Chemical composition and sources of particles emitted from recent LPG passenger cars

Akihiro Fushimi[1], Katsumi Saitoh[1,2], Yoshinori Kondo[1], Yuji Fujitani[1], Tadao Goto[3], Shuji Hayami[3], Shinji Kobayashi[1], Kiyoshi Tanabe[1] and Koichiro Sera[4]

[1]National Institute for Environmental Studies
16-2 Onogawa, Tsukuba 305-8506, Japan

[2]Environmental Science Analysis & Research Laboratory
1-500-82 Matsuo-yosegi, Hachimantai, Iwate 028-7302, Japan

[3]LPG Vehicle Promoting Association in Japan
2-16-1-522 Shinbashi, Minato-ku, Tokyo 105-0004, Japan

[4]Cyclotron Research Center, Iwate Medical University
348-58 Tomegamori, Takizawa, Iwate 020-0603, Japan

Abstract

Liquefied petroleum gas (LPG) vehicle is the third largest vehicle type in mileage after gasoline and diesel vehicles, however, emission factor of particles and their characteristics have rarely been investigated. We examined the emission factors and sources of fine particles emitted from recent LPG passenger cars. Fine particles emitted from two recent LPG passenger port injection cars (a liquid-injection type and a gas-injection type) were collected and particulate mass and chemical components (elemental and organic carbons, elements, ions, and organic compounds) were measured. For comparison, gasoline port injection (GPI) cars equipped with engines same as LPG vehicles, and a diesel car equipped with diesel particulate filter and oxidation catalyst were also tested. Particulate mass emission factors of the recent LPG passenger cars were one fifth or smaller than the emissions from gasoline direct injection (GDI) passenger cars, and were equal to or smaller than those of the GPI cars equipped with same types of engines. Particulate mass emission factors of the liquid-injection LPG vehicle were larger than the gas-injection LPG car. The proportions of elemental carbon in the LPG exhaust particles were very small (≈10%) and organic carbon was the primary components. The oil contributions to the particulate phase elements estimated from Ca and Zn were 35±39% for the gas-injection LPG vehicle and 55±9% for the liquid-injection LPG vehicle. For the liquid-injection LPG exhaust particles, organic components in the rage of $C_{27–37}$, those are less volatile than general diesel and GDI exhaust particles, were dominant. Chromatogram pattern analysis suggested that 70–80% of the organic components of the liquid-injection LPG exhaust particles consisted of unburned oil, and the contribution of fuel was small. We therefore suggested that the most important source to the liquid-injection LPG exhaust particles is engine oil.