DETERMINATION OF THE VAPOR PRESSURES OF MOTH SEX PHEROMONE COMPONENTS BY A GAS CHROMATOGRAPHIC METHOD

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Abstract—The vapor pressures of decyl acetate, five decenyl acetate isomers, (Z)-7-dodecenyl acetate, and (Z)-9-tetradecenyl acetate have been determined at three to six temperatures in the interval 25–45°C by a gas chromatographic method suitable for accurate measurements of the low vapor pressures of moth sex pheromone components at biologically relevant temperatures. The vapor pressure values at 30.5°C are 3.80 Pa for decyl acetate, 4.08–5.40 Pa for the decenyl acetate isomers, 0.562 Pa for (Z)-7-dodecenyl acetate, and 0.094 Pa for (Z)-9-tetradecenyl acetate. The vapor pressures of the decenyl acetates show a small but significant dependence on the double bond position. Four of the compounds in this study, 10:Ac, Z5-10:Ac, Z7-12:Ac, and Z9-14:Ac have recently been identified as sex pheromone components of the turnip moth, Agrotis segetum. Large differences between the mole percentages of the component as found in liquid extracts of female abdominal tips and the corresponding mole percentages in the vapor phase are predicted.

Key Words—Vapor pressure, gas chromatography, sex pheromone, olefinic acetates, turnip moth, Agrotis segetum, liquid–vapor equilibrium.

INTRODUCTION

The volatility, measured as the saturated vapor pressure, of pheromone components is an important factor in studies on the physicochemical aspects of insect pheromones. Hirooka and Suwanai (1976) have, for instance, derived an equation which relates the rate of pheromone release by a female moth to the vapor pressure, the diffusion coefficient, and the size and form of
the pheromone gland. For moth species the pheromone generally is a mixture of several compounds, mainly olefinic acetates with varying chain lengths. In many cases geometrical and/or positional isomers are also present in the pheromone blend (Ritter, 1979). The female moths produce a well-defined ratio of the different compounds and the component ratio has been found to play an important role for optimal attraction of males in the field (Roelofs, 1978). However, when the vapor pressures of the pheromone components differ significantly, the ratio of the components in the vapor phase is different from that on the female gland. The former ratio depends on the relative saturated vapor pressures of the components and their relative mole fractions in the liquid phase (Hirooka and Suwanai, 1978).

In connection with field trapping studies more basic work concerning the release rates of pheromones from controlled release systems are needed (Weatherston, 1981). In such investigations physical data on the volatility relationships should be of great value.

In electrophysiological studies on dose–response relationships, the volatilities of the test compound should be taken into account to make it possible to determine the amount of substance to be used in the experiment.

Although the vapor pressures of the compounds used by insects as sex pheromone components thus enter into many different types of pheromone studies, very few experimental values are available. Hirooka and Suwanai (1978) used a gas saturation method to determine the vapor pressure of a few compounds used as pheromone components by moth species.

In this paper we report on vapor pressures for some pheromone components and related compounds determined by a gas chromatographic method, developed by two of us (Olsson et al., 1976). It has previously been used for several applications (Jönsson et al., 1980; Jönsson and Pscheidl, 1981).

Four of the compounds chosen for this work, decyl, (Z)-5-decenyl, (Z)-7-dodecenyl and (Z)-9-tetradecenyl acetate, have been identified as sex pheromone components of the turnip moth, Agrotis segetum, (Tóth et al., 1980; Arn et al., 1980; Lofstedt et al., 1981). To investigate the influence of the position of the double bond on the vapor pressure, (Z)-3-, (Z)-4-, and (Z)-6-decenyl acetate were included in the study. Finally, the vapor pressure of a geometrical isomer, (E)-5-decenyl acetate, was determined.

**METHODS AND MATERIALS**

**Principles.** The substance under study is used as the stationary liquid phase (SLP) in a gas–liquid chromatographic column. A suitable sample compound, the "probe," is repeatedly injected into the gas chromatograph and the net retention volume \( V_N \) is carefully measured. According to basic gas chromatographic theory, the following equation applies: