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ONLINE MEASUREMENT OF VOCs EMISSIONS FROM VEHICLES USING A PORTABLE SAMPLING SYSTEM

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ABSTRACT

We investigated the relation of vehicular speed with VOCs concentration in exhaust gas, amount of VOCs emission and VOCs emission factor. Exhaust gas samplings were carried out by directly captured exhaust gas in muffler connected to a constant volume sampling pump. The experimental results revealed that the emission factor was relatively higher than Environmental Ministry, because old vehicles emitted higher VOCs concentration in exhaust gas than new vehicles.

KEYWORDS

Emission factor, Exhaust gas, VOCs

INTRODUCTION

Air pollutions of suspended particulate matter (SPM) and photochemical oxidant are still serious in Japan. Even now an impact of SPM on human health is apprehended and the health damage of photochemical oxidant is obvious, so we imperiously have to solve these matters. SPM and photochemical oxidant pollutions are induced by various factors and volatile organic compounds (VOCs) are the important precursor substances. VOCs are emitted from immobile sources such as factories and from mobile sources such as vehicle.

In this study we directly sampled the exhaust gas of the moving vehicles, determined the concentration of VOCs, and revealed the relation vehicular speed with VOCs concentration in exhaust gas, amount of VOCs emission and VOCs emission factor. The VOCs analyzed were Benzene, Toluene, Ethylbenzene, and o,m,p-Xylene.

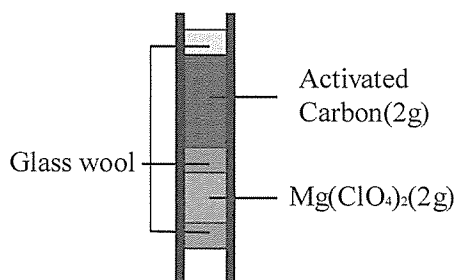


Fig.1 The schematic sampling tube

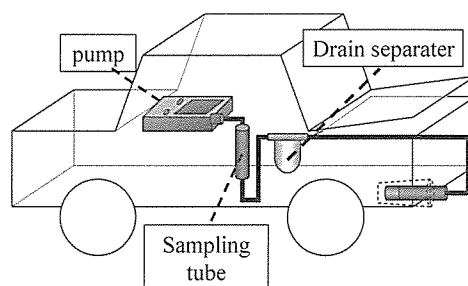


Fig.2 The experimental overview

EXPERIMENTAL METHODS

Exhaust gas samplings were carried out by directly captured exhaust gas in muffler connected to a constant volume sampling pump, and VOCs in exhaust gas were adsorbed by activated carbon into a sampling tube as shown in Fig.1. The diameter of activated carbon ranges from 0.485 mm to 0.847 mm and the weight of activated carbon is 2g. Magnesium perchlorate ($Mg(ClO_4)_2$) was used in order to absorb water. Fig.2 shows the experimental overview. Water in exhaust gas was removed by passing through the drain separator, thus exhaust gas, hardly contained water, was adsorbed by

activated carbon. The pump was controlled in accordance with a stop and a run of vehicles. After sampling, the activated carbon was dissolved in carbon bisulfide (CS₂) and mixed by magnetic stirrer. After that, VOCs in the solvent were analyzed by GC/MS. VOCs concentration in exhaust gas, amount of VOCs emission and VOCs emission factor were calculated using the following formula.

$$C = cdv/qt \quad (1)$$

$$Q = CV\Omega t \quad (2)$$

$$EF = Q/L \quad (3)$$

where C ($\mu\text{g/L}$) is VOCs concentration in exhaust gas, c (ppm) is VOCs concentration in solvent, d (g/cm^3) is VOCs density, v (mL) is the volume of solvent, q (L/min) is the flow rate, t (min) is the sampling time, Q (μg) is the amount of VOCs, V (L/r) is the engine displacement, Ω (r/min) is the revolution, EF ($\mu\text{g/km}$) is the emission factor, and L (km) is the travel distance. The target VOCs were benzene, toluene, methylbenzene, and o,m,p-xylene.

