Water Vapor Permeability of Films

proUmid GmbH & Co. KG

Application Note 12-01

Objectives

Precise determination of the permeability for water molecules through a material is a big concern for the characterization of films and determination of their usability as packaging material and barrier for zones of different water vapor pressure.

In general two different principles are described for determination of the permeability rate of films and defined in several standards:

A quite common method is a setup with the film exposed to an atmosphere of very high relative humidity at one side with a flow of dry gas passing the other side of the film. Water molecules passing the film are carried by the dry carrier gas and detected by a NIR sensor. Thus providing quick results, this method requires calibration of the setup using reference materials with given permeability rates.

The second method uses dishes covered with the film material under test. By filling those dishes either with a desiccant, saturated salt solution or water, a difference to the partial water vapor pressure of the environment is generated, resulting in a migration of water molecules through the film.

Fig. 1: A set of dishes with a fixture to hold the film tightly sealed on top provides the necessary setup for determination of permeability of films.

This migration is determined gravimetrically by weighing the mass of the dish. Thus being more time consuming than NIR determination, this method provides very precise results allowing even to generate reference films for calibration of NIR instruments.

Application

Providing a highly sensitive analytical balance and an environment of controlled temperature, humidity and air circulation, the SPS multisampling water vapor sorption systems are ideally prepared for permeability testing (Fig. 1).

Sample preparation

Fig. 2 shows a schematic drawing of the sample pan and sample preparation for water vapor permeability measurements.

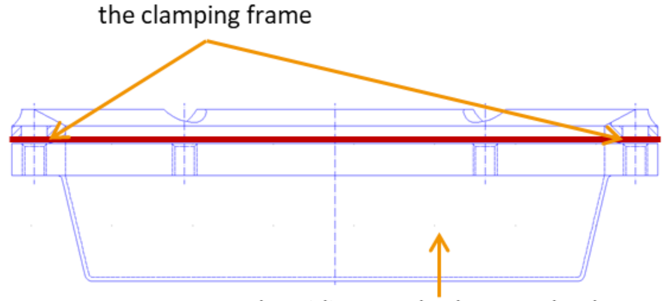

Fig. 2: Schematic drawing of the sample pan and sample preparation for WVTR measurements

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Measurement Principle

Due to the different partial water vapor pressures between the controlled climatic conditions within the SPS and the interior of the sample dish, a migration of water molecules through the film is induced.

The result is a constant change of the sample dish weight measured by the analytic balance of the SPS moisture sorption instrument (Fig. 3).

A continuous increase of weight indicates uptake of water molecules that have migrated through the membrane by the adsorbent placed inside the dish.

Continuous weight loss indicates the evaporation of water molecules from a salt solution or water-soaked sponge placed inside the dish and migrating through the membrane into the SPS chamber.

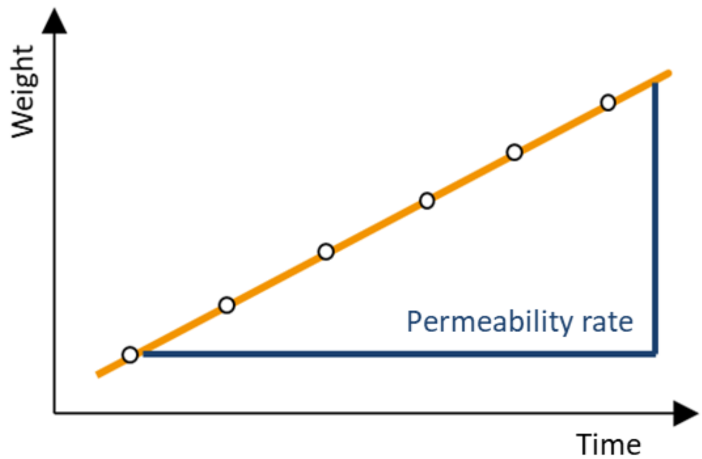

Fig. 3: Exemplary curve of a water vapor permeability measurement.

Results

In Fig. 4 shows an exemplary results of a permeability test. Water vapor transition of a standard, commercially available wrapping film for domestic applications is compared with with alumina foil.
A molecular sieve was placed as an adsorbent inside the dish to adsorb all water molecules passing through the film and to maintain low partial water vapor pressure.

Beside surface coverage effects, the alumina foil did not show noticeable water permeation, indicating that the sealing of the alumina foil against the dish was functioning properly.

