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Development of methods to assess the release of pheromones in the air from dispenser products for improvement of biocontrol solutions

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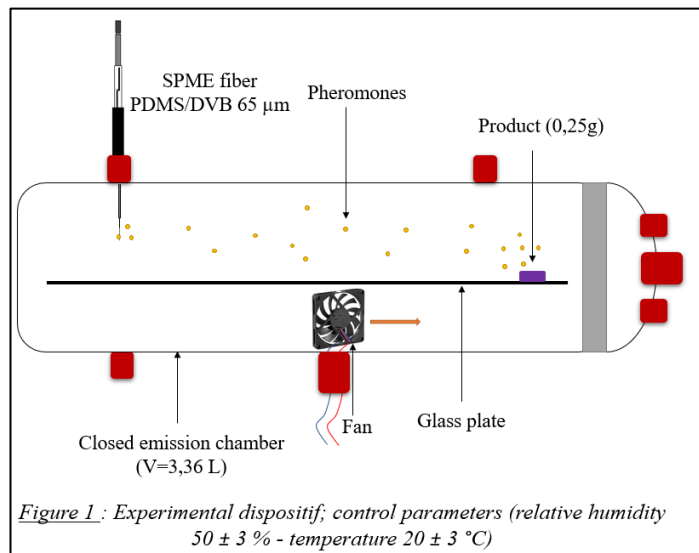
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Context: To reach the international objective of reducing pesticides in agriculture, M2i develops various products (sprays and batters) containing sex pheromones which introduced in the cultural landscape create mating disruption and to reduce population of insect pests. This is an alternative and cost-effective solution in integrated biological control for crop protection. Pheromones are volatile organic compounds (VOCs) or semi-volatile compounds (SVOCs), most often with a long carbon chain and containing one or more oxygenated functions. At present, the effectiveness of the products is commonly evaluated on the target insect population and damage to crops (monitoring). To ensure the effectiveness of these treatments, it is necessary to define the amount of treatment product to be introduced into the cultural landscape. The main drawbacks encountered with current dispensers are the difficulty to maintain a sufficient release rate over a long time (several tens of days) and a concentration detectable by insect around the dispenser. The diffusion of active molecules in the air towards the target is not evaluated in the field due to the lack of sampling and analysis methods suitable for low levels of concentrations to be measured (a few ng.m⁻³) [1]. To the aim, a model product developed by M2i was tested in emission chamber under various conditions to assess the parameters describing the release rate of pheromone.

Methodology: The pheromone studied (Lauryl acetate) is microencapsulated in a solid emulsion. The gaseous concentrations of pheromone were monitored using a solid phase microextraction (SPME) sampling method and analysis by GC-MS-FID [2]. The release process from this solid to the air was performed in a closed emission chamber (figure 1) and several key parameters can be characterized: the diffusion coefficient in the product (D_m), the initial emittable concentration in the product (C_0), the product/air partition constant (K) and the mass transfer coefficient (h_m).

To determine these parameters, variable volume loading (VVL) method [3] and the C-history model [4] were used. The VVL method allows to determine C_0 and K considering different sets of experiments in this case with three products amounts (0.5-0.75-1g) in the emission chamber. In addition, the C-history method in the case of a closed chamber (figure 1), allowed to determine h_m and D_m simultaneously.



Results and discussion: The figure 2 show the experimental kinetics (concentration vs time) obtained with 2 x 0.25g of product. Modelled kinetics were adjusted according to the VVL method and C-history model (green line) on the experimental data (blue dots). The value of K obtained turns out to be low 1.3×10^4 (dimensionless). In addition, Dm in the product determined was $1.10 \times 10^{-9} \text{ m}^2 \cdot \text{s}^{-1}$.

Figure 2 : Comparison of C-history model, expérimental values and model without considering the diffusion in the formulation (2 x 0,25g)

Other dimensionless parameters: the ratio of the mass transfer Biot number to the partition coefficient; the mass transfer Fourier number; and the ratio of the pheromone mass in the product to that measure in the chamber at equilibrium were examined to evaluate factors that affect the pheromone release from the product. One of them shows that mass transfer by external transfer could play an important or even main role in the diffusion. That allowed to develop a simplified model without considering the diffusion in the product which perfectly fits with the experimental data (orange line in figure 2). That also indicates that the diffusion is mainly governed by the diffusion in air under the experimental conditions (closed emission chamber). It should be noted that all parameters are determined under the influence of the test conditions (figure 1).

Conclusions and perspectives: The determination of the parameters describing diffusion in product and in air will allow to develop and adjust a model under dynamic conditions close to those of greenhouse culture. In parallel, experimental tests in greenhouse culture following the remaining quantity of pheromone in the product are set up for a better adjustment of model. Thus, the study of the emission of a compound from products developed against pests in the laboratory allows to better understand the release process. In order to be able to transpose them to the field and solve the problems encountered during treatments.

Keywords: Biocontrol; Pheromones; Air analysis; Release kinetics; emission modelling

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