Fate of musk compound (Galaxolide, HHCB) in the aquatic environment by using compound-specific isotope analysis (CSIA): Insight from photodegradation and microbial processes

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Résumé

Understanding the isotopic fingerprints of organic pollutants is crucial to assess their fate in the environment. This knowledge allows us to track their origin and investigate the processes involved in their transformation. The increasing use of fragrances in household and cosmetic products without specifying whether they are natural or synthetic, significantly impacts the aquatic environment. Galaxolide (HHCB) is the most frequently used synthetic musk compound worldwide. It is listed as a high production volume of chemicals by OECD. However, despite its widespread use and its potential life-threatening effects, a comprehensive understanding of the environmental reactivity of HHCB in aquatic ecosystems remains a challenge. This study aims to evaluate how potential abiotic (photodegradation), and biotic (biodegradation) processes may impact the isotopic composition of HHCB and provide insights into its environmental fate using compound-specific isotope analysis (CSIA). Photodegradation experiments were carried out to investigate direct and indirect photolysis under natural (solar irradiation) and treatment process (UVC irradiation) in ultra-pure, riverine and Wastewater Treatment Plants (WWTPs) effluent including nitrate (NO3-), carbonate (CO32-), humic acid associated with different experimental conditions, and hydrogen peroxide (H2O2) in relation to the treatment process. Pure bacterial strain was cultivated to test HHCB microbial degradation. Concentrations and carbon isotopic signatures were determined by GC-MS and GC-C-IRMS, respectively. The results clearly indicated the effectiveness of direct photolysis in degradation of HHCB under both light conditions. The presence of H2O2 led to the most effective degradation of HHCB, primarily due to the high production of hydroxyl radicals induced by UVC. Up to 90% of the HHCB depletion was driven by a bacterial strain which belongs to genus Bacillus sp. Despite achieving a high level of degradation for HHCB for both abiotic and biotic processes, our study showed limited isotopic fractionation resulting from either photodegradation or biodegradation processes. This

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suggests that the isotopic composition of HHCB remains relatively stable during these environmental degradation processes. Based on this finding, the isotopic composition of HHCB can be used to directly trace the sources of galaxolide from environmental or commercial samples using CSIA.

Mots-Clés: Carbon isotope, isotopic fingerprints, degradation, organic compounds, musks, synthetic fragrances