Both samples of wrapping film sample showed a distinct linear gradient of mass increase resulting from water molecules migrating through the film and getting adsorbed by the molecular sieve. The slope of the curve is directly related to the difference in water vapour pressure between the inside and the outside of the dish.

The difference in water uptake between the wrapping films is a result of deviations in the film thickness.

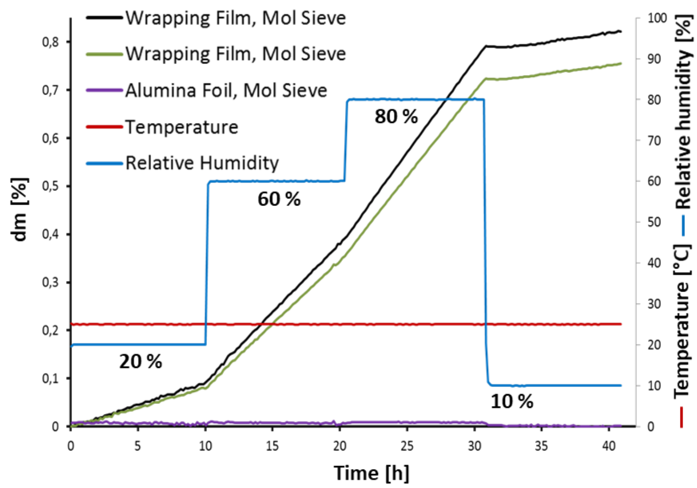

Fig. 4: Exemplary results of a permeability test

After lowering the RH from 80 % to 10 %, a short period of desorption from the wrapping film was observed. Subsequently, however, a linear increase could be observed again, but with a smaller gradient due to the reduced water vapor pressure difference. This indicates a progressive water migration through the film.

Therefore it is very important only to use the linear part of permeability curves for the calculation of water vapor migration rates.

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Calculation of the permeability rate

Calculations were done on the basis of the EN ISO 7783-1 for the determination of water-vapor transmission rate Part 1: “Dish method for free films” .

The measurement unit for this standard is gram per square meter and day [g/(m^2*d)]. Results are summarized in Fig. 5.

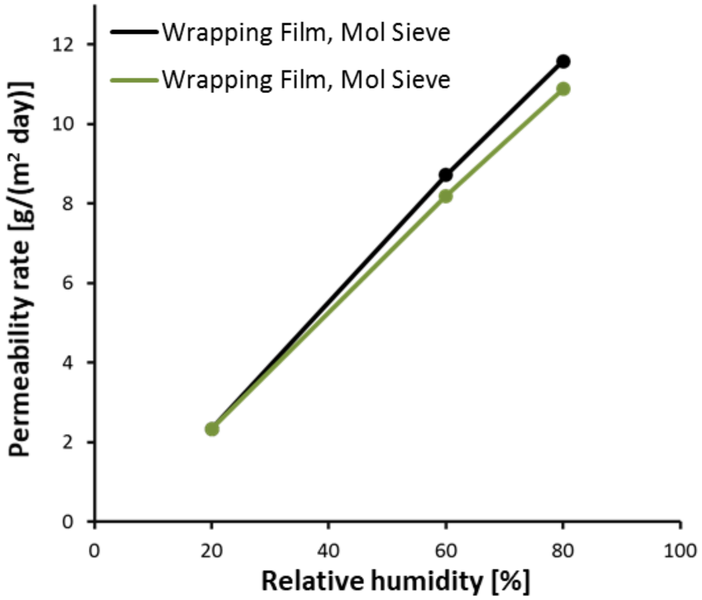
Calculation basics

Membrane surface:

A = 3504 mm^2 = 0.003504 m^2

Time:

t = 600 min = 0.417 days per period of constant RH



Relative Humidity 20%

Diffusion 2.34 g/(m² day)
Diffusion 2.33 g/(m² day)

Relative Humidity 60%

Diffusion 8.72 g/(m² day)
Diffusion 8.20 g/(m² day)

Relative Humidity 80%

Diffusion 11.58 g/(m² day)
Diffusion 10.89 g/(m² day)

Fig. 5: Permeability rate of wrapping film samples depending on the relative humidity

Conclusions

- The sorption instruments of the SPS series provides precise results for the analysis of water vapor migration through films.
- Due to the large temperature and humidity range of the SPS, a wide range of climatic conditions can be tested.
- The high accuracy of this measurement enables the recording of permeability rates down to 0.05 g/(m^2*day)
- The multi sample capability of the SPS series enables the testing and comparing of up to five permeability samples simultaneously and thus providing the detection of variations between different sections of a film.