Pyrolysis-GC-MS as a versatile tool for environmental and multidisciplinary applications

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Pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) is a powerful thermo-analytical technique widely applied in both research and industry. Its use in environmental sciences has remarkably expanded in recent years, especially for the identification and quantification of micro- and nanoplastics, and to detect polymer additives in complex matrices including sediment, soil, and wastewater. Another major application of this technique is the analysis and quantification of tire and road wear particles. During pyrolysis, synthetic and natural rubbers release characteristic degradation products, which serve as markers to trace degradation processes and evaluate the contribution of tire wear particles to particulate pollution. Outside environmental applications, Py-GC-MS plays a central role in materials science where it is applied to the characterization of resins, composites, and coatings, and in forensics for the detection and identification of explosives, adhesives, paints and fibers. Furthermore, Py-GC-MS is widely used in cultural heritage studies enabling the analysis of the composition of ancient paints and binders. The cross-disciplinary applicability of this technique derives from its minimal requirements for sample preparation, its suitability for both natural and synthetic materials, and the detailed molecular information gained by the GC separation coupled with MS detection. This broad spectrum of applications highlights the central role of Py-GC-MS as a highly adaptable method for qualitative and quantitative analysis not only in environmental monitoring but also across multiple disciplines.