

# Determination of vapor pressure curves of warifteine and methylwarifteine by using thermogravimetry

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**Abstract** Warifteine and methylwarifteine are bisbenzylisoquinoline alkaloids from *Cissampelos sympodialis* Eichl., produces a reversible, nonspecific, and noncompetitive antagonism of histamine, anti-allergic therapy, and used in the folk medicine for the treatment of airway respiratory diseases. Thermal techniques are used for several purposes, e.g., for thermal characterization, and measurement of the vapor pressure with objective of the quantitative determination. The objective of this study was to evaluate of the vapor pressure of the curves of warifteine and methylwarifteine by thermogravimetry analysis, how a fast and sensible method for quantitative determination. This method is based on the ratio of the Arrhenius, Langmuir, and Antoine equations for a reference material and the sample under investigation. The results showed these alkaloids follow zero-order kinetics with respect to volatilization. The vapor pressure curves of warifteine and methylwarifteine were plotted for the rates of 10, 15, and 20 °C min<sup>-1</sup>. The proposed method also possesses the potential.

**Keywords** Warifteine · Methylwarifteine · Thermogravimetry · Vapor pressure · Langmuir and Antoine equations

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## Introduction

Warifteine, a bisbenzylisoquinoline alkaloid from *Cissampelos sympodialis* Eichl., produces a reversible, nonspecific, and noncompetitive antagonism of histamine, carbachol, and bradykinin. It induces contractions of the guinea-pig ileum, and it has inhibitory activity of the phosphodiesterase enzyme. Also, it may be responsible for antidepressant effects and may cause muscle relaxation by inhibiting Ca<sup>2+</sup> channels and by modifying the intracellular Ca<sup>2+</sup> stores sensitive to noradrenaline.

Methylwarifteine, a bisbenzylisoquinoline alkaloid from *Cissampelos sympodialis* Eichl., is used in the folk medicine for the treatment of airway respiratory diseases and may be a promising anti-allergic therapy, inasmuch as it presents potent anti-cosinophil and anti-leukotrienes activities [1].

Thermal techniques are used for several purposes, e.g., for thermal characterization [2–7], study of drugs stability and preformulation studies [8–15], as well as measurement of the vapor pressure of substances [16–24].

Evaporation can be stated as the transition from the liquid phase to the vapor phase, without a change in chemical composition. Several factors such as vapor pressure of the substance, molecular weight, amount of exposed surface area, etc., can alter the evaporation patterns. The primary influential factor, however, is the rising temperature conditions that the preservatives are being subjected to. The evaporation parameters can be determined by the rate of mass loss as the substance undergoes the phase transition from liquid to vapor. This can be achieved with a rising temperature program in thermogravimetric analysis [23].

The objective of this study was to evaluate of the vapor pressure of the curves of warifteine and methylwarifteine using thermogravimetry analysis.

## Methods and materials

Methylparaben (reference) was purchased from Dinalab (NF00222). Warifteine and methylwarifteine were purchased from *Cissampelos sympodialis* (Menispermaceae) bark submitted to March for isolation of alkaloids. Then it was purified and identified by  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectral data in agreement with literature [25]. Methylparaben is the methyl ester of *p*-hydroxybenzoic acid. The methylparaben was used as the reference standard because it evaporates following zero-order kinetics.

The pressure values for methylparaben over a temperature range of 200–224 °C were calculated using the Antoine equation stated below [17].

Non-isothermal thermogravimetric curves of warifteine and methylwarifteine were obtained using a Shimadzu TGA-50H thermobalance applying 10, 15, and 20 °C min<sup>-1</sup> heating rates up to 900 °C in synthetic air (at a flow rate of 20 mL min<sup>-1</sup>) and purge nitrogen (50 mL min<sup>-1</sup>).

Non-isothermal thermogravimetric curves of methylparaben were recorded using the same Shimadzu thermobalance and also in the same heating rate up to 400 °C, when the process of mass loss finished (three parallel runs were recorded). The initial sample mass was 5.0 ± 0.5 mg, which was put in an alumina crucible.

The curves were analyzed by TASY program from Shimadzu in order to characterize the mass loss stages.

### Arrhenius, Antoine, and Langmuir equations

Non-isotherm thermogravimetric data were used to determine the reaction order by Arrhenius equation [23].

$$k_{\text{vap}} = Ae^{-E_{\text{vap}}/RT}$$

where  $E_{\text{vap}}$  is the vaporization energy,  $A$  is the pre-exponential factor,  $R$  is the universal gas constant,  $T$  is the absolute temperature, and  $k_{\text{vap}}$  is the evaporation coefficient.

