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DVS Application Note 07

Measurement of Diffusion of Liquids and Vapours Through Real Polymer Tube Packaging Devices

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This application note describes the use of DVS technique to measure the diffusion through the polymer packaging systems.

Introduction

The measurement of diffusion and permeation of vapours and liquids through real packaging devices is important for the development of both pharmaceutical and food packaging solutions. Typical requirements of these packaging systems are that the ingress and/or loss of moisture over long storage periods must be kept to a minimum in order to prolong the shelf life of the product.

In recent years, the use of high resolution gravimetric flowing gas or Dynamic Vapour Sorption instrumentation has been adopted for accurate measurement of the uptake and desorption of moisture and organic vapours in pharmaceutical and food products. Surface Measurement Systems have developed a novel method for rapidly measuring the diffusion of saturated vapours through real polymer packaging systems using existing Dynamic Vapour Sorption instrumentation.

Method

The basic principal of the developed method is to measure the rate of loss of vapour diffusing through a sealed packaging tube containing a fixed quantity of solvent. Figure 1 shows a schematic of how this technique may be applied to a polypropylene tube packing device, which is open at one end and closed at the other. The required quantity of liquid is accurately pipetted out and the top of the tube is sealed with a glass slide and a glassy epoxy sealant. An approximately eight-hour curing period for the epoxy is performed before commencing diffusion measurements to allow for diffusion of solvents out of the epoxy. Measurements on an empty tube have shown that the diffusion of solvent vapours after the curing time is not significant.

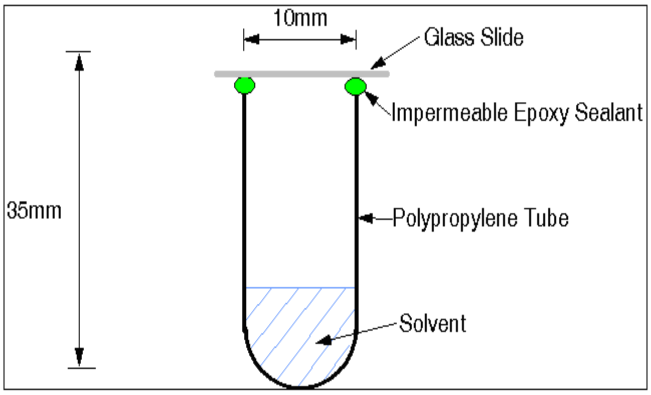

Figure 1. Schematic of the sealed polypropylene packaging tube.

The diffusion measurements were made on DVS instrument with a mass resolution of 0.1-μg and temperature stability of ± 0.1 °C. The high mass resolution combined with good temperature stability means that the instrument is capable of measuring diffusion rates below 1 μg per hour. To make the diffusion measurements, both the filled tube and an empty reference tube were suspended from the balance and dry nitrogen flowed over the cells at a total flow rate of 200 sccm. The empty reference cell provides a suitable counterbalance and also cancels out any local buoyancy effects. In this case the diffusion rate measured is a combination of both liquid and vapour diffusion through different parts of the tube, hence the diffusion data is best used as a guide for ranking materials formed in the same geometries.

Results

Table 1 shows calculated diffusion parameters for diffusion of water and also isopropyl alcohol (IPA) sealed inside the tubes at 25°C.

Table 1. Diffusion parameters for water and isopropyl alcohol.

Packaging Tubes 25 °C	Water	IPA
Film Thickness / m	4.50E-04	4.50E-04
Area / m^2	1.10E-03	1.10E-03
Diffusion Rate / kg s^{-1}	3.61E-12	5.21E-12
Flux / kg s^{-1} m^{-2}	3.28E-09	4.74E-09

These data show that IPA and water have similar diffusion rates through the packaging tube at this temperature. However they also show that these particular packaging tubes may not be suitable for storing water or IPA based solutions for long periods of time as extrapolation of the diffusion data indicates that the entire contents of the tube would evaporate within six months, if stored under similar conditions to our experiment.

Conclusion

This application note demonstrates that existing DVS instrumentation may be used to measure diffusion of water and organic vapours and liquids through real polymer packaging devices. This method may be applied as a rapid screening method for both packaging films and real packaging systems.

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