re-litigate what has already been painstakingly documented after decades of research that conclusively proved the extensive human health damages from cigarette smoke, which enters the human body in essentially the same way particle-borne toxics from gasoline exhaust enter the lungs, bloodstream, and organs.

More than 10 years ago, in 2000, the California Office of Environmental Health Hazards Assessment (OEHHA) assembled experts on the health effects of gasoline emissions, including PAHs. Even then, what the experts knew and/or strongly suspected is striking, including the connection between gasoline

exhaust PAHs and cigarette smoke PAHs. Regrettably, this report suggests that very little progress has been made over the past 12 years in regulating this permeating source of toxic pollutants.

ASSESSMENT FINDINGS:

1. p. 5: "Light-duty gasoline...vehicles emit significant numbers of ultrafine particles...LDVs emit particulate matter containing higher fractions of particulate PAHs. LDVs are significant sources of gas phase PAHs. Cold starts, high accelerations, and high emitters account for most of the LDV particulate matter emissions...it appears that LDV particulate matter emissions are significantly underestimated in current inventories. LDVs are the major source of 1,3 butadiene and BTEX."

2. p. 26: "But for heavier end PAHs, there are several where gasoline is the dominant source. Heavy PAHs should not be showing up in gasoline, considering they are not in the right boiling range. However, there are other process units besides distillation in the refinery, specifically the process unit that makes aromatics."

3. p. 30: "In '87 there was a tunnel study that showed that hydrocarbon emissions were underestimated by factors of three to seven compared with the then EMFAC model...A group in Australia...found that a number of organic compounds were hidden in the noise of a normal GC. They found that the ambient load of VOCs would be something 60% or more higher than what one would normally find. The organics were in the C6 to C14 range and they concluded the compounds were aromatics largely. If this is correct it challenges the emissions inventory and/or the modeling."

4. p. 31: "There is more evidence now from European studies in particular that nearness to a roadway is a major factor in exposure."

5. p. 35: "The parallels between ETS (second-hand smoke) and gasoline emissions are numerous: Both are ubiquitous; Both are present in low concentrations; Both have potential for high, intermittent exposure; ETS has long-term chronic effects, which are likely to be associated with gasoline emissions as well; ETS is a carcinogen, and gasoline emissions have carcinogenic components."

6. p. 43: "The results of the analysis indicate that PAHs alone may be responsible for between 15 and 38% of the lung cancer deaths from cigarette smoke...somewhere between 8 and 70% of the deaths would be due to benzene."

7. p. 46: "What size fraction of gasoline PM contains the toxicologically important compounds?...One size category that may be most relevant would be ultrafine particles, those that are less than .1 micron in diameter...They can serve as an important vehicle for carrying other toxicants into the lung."

8. p. 47: "The lesson from the smoking example is that we cannot fully account for the effects of cigarette smoking on cancer risk simply by looking at the individual constituents...Children should be studied further. During our early years, the lungs are undergoing tremendous changes...The studies of children and their vicinity to freeways currently underway in California should be very enlightening." http://www.oehha.ca.gov/public_info/pdf/GasOEHHA.pdf

Endocrine Disruptor Compounds. Recently, mainstream media articles have highlighted increasing evidence that common hormone-mimicking chemicals, called endocrine disruptors, pose serious health threats to humans. In particular, experts warn that prenatal exposure could have enormous adverse effects, including serious genetic damage that can be transmitted to future

generations[8]. In a May 2, 2012 editorial in the New York Times, "How Chemicals Affect Us," Nicholas Kristof noted that "chemical disruptors are everywhere", and health experts are calling for bans on bisphenol-A (BPA) in food packaging. What Kristof neglected to mention was that PAHs are recognized on a par with BPA as one of the "two classic endocrine disruptors" according to a 2011 paper by Perera, et al. from Columbia Center for Children's Environmental Health.[9] Many experts believe that PAHs from gasoline exhaust are even more pervasive than BPA in our largest cities. Unfortunately, unless EPA acts to improve gasoline quality, urban exposure to PAHs is likely to increase, perhaps by orders of magnitude.

ULTRAFINE PARTICLES, PAHs, AND BC ARE INEXTRICABLY TIED TO GASOLINE COMPOSITION, AND THEIR EMISSIONS ARE EXPECTED TO INCREASE IN URBAN AREAS IF FUEL QUALITY IMPROVEMENTS DO NOT COMPLEMENT ADVANCED ENGINE DESIGNS.

