

Interactive comment on “Effect of organic compounds on nanoparticle formation in diluted diesel exhaust” by U. Mathis et al.

U. Mathis et al.

Received and published: 26 January 2004

We thank the reviewer for his comments.

Comment: Firstly, the authors use a primary dilution ratio of around 8:1. Kittelson has made the point on many occasions that whilst such a ratio is commonly used in engine test bed dilution tunnel work, it grossly underestimates the dilution which occurs during operation of a vehicle and emission to the atmospheric where dilution ratios of around 1000 would be more appropriate.

Response: Large variation in atmospheric dilution depending on driving and ambient conditions is observed while our dilution offers the possibility of a very controlled and stable dilution process. We are convinced that our two stage dilution unit provides a good simulation of exhaust dilution found under atmospheric conditions. We diluted the exhaust with a primary porous tube diluter (dilution ratio of 8) that facilitated a

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fast dilution within a time period of around 20 ms. Downstream of the primary diluter, a residence chamber was inserted to offer 2.5 +/- 0.15 s for the relevant nucleation compounds to nucleate. The nucleation process was quenched by the second diluter (dilution ratio of 10). Therefore, the exhaust was diluted with a total dilution ratio of 80, which is sufficient to detect a stable particle number size distribution. Our dilution ratios for the primary dilution (PDR) and the secondary dilution (SDR) are in line with a selection of similar studies conducted in this field:

Abdul-Khalek et al. (1999): PDR 12 to 40 / SDR 28

Maricq et al. (1999): PDR 10 to 32 / SDR 1 or 8

Tobias et al. (2001): PDR 16 / SDR 4

Kytö et al. (2002): PDR 6 to 47 / SDR 7.5

Sakurai et al. (2003b): PDR 14 or 20 / SDR 27

Comment: Secondly, recent published and unpublished studies indicate that the compounds most responsible for formation of the nanoparticle mode are medium molecular weight hydrocarbons derived from lubricating oil. In this study, however, relatively low molecular weight compounds have been used which, if present would originate from the fuel rather than from the lubricating oil.

Response: We chose compounds of high volatility to prevent losses by condensation on the sampling system. We are aware that less volatile organic compounds are more likely to be involved in the nucleation process under atmospheric conditions. Sakurai et al. (2003b) reported that organic compounds from diesel nanoparticle were comprised of medium molecular weight with carbon numbers in the range from C24 to C32 for aliphatic hydrocarbons. However, our primary objective of this laboratory study was to identify the functional groups that are involved in the nucleation process. Therefore, the volatility of the organic compounds only played a secondary role for the interpretation of our data.

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Comment: A further weakness is the use of a diesel fuel with a sulfur content of 323 PPM which is out of line with current concentrations of sulfur in automotive diesel fuel in western Europe.

Response: The current limit value for sulfur in diesel fuel is still 350 ppm in the European Union and Switzerland. We agree that the fuel sulfur content has been reduced in the last years since the future limit value will be 50 ppm (year 2005) and an industry obligation for 10 ppm. The sulfur content in diesel fuel has an important effect on the concentration of volatile particles, but the fundamental formation mechanism is most likely uninfluenced. Because our objective was to gain a better qualitative understanding of functional groups involved in nucleation, the fuel sulfur content was of minor relevance. The main advantage of using a diesel fuel with high sulfur content was the stable and repeatable formation of volatile nanoparticles, which was the prerequisite for our investigation. In many studies a high fuel sulfur content was used to investigate volatile nanoparticles emitted from diesel engines:

Abdul-Khalek et al. (1999): 400 ppm and 10 ppm

Shi and Harrison (1999), Shi et al. (2000): 427 ppm

Khalek et al. (2000): 400 ppm and 19 ppm

Tobias et al. (2001): 410 ppm

Kwon et al. (2003): 310 ppm

Sakurai et al. (2003a): 96 ppm and 360 ppm

Lyyräinen et al. (2004): 433 ppm

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