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DVS Application Note 22

A Simple Shelf Life Prediction of Crackers

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The aim of this paper is to investigate the water sorption behaviour of cracker materials and calculate the shelf-life stability.

Introduction

The moisture sorption properties of foods are critical for their shelf-life stability. This is especially true for materials like biscuits or crackers which are vulnerable to either temperature or humidity shocks. These products can take up a high amount of water, melt and collapse thus rendering them unsalable.

Method

Moisture uptake kinetics for a dry cracker was studied using a DVS Advantage-2 vapor sorption instrument. This instrument is especially designed for real world samples and can accommodate products of up to 5 cm in diameter and 4 g in weight as a standard sample.

In addition data was also recorded for a 15 mg sample of cracker powder using a DVS Advantage-1 vapor sorption instrument.

All work reported was conducted at 25°C.

Results

Experimental data is shown below in Figure 1 for a 15 mg sample of powder made from cracker. The powder was equilibrated at 0% RH for five minutes before the experiment was started. Then a desorption step at 0% RH was performed followed by sorption study at different RH steps up to 90% RH. Finally desorption was performed step-by-step up to 0% RH. The relative humidity cycle is shown in blue in Figure 1

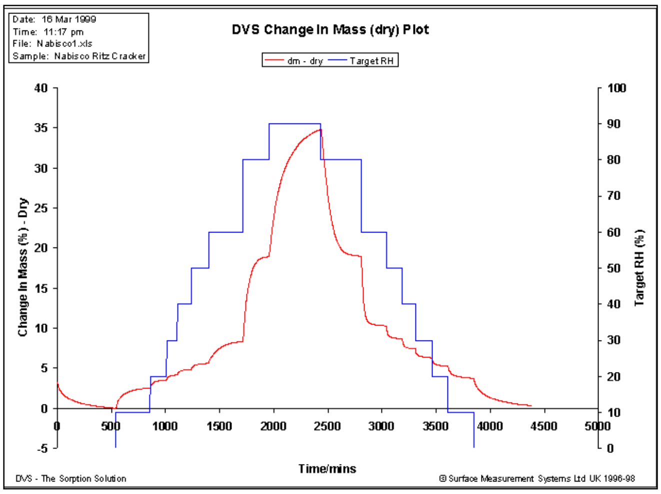

Figure 1. Experimental water sorption data for cracker powder (ground up) at 25°C

The resultant isotherm is shown below in Figure 2. A low level of hysteresis was observed for the sample.

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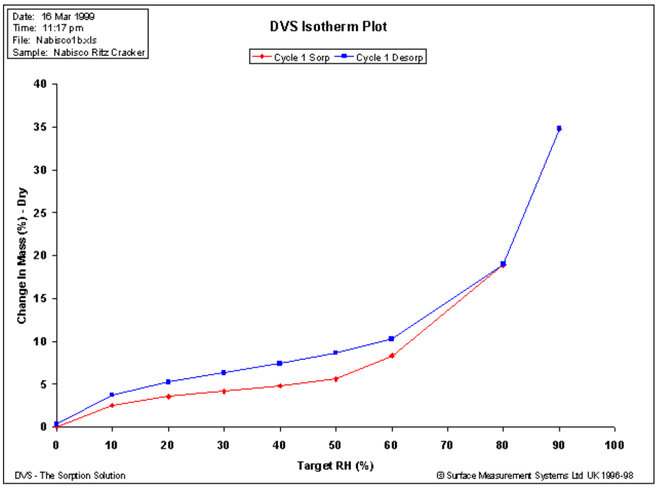

Figure 2. Water sorption/desorption isotherm for cracker (ground up)

Experimental sorption/desorption data was also reported for a full single cracker, which was in the DVS Advantage2 device as shown below in Figure 3.