While it is well documented that certain gasoline compounds are the primary source of UFPs, PAHs, and BC in urban areas, what has not been understood until recently is that advanced engine technologies needed to comply with the new carbon and fuel efficiency rules are likely to make these emissions worse unless fuel quality is improved. This is primarily due to the emission effects of spark ignition engines equipped with direct injection technology.

A recent Ford Motor study (Maricq, et al., *Aerosol Science and Technology*, 46:576-583, 2012)[10] noted that motor vehicles and air quality are undergoing major changes due to several emerging trends, one of which is "the growth of gasoline direct injection (GDI) engine technology, aimed to offer fuel economy and CO_2 emissions benefits." For all of its many benefits, however, Ford notes that GDI "risks incomplete fuel volatilization and impingement onto piston and cylinder surfaces, exacerbating particulate matter (PM) emissions…Consequently, it is important to examine the interplay and potential synergies between fuel composition and engine technology in efforts to reduce emissions." P. 576

"The present study of GDI vehicle exhaust PM reveals interesting features not typically associated with gasoline vehicles: (1) a high fraction of elemental carbon and (2) a correlation between particle mass and number emissions. Normally, gasoline vehicle PM is considered primarily organic in nature; for example, EPA's Kansas City Study reports that OC (organic carbon) accounts for about 80% of the particulate emissions…But this reasoning applies to port fuel injection, where the fuel is vaporized at the intake port. Direct injection provides less opportunity for fuel vaporization…and the resulting combustion of liquid fuel produces soot. HC precursors to organic PM, though, are removed by the three-way catalyst, leaving the tailpipe PM with a high EC/OC content." (p. 582)

The HONDA R & D, SAE International, 2010-01-2115, Aikawa, et al., 10/25/10 study, "Development of a Predictive Model for Gasoline Vehicle Particulate Matter Emissions," directly addresses the question of aromatics' role in particle emissions, and the need for fuel quality improvements in addition to vehicle hardware advances.

1. "The results indicated that aromatics with a higher boiling point and double bond equivalent (DBE) value tended to produce more emissions."

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[8] http://healthland.time.com/2012/04/17/exposure-to-air-pollution-in-pregnancy-may-boost-chances-of-obese-kids/
[9] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3171169/
[10] http://dx.doi.org/10.1080/02786826.2011.648780

2. "…it was concluded that worldwide PM emissions can be reduced not only through improvements in engine hardware, but also improvements in fuel quality." P. 1
3. "…recent studies report that a substantial amount of PM emissions are produced not only by diesel engines, but by gasoline engines as well. Given this situation, Europe has already begun considering the regulation of solid PN emissions from gasoline engines under EUR06. Similar efforts are underway by CARB regarding total PM mass limits for the upcoming LEV-III emission category." P. 1
4. "…PM is also associated with aromatic substances that are well-known sources of PM emissions…[all of the additional PN is considered a PAH (polycyclic aromatic hydrocarbon) with a high boiling point or soot. The higher the boiling point hydrocarbon added, the more the PN increases. This trend is particularly notable with aromatic substances."] Pp. 1-2
5. "Accordingly, PM emissions from gasoline engines can be significantly reduced by improving the quality of fuels sold around the world." P. 7
6. "Given their potential health risks to the human body as well as possible links to global warming, it is clear that PM in air must be reduced. To accomplish this, PM emitted from gasoline engines must be reduced without exception." P. 8
7. "…PM emissions will not decrease as long as the percentage of fuels that generate more PM emissions increases in the market. As a result, efforts are needed to not only improve engine hardware, but also to improve gasoline quality worldwide." P. 8

In 2011, Delta Powertrain experts raised particulate concerns with SIDI engines compared to diesel engines. [DELTA POWERTRAIN SYSTEMS, LUXEMBOURG, SAE International, 2011-01-1212, Piock, et al., 4/21/11: "Strategies Towards Meeting Future Particulate Matter Emission Requirements in Homogeneous Gasoline Direct Injection Engines".]

> "ABSTRACT: Since the introduction of the Euro 5 emission legislation particulate matter emissions are no longer only a concern in the development of Diesel engine powertrains. In addition to particulate mass (PM) requirements, the new European legislation will also foresee the implementation of a particulate number (PN) requirement for all spark ignition (SI) vehicles with the introduction of EURO 6…One of the major current gasoline engine trends is to downsize and boost in combination with direct gasoline injection…it becomes obvious that the discussed particulate number targets will be a significant challenge for gasoline engines with direct injection…while the particulate mass limits can be easily achieved."
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> "However, the number size distribution shows for homogenous gasoline engines compared to Diesel engines typically a higher number of particles at smaller sizes…The typically smaller particles generated by gasoline engines require a finer filter characteristics…which consistently leads to a…negative impact on performance, fuel consumption, and CO2 emissions."

