MEASUREMENT OF AEROSOL FROM EXHAUST EMISSION OF MOTOR VEHICLES USING PHOTOACOUSTIC SPECTROSCOPY

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Abstract

There is an international concern about the adverse health effects of motor vehicles generated air pollutants in many towns and cities. To investigate the importance and effects of exhaust emissions from both diesel and gasoline motor vehicles to the human population, it is required to effectively measure the aerosol levels emitted into the atmosphere. This work aimed to measure emitted exhaust gases from diesel and gasoline light duty vehicles during controlled laboratory experiments using photoacoustic spectroscopy (*PAS*) method and a commercially available soot sensor (Opacimeter) as a control set up. Diesel and gasoline light duty vehicles were tested with altering engine speed without load (without dynamometer brake). From the experiments it was established that the response of the PAS system in aerosol measurements agreed well with the well-established and commercially available Opacimeter.

Introduction

Aerosol emission from anthropogenic sources e.g. automotive industry has become an environmental concern on both global and regional scales, mostly because of the emitted chemicals harmful to both animals and humans [1]. Of major interest are the gaseous pollutants present in the vehicles exhaust emissions whose measurement has previously been done using several documented methods which largely depended on the sampling technique and instrument used [2]. Hence there is need to use instruments with great sensitivity that are capable of real time measurement e.g. Photoacoustic Spectroscopy (PAS). PAS is the measurement of the effect of absorbed light on matter (gas, liquid and solid) by means of acoustic detection and has been labelled as highly sensitive and selective method under laboratory and field conditions. Absorption of amplitude-modulated light periodically heats light-absorbing particles in the sample aerosol. Conduction of this heat to the surrounding gas generates pressure waves (acoustic), which are recorded by a microphone. Therefore, the microphone signal is proportional to the volume concentration of the measured aerosol [3].

Experimental

In the experimental set up, two test vehicles were used: Volvo (diesel engine) and Skoda (gasoline engine). Measuring instrumentation was attached to the exhaust pipe of each vehicle using PTFE pipes as shown in Fig. 1. The inlets of the two instruments were placed as close as possible to each other and to the exhaust end to ensure homogeneity in sampling time and points. Gaseous aerosol from the exhausts was then sampled using both PAS and Opacimeter in a time scale of 20 to 40 minutes each. For the PAS, a diode laser at an emission wavelength of 1064 nm was carefully chosen to be the light source. Measurement was then done under altering engine speed without load (without dynamometer brake). The signal generated was then recorded and analysed using electronics (manufactured by Videoton Holding Zrt.), which was connected to a computer.

Figure 1: Picture showing connection of the pipes to the car exhaust

Results and discussion

The longitudinal chamber used was first calibrated and tested with reference to the Soot sensor (opacimeter) and the results are as shown below.

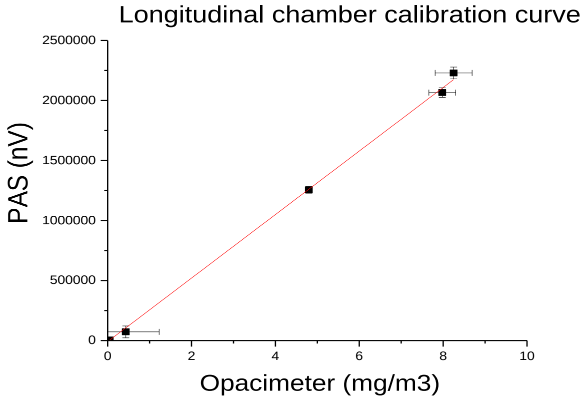

Figure 2: Calibration results

The two instruments were then operated simultaneously. Figure 3. shows the recorded photoacoustic signal and the aerosol concentration measured by the opacimeter.

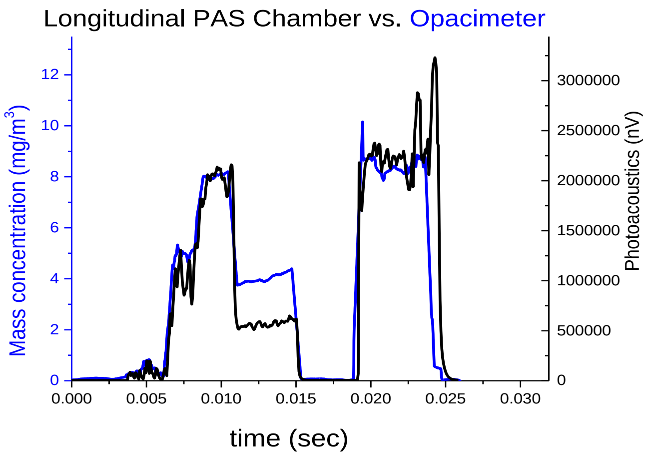

Figure 3: Performance comparison between PAS and the commercial Opacimeter

The Pearson's correlation coefficient between PAS (longitudinal chamber) and the commercial Opacimeter was also calculated and found to be 0.95845. This shows that the two equipment have a positive linear dependence i.e., an increase in one corresponds to an increase in the other.

Conclusion

It has been demonstrated that PAS of laser wavelength 1064 nm, can be used to quantitatively measure the concentration of gaseous aerosol emission in both diesel and gasoline vehicle exhaust. From the experiments it was established that the response of the PAS system in aerosol measurements agreed well with the well-established and commercially available

Opacimeter. The signal delay observed in the results was mainly due to the use of different pipe lengths and flow rates during aerosol sampling.

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