LINKING CNG VEHICLE EMISSIONS TO CELLULAR RESPONSES: PARTICLE CHARACTERISTICS AND TOXICOLOGICAL INSIGHTS

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INTRODUCTION

Compressed natural gas (CNG) is used worldwide as an alternative to gasoline and diesel, due to its lower CO2 emissions but also in order to reduce particle emissions, that constitute a significant factor in urban air quality degradation (Fan *et al*., 2018). Comparative studies among fuels have shown that vehicles running on CNG have competitive emission levels for regulated pollutants, even when vehicles with the other technologies are equipped with state-of-the-art exhaust after-treatment systems (Kontses *et al*., 2020; Rašić *et al.*, 2017). More precisely, concerning regulated particle emissions, CNG vehicles demonstrate comparable emission levels to those of diesel vehicles equipped with diesel particulate filters (DPF). However, studies regarding size distribution revealed that the mean geometric diameter of CNG particles is much smaller than that of the other fuels. Therefore, when particles with size smaller than the legal limit of 23 nm were measured, CNGs show significantly higher emissions (Toumasatos *et al*., 2021). At the same time, it is estimated that particles with sizes of 10-40 nm particles are deposited more efficiently in the alveolar region (Geiser *et al*., 2010), causing health complications (Leikauf *et al*., 2020). The present study aims at scrutinizing the nature and toxicity of a CNG passenger car particle exhaust emission, under various driving conditions.

METHODS

A CNG vehicle was tested on the chassis dyno under different driving conditions including mild or dynamic driving cycle, and hot or cold engine start. The number of solid and volatile particles was recorded at various cut-off sizes along with their size distribution. During the driving cycles, human epithelial A549 cells were exposed to diluted exhaust gases using an Air Liquid Interface (ALI) system. The effect of particles on cell viability was evaluated, since in the ALI set-up the cells are exposed to filtered and unfiltered exhaust gases.

RESULTS

Although reducing the cutoff size from 23 nm to 10 nm does not show a notable increase in solid particle concentration, the measurement of volatile particles shows a substantial rise of emission levels, ranging from one to two orders of magnitude. It should be noted that the cellular exposures encompassed the total of volatile and solid particles.

As far as toxic cellular effects were concerned, cell viability diminished consistently across all cases (filtered and unfiltered samples), with a more significant reduction observed during exposures initiated with a cold start. Simultaneously, the LDH release from exposed cells test confirmed the presence of cell death in these cell cultures.

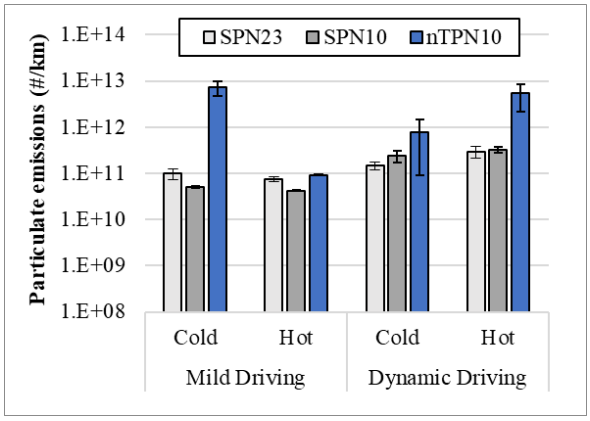

Figure 1 Particle emission levels

CONCLUSIONS

The evaluation of passenger vehicle CNG emissions revealed a significant decrease in cell viability, particularly evident during cold cycles, compared unexposed cell culture. In addition, the inclusion of volatile particles in the calculation of the emission resulted in a noteworthy surge, highlighting the distinctive nature of CNG particles. These findings underline the importance of examining both particle size characteristics and exposure conditions for a comprehensive understanding of potential adverse effects on cellular health.

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