Finally, Southwest Research Institute experts noted important differences between particle MASS vs. particle NUMBER regulatory approaches. [SOUTHWEST RESEARCH INSTITUTE, 2011 SAE International, Khalek and Bourger, "Particle Emissions from a 2009 Gasoline Direct Injection Engine Using Different Commercially Available Fuels"]. This study reports results from several fuels tested under the US FTP and US06 drive cycles, with comparisons made to both the CARB LEV III and Euro 6 particle mass and particle number limits.

> 1. "Substantial differences in particle mass and number emissions levels were observed among the different fuels tested. The more volatile gasoline fuel [lowest aromatics content fuel]...resulted in the lowest total...solid particle mass and number emissions."

2. "...modeling work...showed a good correlation between the decrease in fuel high boiling point aromatics and double-bond equivalent value and the decrease in soot emissions.
3. "Although the Euro 6 limit is based on the NEDC and not the FTP-75, this GDI engine met the Euro 6 PM mass emissions over the FTP-75 and failed the solid particle number limit by a factor of 3 to 10 with the different fuels."
4. "This work showed that gasoline fuel physical and chemical properties play an important role in reducing PM emissions from a GDI engine."
http://saefuel.saejournals.org/content/3/2/623.abstract

As noted elsewhere, entities like CARB, EPA, and the Health Effects Institute have also acknowledged that advanced engine designs are likely to increase emissions of fine particulates (especially UFPs) and BC.

COST EFFECTIVE AND TECHNOLOGICALLY AVAILABLE METHODS OF IMPROVING FUEL QUALITY ARE AVAILABLE.

UAI recognizes that in setting the PM NAAQS standards, EPA may not consider the costs. However, EPA did set forth some cost-benefit calculations in the RIA, see 38894 of the proposed rule. Based upon an extensive body of work that has been conducted by stakeholders ranging from automakers to refinery experts, UAI believes there are technologically available, market-based, and cost effective methods of improving fuel quality standards that would make major contributions to the goals outlined in this rulemaking.

One such method was outlined by Ford Motor researchers in the recent study by Maricq, et al., mentioned earlier. In "The Impact of Ethanol Fuel Blends on PM Emissions from a Light-Duty GDI Vehicle," Maricq and his colleagues reported that "When the ethanol content increases to >30%, there is a statistically significant 30 – 45% reduction in PM mass and number emissions observed for both engine calibrations…Engine-out hydrocarbon and NOx emissions exhibit 10 – 20% decreases, consistent with oxygenated fuel additives." The Ford study also found that EC/BC emissions fall by approximately 45% when high-octane E30+ blends are used in direct injection engines. These are substantial reductions, and some believe that EPA's goal of a 20% reduction in PM2.5 emissions could be largely achieved if a nationwide E30+ clean octane program were in place by 2025.

Some experts contend that cost effective reductions can be achieved with other alternative fuel formulations, including CNG in centrally fueled fleets. It is important for EPA to take the appropriate actions in this rulemaking to reduce ambient particulate matter, particularly in urban areas, by improving fuel quality. The marketplace will drive technological advances and innovation to meet the need for cleaner fuels to complement the advanced engine technologies being developed by auto manufacturers.

EPA HAS CLEAR STATUTORY AUTHORITY, AND SOME EXPERTS SAY THE LEGAL OBLIGATION, TO IMPROVE GASOLINE QUALITY STANDARDS.

On 38899 of the proposed rule, EPA states: "Federal programs provide for nationwide reductions in emissions of PM and other air pollutants through the Federal motor vehicle and motor vehicle fuel control program under Title II of the Act (CAA sections 202 to 250) which involves controls for emissions from mobile sources and controls for the fuels used by these sources."

Some have speculated about possible gray areas in EPA statutory authorities to regulate gasoline composition, particularly with regard to PM/PN reductions. It is widely known that Congress engaged in extensive colloquy in the House and Senate conference reports that clearly establish Congressional intent

as it relates to Section 202(l)(2) of the Act, dealing with air toxics standards. However, some have contended that EPA has done enough in reducing gasoline benzene levels to satisfy the language which requires that these "standards must reflect the greatest degree of emission reduction achievable through the application of technology which will be available," subject to various criteria.