Data obtained from thermogravimetric experiments of methylparaben were used to construct the vapor pressure curves, using the Antoine equation and after determining the value of ' $k$ ', which was used to construct the vapor pressure curves of warifteine and methylwarifteine, using the Langmuir equation.

The Antoine's equation [23] is presented as:

$$\log P = A - B/(T + C)$$

where  $P$  is the vapor pressure;  $T$  is the absolute temperature; and  $A$ ,  $B$ , and  $C$  are the Antoine's constants in the studied temperature interval [23]. Antoine constants for methylparaben are:  $A = 5.23662$ ,  $B = 1159.34$ , and

$C = -220.03$ , in the 446–517 K temperature interval [23]. The Langmuir equation [23] is

$$dm/dt = P\alpha(M/2\pi RT)^{1/2}$$

where  $dm/dt$  is the rate of mass loss per area unit,  $P$  is the vapor pressure,  $\alpha$  is the vaporization constant, and  $M$  is the molecular mass of the evaporated vapor. The Langmuir equation can be modified in order to obtain the vapor pressure values of many simple components. The following modification is described [23]:

$$P = [\alpha - 1(2\pi R)^{1/2}] \cdot [(T/M)^{1/2}(dm/dt)] = k \cdot v$$

where  $k = \alpha - 1(2\pi R)^{1/2}$  e  $v = (T/M)^{1/2}(dm/dt)$

If  $k$  is constant,  $t$  is a group of data and it is independent of the used material, so the graphic of  $P$  versus  $v$  gives the value of  $k$ .

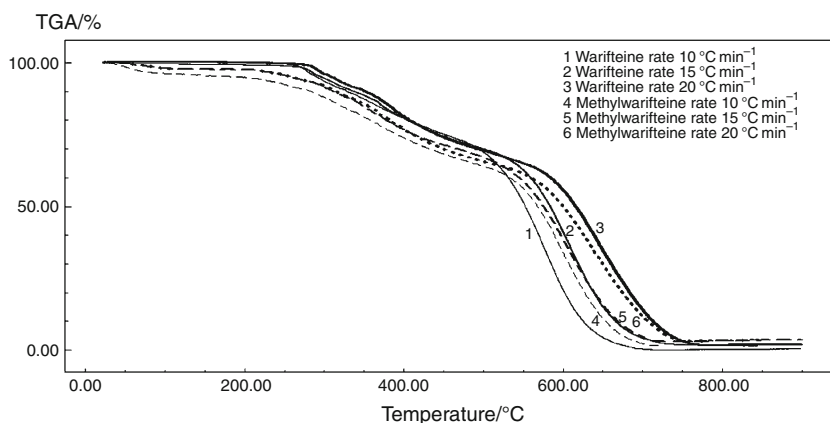
## Results and discussion

Dynamic thermogravimetric curves of warifteine and methylwarifteine of the heating rates of 10, 15, and 20 °C min<sup>-1</sup> can be seen in Fig. 1. The curves show that warifteine presents two stages of decomposition in all the heating rates. The temperature range of the heating rates of 10 °C min<sup>-1</sup> to first and second stages were 265–406 and 535–630 °C min<sup>-1</sup>, respectively. The temperature range of the heating rates of 15 °C min<sup>-1</sup> to first and second stages were 351–397 and 576–669 °C min<sup>-1</sup>, respectively. The temperature range of the heating rates of 20 °C min<sup>-1</sup> to first and second stages were 360–402 and 607–721 °C min<sup>-1</sup>, respectively. This temperature range was used and their mass loss to determine the reaction order for the two decomposition stages, according to Arrhenius equation. The warifteine showed order zero and the data are presented in Table 1.

The Fig. 1 shows that methylwarifteine presents two stages of decomposition in all the heating rates. The temperature range of the heating rates of 10 °C min<sup>-1</sup> to first and second stages were 330–380 and 565–663 °C min<sup>-1</sup>, respectively. The temperature range of the heating rates of 15 °C min<sup>-1</sup> to first and second stages were 345–366 and 583–675 °C min<sup>-1</sup>, respectively. The temperature range of the heating rates of 20 °C min<sup>-1</sup> to first and second stages were 350–384 and 597–715 °C min<sup>-1</sup>, respectively. This temperature range was used and their mass loss to determine the reaction order for the two decomposition stages, according to Arrhenius equation. The methylwarifteine also showed order zero and the data are presented in Table 1.

