Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.27631

Heterogeneous Atmospheric Reactivity of Viticultural Pesticides: Implications for Long-Range Transport and Regulatory Assessments

MR. BOULOS SAMIA[1], SYLVAIN MARQUE[2], AMANDINE DURAND[1], BRICE TEMIME ROUSSEL[1], SYLVAIN RAVIER[1], ETIENNE QUIVET[1] AND HENRI WORTHAM[1]

[1]Aix Marseille Univ, CNRS, LCE
[2]Aix Marseille Univ, CNRS, ICR

Current-use pesticides (CUPs) are extensively applied in agriculture, yet a significant fraction enters the atmosphere through different processes. Due to their semi-volatile nature, these compounds partition between the gas and particulate phases, influencing their persistence and potential for long-range atmospheric transport. However, European regulations estimate atmospheric lifetimes solely based on gas-phase reactivity with OH radicals, neglecting that degradation on particles can be up to 100 times slower [1]. This underestimation may lead to an inaccurate assessment of their environmental impact, particularly in remote ecosystems.

This study aims to (i) determine the particle-adsorbed half-lives of nine CUPs commonly used in viticulture, (ii) identify their degradation products, including potentially more toxic derivatives, and (iii) investigate the effects of temperature and humidity on their gas-particle partitioning.

A mixture of Boscalid, Cypermethrin, Cyprodinil, Deltamethrin, Folpet, Pendimethalin, Spiroxamine, Tebuconazole, and Trifloxystrobin was adsorbed onto model atmospheric particles and exposed to Ozone and OH radicals using a flow reactor. Our results revealed a wide range of half-lives, from three days (Cyprodinil) to over one month (Folpet), surpassing the persistence threshold of two days, classifying them as persistent organic pollutants.

Using LC-Orbitrap-MS/MS and GC-MS, we identified degradation products that remained adsorbed on particles, while SRI-ToF-MS enabled the detection of volatile degradation products in the gas phase. Additionally, our mechanistic study identified several unknown and non-commercially available molecules, emphasizing the need for further toxicity assessments. Some of our transformation products were also reported in surface water, soil, plants, and biota, suggesting common degradation pathways across environmental compartments.

Lastly, we examined the influence of temperature and humidity on the gas-particle partitioning of semi-volatile CUPs to refine partitioning models due to significant discrepancies found in model predictions, including the widely used Junge-Pankow model, which often fails to align with field observations [2].

This study provides key insights into the atmospheric fate of CUPs, highlighting the need for updated regulatory frameworks that account for heterogeneous degradation processes.

References

[1] Mattei et al. (2019), Science of The Total Environment, 664, 1084–1094.

[2] Sauret et al. (2008), Atmospheric Environment, 42(3), 544–553.