

Determination of tire and road wear particles (TRWPs) in Particulate Matter by Pyrolysis-Gas Chromatography Mass Spectrometry (Py-GC/MS)

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ABSTRACT

Traffic emissions are classified into tailpipe emissions and non-tailpipe emissions. Over the years, tailpipe emissions, which originate from fuel combustion and volatilization, have been thoroughly researched. Additionally, stringent regulations for combustion emissions from mobile sources, improved air pollution control technology, and the adoption of electric vehicles have significantly reduced tailpipe emissions, especially in metropolitan areas. On the other hand, non-tailpipe emissions, including tire and road wear particles (TRWPs), which make up about 10% of total suspended particulates (TSPs), have received little attention. Among them, microplastics (MPs), formed by the abrasion of the polymer materials, pose a direct threat to respiratory health. Their concentrations in ambient air are continuously increasing.

Vehicle tires contain 40-50% polymer material, 30-35% filler, 15% softener, 2-5% vulcanizer, and 5-10% additives. The polymer material is mainly in the form of natural rubber (NR), synthetic isoprene rubber, butadiene rubber (BR), and styrene-butadiene rubber (butadiene rubber, SBR).. During pyrolysis, NR, BR, and SBR form two unique dimer compounds as the pyrolysis products: 4-vinyl cyclohexene (butadiene, 4-vinyl cyclohexene, 4-VCH) and isoprene dimer (isoprene dimer, dipentene, DP). These two markers are applied in the laboratory to quantify the proportion of MPs in tire and road wear particles. The research center has developed a laboratory method which uses pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) to investigate the polymer compositions in TRWPs. In the method development, tire rubber powder produced by recycling tires is mixed with diatomaceous earth as a quantitative reference standard. After successfully implementing the detection and quantification procedures, the concentration of MPs in TSP and PM₁₀ were investigated.

Keywords: Particulate matter; tire and road wear particles; pyrolysis; microplastics.