After a vehicle was driven at 50km/h speed for over 10 minutes, the experiments were performed in the three constant speeds of 20km/h, 40km/h, and 60km/h and in idling (0km/h). The sampling flow rate was 4 mL/min, and the sampling time was 10 minutes. Six different vehicles were used as shown in Table 1.

Table1 Speciation of test vehicle

	Vehicle A	Vehicle B	Vehicle C	Vehicle D	Vehicle E	Vehicle F
Automakers	Suzuki	Toyota	Nissan	Mazuda	Mazuda	Honda
Engine displacement (ℓ)	0.65	0.99	1.76	1.8	2.3	2.25
Weight (kg)	990	1165	1460	1500	1665	1725
Total distance(km)	83000	11200	130000	50000	61038	141000
Age(year)	1999	2002	2001	2003	2003	1998
Gasoline	Regular	Regular	Regular	Regular	Premium	premium

RESULT AND DISCUSSIONS

Relation of vehicle speed with the amount of VOCs emission

The relation of the VOCs concentration in exhaust gas with vehicle speed in vehicle A and vehicle C is shown in Fig.3 and Fig.4. The VOCs concentration in exhaust gas decreased as the vehicle speed increased. The results in other four vehicles were the almost same. The concentrations at idling in vehicle A were the highest but the concentrations at the constant speed of 20km/h in vehicle C were the highest. The relation of the amount of VOCs emission with vehicle speed in vehicle A and vehicle C is shown in fig.5 and fig.6. The amount of VOCs emission decreased as the vehicle speed increased. The amount in a few vehicles was the lowest at the constant speed of 40km/h as shown in Fig.5, the amount in other vehicles was the lowest at the constant speed of 60km/h as shown in Fig.6. The relation of the emission factor with vehicle speed in vehicle A and vehicle C is shown in fig.7 and fig.8. The emission factor decreased as the vehicle speed increased. The emission factor was considerably different between 20km/h and 40km/h, but was the almost same between 40km/h and 60km/h.