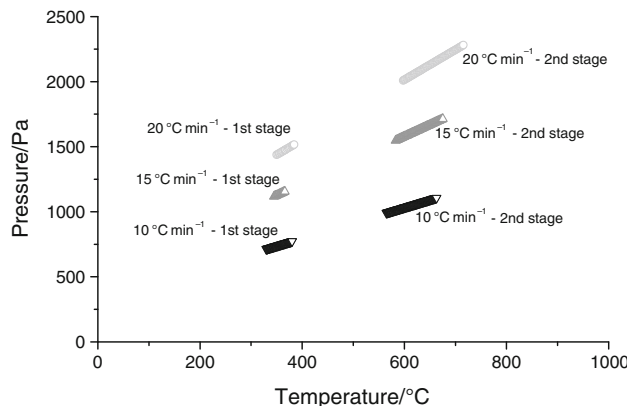
Methylparaben was used to calibrate the system due to its zero-order kinetics, which corresponds to evaporation according to the literature [23]. The ' $k$ ' value

**Fig. 1** Thermogravimetric curves of bisbenzylisoquinolines alkaloids (warifteine, *solid*/methylwarifteine, *dash*) of the heating rates of 10 °C min<sup>-1</sup> (*small lines*), 15 °C min<sup>-1</sup> (*medium lines*), and 20 °C min<sup>-1</sup> (*large lines*)

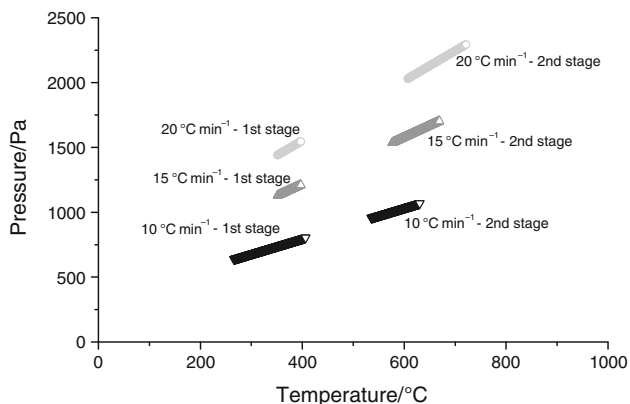


**Table 1** Decomposition constants of bisbenzylisoquinolines alkaloids, warifteine and methylwarifteine, for first and second decomposition stages

Bisbenzylisoquinoline alkaloid	Heating rate/°C min <sup>-1</sup>	Decomposition constants	
		First stage	Second stage
Warifteine	10	5.39E-05	1.84E-04
	15	8.80E-05	4.78E-04
	20	1.36E-04	5.12E-04
	10	2.61E-04	1.70E-03
Methylwarifteine	15	4.22E-04	2.38E-04
	20	5.81E-04	2.47E-03



**Fig. 3** Vapor pressure of the curves of methylwarifteine in the heating rates of 10, 15, and 20 °C min<sup>-1</sup> in the first and second stage of decomposition



**Fig. 2** Vapor pressure of the curves of warifteine in the heating rates of 10, 15, and 20 °C min<sup>-1</sup> in the first and second stage of decomposition

obtained experimentally to methylparaben at 10, 15, and 20 °C min<sup>-1</sup> heating rates in synthetic air were 125555, 192060, and 245191, respectively, close to the literature [20–22]. The data showed that the warifteine and methylwarifteine present zero-order kinetics for both stages of decomposition. The ‘k’ values of methylparaben were used to obtain the pressure values and the curves for warifteine (Fig. 2) and methylwarifteine (Fig. 3) in synthetic air at 10,

15, and 20 °C min<sup>-1</sup> heating rates in the first and second stages of decomposition. The Figs. 2 and 3 showed that occurs an increase of vapor pressure with the increase of heating rate for the first to the second stage of decomposition. The results showed that estimating vapor pressure curves by thermogravimetric is a suitable convenient method for characterization of pharmaceuticals.

**Conclusions**

The warifteine and methylwarifteine showed zero-order kinetic for Arrhenius equations. Therefore, the vapor pressure curves were constructed for first and second decomposition stages. This article presents the thermogravimetric as a thermal technique can be used to obtain data useful in constructing the curves of vapor pressure. Because it is a quick method that uses a small amount of sample is adequate to construct the vapor pressure for pharmaceutical products. Previous articles also suggest the quantitative determination from the curves of pressure thermogravimetry, which must be performed for this study.

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