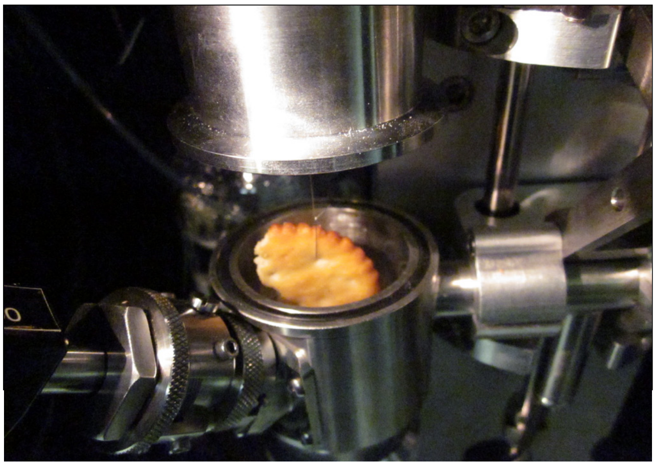

Figure 3. Cracker inside DVS Advantage2 manifold prior to start of experiment.

One of the most useful facets of the DVS Advantage2 is the ability to study real materials, such as complete objects. The large sample manifold provides a unique ability to undertake such investigations (see above Figure 3).

A rapid technique was developed for predicting shelf life of an entire cracker. This was an alternative to running a full isotherm for a cracker, which would have taken more time than was available. The data shown below in Figure 4 was obtained by exposing the biscuit to a series of increasing humidities following an initial drying step. The data shown of mass versus time does not show a true equilibrium, as it is the case for the data shown in Figure 1. However, we have used this data to estimate the maximum rate of mass uptake during the first hours of sorption or desorption.

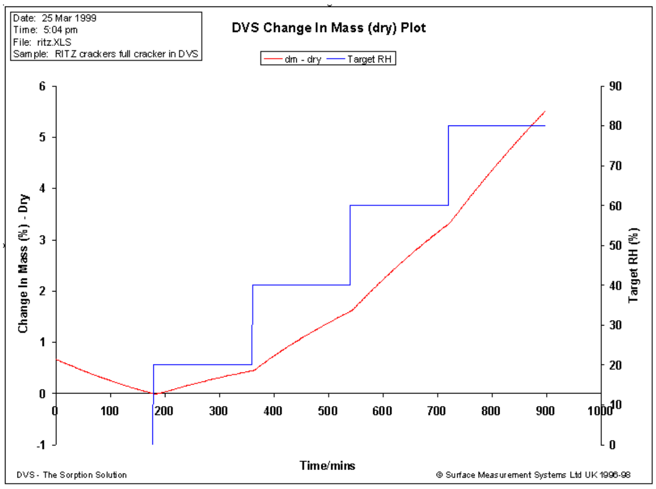

Figure 4. Non-equilibrium data for water desorption/sorption for a single cracker.

By estimating the initial rate of moisture uptake at each %RH, it is possible to obtain the maximum rate of moisture gain. From the sorption isotherm shown in Figure 2, we can make a simple linear prediction of the time it will take to dry a cracker to reach these equilibrium moisture contents. This is a worst case prediction and a better approximation would be to take twice this linear predicted time. This makes a crude allowance for the actual Fickian (non-linear) nature of the moisture diffusion process. With knowledge of the cracker dimensions it is thus possible to estimate the rates of moisture flux onto the sample surface. This rate has also been calculated and is shown below in the Table 1.

This is an interesting feature of DVS performance, and is useful for illustrating the effects of cumulative damage due to relative humidity. This could simulate the ambient relative humidities in different countries. Humidities were chosen that would span a sufficient range to severely challenge the sample but not lead to collapse during a single event.

Table 1. Kinetics of Moisture uptake into a cracker

% RH	0	20	40	60	80
dm/dt during first hour (%/min)	-0.0044	0.00287	0.00728	0.01035	0.01312
dm/dt during first hour (10^6 kg/min)	-13.6	8.87	22.47	31.96	40.49
dm/(dtdA) (10^3 kg/ (min.m^2))	-3.38	2.20	5.59	7.95	10.07
Linear Shelf Life (min)	720	1235	665	800	1440
Shelf Life Prediction (min)	1440	2470	1350	1600	2880
Equilibirium Moisture content (%) (from Isotherm)	-3.20	3.55	4.84	8.32	18.90

Cracker's weight: 10 crackers = 33.226 g means 1 cracker = 3.3226 g

Cracker diameter: 4.8 cm = 0.048 m

Cracker thickness: 4 mm = 0.004 m

Conclusion

DVS is a useful tool for determining the moisture uptake behaviour of powders and complete food products. In the case of crackers, a simple moisture uptake study can be conducted in less than 1 day for a complete cracker.

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