A careful reading of the Act itself and the extensive colloquy surrounding the Title II provisions makes it clear that such a contention is unfounded. In its proposed GHG – CAFE rulemaking released on December 1, 2011, EPA discussed the health effects of non-GHG pollutants. Within the "Air Toxics" heading, at 75108, EPA recognized "Polycyclic Organic Matter" as an air toxic, and specifically cited the PAHs. The Agency noted: "In 1997 EPA classified seven PAHs…as Group B2, probable human carcinogens. Since that time, studies have found that maternal exposures to PAHs in a population of pregnant women were associated with several adverse birth outcomes, including low birth weight and reduced length at birth, as well as impaired cognitive development in preschool children…**EPA has not yet evaluated these studies." UAI thinks it is important to note that the studies EPA cites in the footnote to this statement were published 10 years ago, in 2002. UAI strongly believes that sufficient time has passed for EPA to have evaluated, and taken a position on, this pervasive and growing threat to the public health and welfare.**

Furthermore, EPA's February 26, 2007 MSAT ruling reveals that it has even broader authority at its disposal. In Fed Reg. Vol. 72, No. 37, p. 8432, EPA states: "Section 211(c)(1)(A) of the Clean Air Act authorizes EPA (among other things) to *control the manufacture of fuel if any emission product of such fuel causes or contributes to air pollution which may reasonably be anticipated to endanger public health or welfare."* (Emphasis supplied)

Later on in that same rulemaking, p. 8440, EPA states: "Another issue related to gasoline PM is the effect of gasoline vehicles and engines on ambient PM, especially secondary PM. Ambient PM is composed of primary PM emitted directly into the atmosphere and secondary PM that is formed from chemical reactions in the atmosphere. **The issue of secondary organic aerosol formation from aromatic precursors such as toluene is an important one to which EPA and others are paying significant attention."** (Emphasis supplied)

UAI firmly believes that a sufficient body of scientific evidence exists to prove without a doubt that it may "reasonably be anticipated" that EPA's failure to improve gasoline composition by reducing precursors of particle-borne PAHQs and other toxics "endangers public health and welfare." It is clear that EPA has clear statutory authority—and a Congressional directive—to regulate the composition of gasoline in order to reduce the threat of the particle-borne toxics which it causes.

CONCLUSION. UAI believes that the scientific evidence is overwhelming. EPA has clear authority, and must act. The health burdens posed by particle-borne PAHQs are well established, cost the nation tens of billions of dollars per year, and can be substantially reduced in the near- to mid-term if appropriate actions to improve gasoline quality standards are taken. Urban PM2.5, UFP, PAHQ, and BC emissions are predominantly caused by mobile sources, and gasoline's contribution far outweighs that of diesel. EPA's proposal to reduce ambient PM by 20% can be substantially achieved in a technologically available, cost-effective, and market-based manner by EPA ensuring that gasoline quality standards are upgraded to complement advanced engine technologies. Multiple benefits would accrue, including substantially reduced carbon emissions, health costs, and petroleum use. Consumers would benefit from cost-effective fuels that promote enhanced vehicle performance, as automakers can take full advantage of higher octane, cleaner burning fuels with more efficient, advanced technology engine designs.

GLOSSARY FOR URBAN AIR INITIATIVE PM2.5 RULE COMMENTS

THE RELATIONSHIP BETWEEN GASOLINE AROMATICS, POLYCYCLIC AROMATIC HYDROCARBONS (PAHs), ULTRAFINE PARTICULATES (UFPs), AND BLACK CARBON (BC) PARTICLES

Black Carbon (BC): The elemental carbonaceous component of particulate matter that is formed through incomplete combustion of organic substances. BC is the most strongly light-absorbing component of PM2.5, and thus has important climate effects. It has a Global Warming Potential of 680 on a 100 year basis (Sierra Nevada Research Institute, 2010). It has been called the second greatest greenhouse gas pollutant, exceeding that of methane. This, along with its short lifetime of a few hours to a few days, makes fossil fuel BC control one of the quickest and most effective ways of slowing global warming. Fossil fuel BC has low OC to elemental carbon ratio, producing an overall warming effect, whereas biomass BC has high OC to EC ratio, with the potential of neutralizing the warming effect of the EC. In addition to its adverse climate impacts, due to the porosity of BC particles and their large surface area, BC can adsorb a variety of chemicals that are present in combustion exhaust, including polycyclic aromatic hydrocarbons (PAHs), which are carcinogenic or mutagenic.

Elemental Carbon (EC): Often used interchangeably with BC. However, whereas BC is the result of incomplete combustion in anoxic environments, EC is carbon fractions measured after oxidative combustion in the presence of oxygen above a certain temperature threshold. EC accounts for approximately 70% of the PM mass emissions from gasoline–powered LDVs (CARB, P-123).