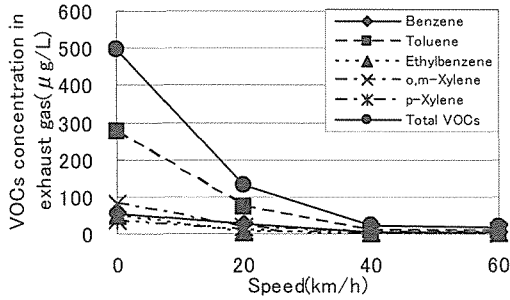


Fig.3 VOCs concentration in vehicle A

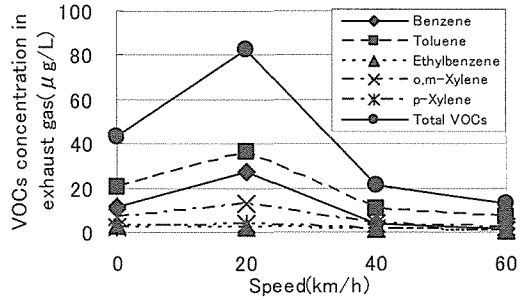


Fig.4 VOCs concentration in vehicle C

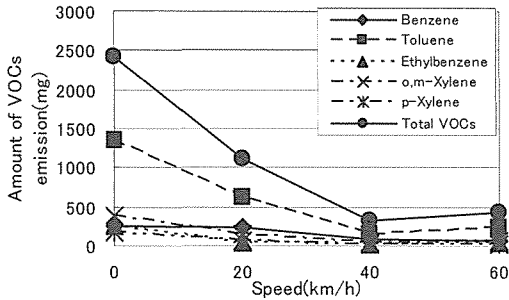


Fig.5 Amount of VOCs emission in vehicle A

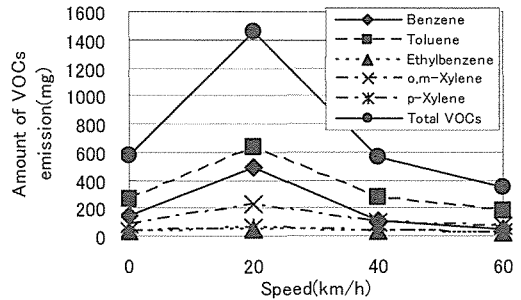


Fig.6 Amount of VOCs emission in vehicle C

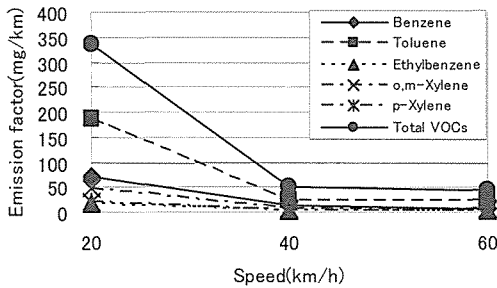


Fig.7 VOCs emission factor in vehicle A

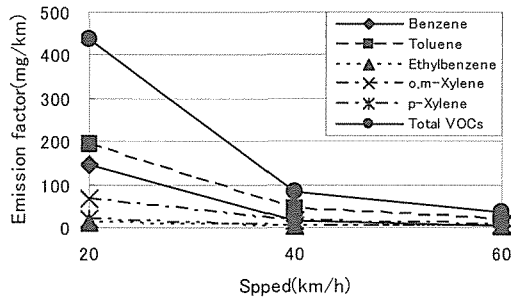


Fig.8 VOCs emission factor in vehicle C

Relation of VOCs emission with vehicle age

The relation of the amount of VOCs emission with the vehicle age at idling is shown in fig.9. The amount of VOCs emission was considerably different by the vehicle age. The amount of VOCs emission in old vehicles was five times higher than new one.

Comparison of emission factor at Environment Ministry

The VOCs emission factor obtained from our experiment and from Environment Ministry is shown in fig.10. The emission factors in vehicle A, B and C were extremely higher than Environment Ministry. The emission factors in vehicle D, E and F were the almost same order as Environment Ministry. These results suggested that the emission factor in Environment Ministry must be improved.

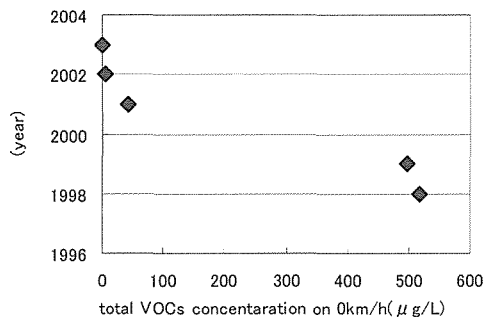


Fig.9 Relation of VOCs concentration with vehicle age

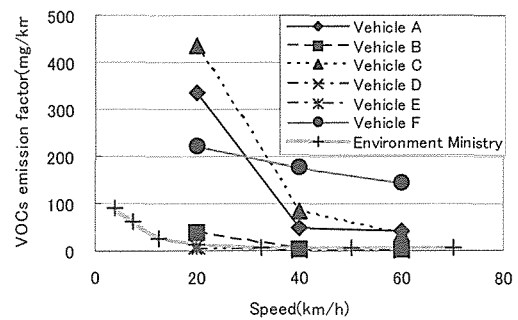


Fig.10 Emission factor of the experiments and Environment Ministry

CONCLUSIONS

VOCs concentration in exhaust gas, amount of VOCs emission and VOCs emission factor decreased with the increase of vehicular speed. The emission factor difference between 40km/h and 20km/h was greater than that between 60km/h and 40km/h. The number of vehicles was limited in this study, so it is necessary to obtain more accurate result by increasing sample vehicles. This study revealed the relation of the amount of VOCs emission with the vehicle age. It is required to get more accurate data by increasing the sample flow rate to increase VOCs adsorbed for new vehicles whose VOCs concentration was lower.