Endocrine Disruptor Compounds: Chemicals that interfere with endocrine (or hormone system) in animals, including humans. These disruptions can cause cancerous tumors, birth defects, and other developmental disorders. Specifically, they are known to cause learning disabilities, severe attention deficit disorder, cognitive and brain development problems, deformations of the body (including limbs); sexual development problems, feminizing of males or masculine effects on females, etc. Any system in the body controlled by hormones can be derailed by hormone disruptors. The critical period of development for most organisms is between the transition from a fertilized egg into a fully formed infant. Experts have identified PAHs and BPAs as the "two classic endocrine disruptors."

PM2.5: Particles with a nominal mean aerodynamic diameter of less than or equal to 2.5 micrometers (µm). While this definition technically covers the most pathogenic sub-group of PM (UFPs, defined as .1µm = 100 nanometers or less), EPA has not established a separate regulatory category for UFPs, as has Europe. Since gasoline exhaust particles are typically smaller than diesel, frequently in the 20 - 100 nanometers range, EPA's regulatory approach fails to account for the considerable health and climate costs that are imposed by UFPs and the highly toxic PAHQs which coat them (see **Ultrafine Particles** definition below).

Polycyclic Aromatic Hydrocarbons (PAHs): Semi-volatile organic compounds (SVOCs) that exist in both gas and particle phases. PAHs are a group of over 100 different compounds that have two or more fused aromatic rings, and are a byproduct of incomplete combustion of gasoline and diesel fuels. Some PAHs, such as benzo[a]pyrene, found in gasoline exhaust and cigarette smoke, are carcinogenic, mutagenic, and genotoxic. PAHs are also endocrine disruptor compounds (EDCs), which mimic the body's natural hormones, and have been linked to a variety of adverse medical conditions. Contrary to conventional wisdom that PAHs originate mainly from diesel exhaust, light-duty vehicles are the main source of PAHs in many urban areas, where gasoline-powered engines predominate. High molecular weight PAHs have high affinity to BC.

Quinones: Oxidative derivatives of aromatics, and polar organic compounds that can act as catalysts to produce reactive oxygen species (ROS) directly, whereas PAHs induce oxidative stress indirectly, through biotransformation to generate redox active quinones. PAHQs "hitchhike" on fine and ultrafine particles, which enable them to penetrate deeply into humans' lungs, bloodstream, and organs.

Secondary Inorganic Aerosols (SIAs): Sulfates, nitrate, and ammonium, generally from stationary sources, the formation of which are widely understood compared to the SOAs. SIAs are formed by the oxidation of gas-phase precursors such as sulfur dioxide, nitric oxide, and nitrogen oxides.

Secondary Organic Aerosols (SOAs): Formed by photo oxidation of gas phase volatile organic compounds (VOCs) in the atmosphere. Approximately 50% of anthropogenic VOCs are emitted by combustion sources. Generally, SOA-forming VOCs have more than six carbon atoms, since the oxidation products of organic compounds with lower carbon numbers are too volatile to condense under ambient temperature conditions. Conventional models significantly understate the amount of SOAs in the atmosphere. Generally, SOA are formed by the oxidation of high molecular weight volatile organic compounds to produce low-volatility products, which subsequently condense onto the existing aerosols.

Semi-Volatile Organic Compounds (SVOCs): Organic compounds that volatilize slowly at standard temperature (20º C and 1 atmosphere). PAHs are SVOCs that exist in both gas and particle phases. A large fraction of primary aerosols generated by combustion includes SVOCs. The semi-volatile fraction of the PM can account for 10 – 30% of the PM mass, and 70 – 90% of PN (CARB, P-70).

Ultrafine Particles (UFPs): Largely organic primary combustion products, including particles with a mobility diameter of less than or equal to 0.1µm, emitted directly to the atmosphere or formed by nucleation of gaseous constituents in the atmosphere. Compared to PM2.5, UFPs are more lethal and pathogenic, due to their smaller size and larger particle numbers; their greater bioavailability and lung retention; and their greater content of redox active compounds (inducing oxidative stress). UFPs contain much higher mass fractions of PAHQs than other particles. CARB reports that 2.5×10^{12} SPN (solid particle numbers) are equivalent to 1 mg/m^3 (milligram per cubic meter) of EC/BC, and that a total SPN limit of 7.5×10^{12} particles per mile corresponds to a PM mass limit of 3 mg/mile. UFP/SPN emissions vary linearly with EC emissions (CARB, P-128).