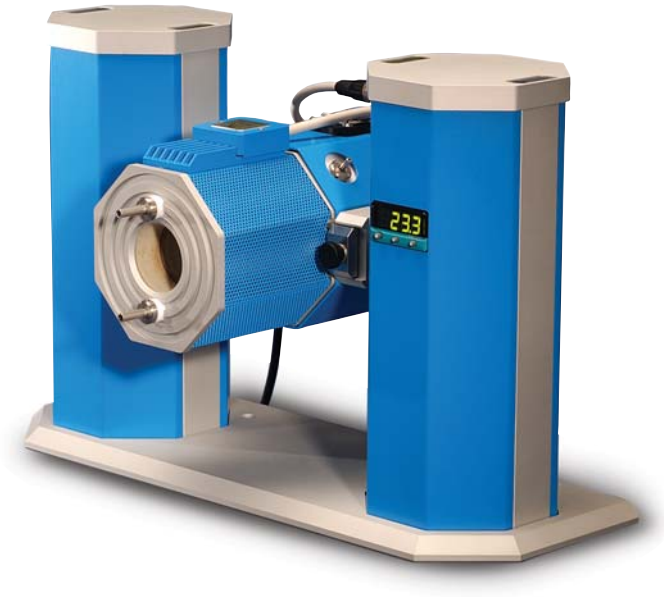
Effect of Humidity on Mechanical Properties of Pasta



Summary

The mechanical properties of pasta are very important. In its dried form, it is very brittle and quite stiff. If introduced into a humid environment and heated, the properties of the pasta change dramatically. This application note will investigate the effect of humidity on pasta under isothermal and temperature scanning conditions.

Introduction

Dynamic Mechanical Analysis (DMA) measures the stiffness of a material. The stiffness of pasta is a good indication as to the stability of the dried product. Dried pasta from the packet is quite stiff and humidity and temperature will decrease the stiffness as the material softens. The modulus gives an indication of the stiffness as it decreases and tan δ indicates when the material becomes more viscous and less elastic.

DMA works by applying an oscillating force to the material and the resultant displacement of the sample is measured. From this, the stiffness can be determined and the modulus and tan δ can be calculated. Tan δ is the ratio of the loss modulus to the storage modulus. By measuring the phase lag in the displacement compared to the applied force it is possible to determine the damping properties of the material. Tan δ is plotted against temperature and a glass transition is normally observed as a peak since the material will absorb energy as it passes through the glass transition.

Dried pasta can be stored for long periods without risk of biological decay. When exposed to water, either by immersion or humidity, the pasta will absorb the water and start to hydrate. The humidity and temperature affect the hydration rate significantly as will be demonstrated.

Results and conclusion

Figure 1 shows the modulus and tan δ response from a sample of pasta at 50 °C and 100% RH. The modulus starts decreasing almost immediately on exposure to the RH and loses all integrity by about 1.5 hours. The tan δ increases steadily over the experiment indicating that the sample is getting more viscous and less elastic until after 1.5 hours, the sample collapses totally. The shoulder seen at 40 minutes indicates the “al dente” point where although fully hydrated, it still has some firm texture.

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precisely.

Experimental

1. **Isothermal experiment at 50 °C and 100% RH.**
   The sample was mounted in the Single Cantilever Bending clamps of the PerkinElmer® DMA 8000 and the temperature set to 50 °C. The experiment was started when the humidity reached 100%.
2. **Temperature scanning experiment at 62% and 100% RH**
   The sample was mounted in the Single Cantilever Bending clamps of the DMA 8000 and the RH was allowed to equilibrate. The samples were run from ambient to over 100 °C.

Equipment	Experimental Conditions	
DMA 8000	Sample:	Pasta
Fluid Bath	Geometry:	Single Cantilever Bending
Humidity Generator	Dimensions:	2.75 (l) x 4.50 (w) x 0.83 (t) mm
Circulator	Frequency:	1 Hz

The responses from the two temperature scanning experiments are show in Figure 2. The black lines correspond to the experiment at 62% RH and the red lines to the experiment at 100% RH. The modulus in both experiments start at approximately the same level, indicating similar material was examined. The higher RH experiment shows a more rapid reduction in modulus as expected. It actually loses structural integrity at about 100 °C. The 62% RH experiment shows a smaller drop in modulus over the temperature range. The 100% RH modulus response clearly shows a similar shoulder at 75 °C, as in the first graph, indicating the pasta reaching "al dente" point.

The tan δ response in the 62% RH experiment shows a gradual increase indicating an increase in viscosity. Like the modulus response, it is not a constant increase, indicating more than one process is involved. It is more obvious, and faster, for the 100% RH sample. Here a peak is observed at about 75 °C which might be a plasticized relaxation event but corresponds to the "al dente" point mentioned earlier. The sample goes on to a very viscous sample as it "cooks" at about 100 °C. This application note has demonstrated the ability of the DMA 8000 to make measurements under a controlled humidity environment. The pasta used in this study showed dramatic mechanical effects when the temperature and humidity of the sample were controlled and changed.

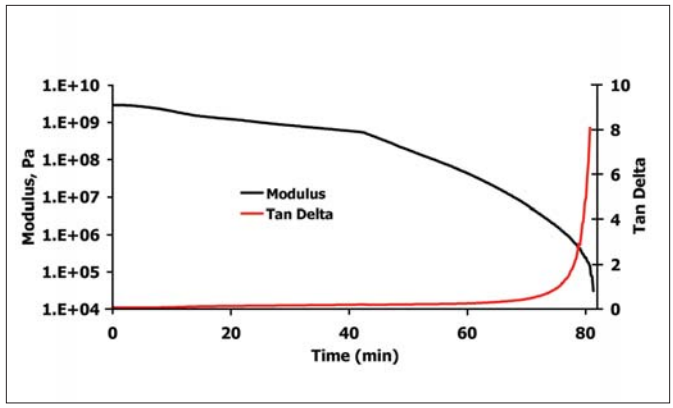

Figure 1. Modulus and tan δ from a sample of pasta at 50 °C.

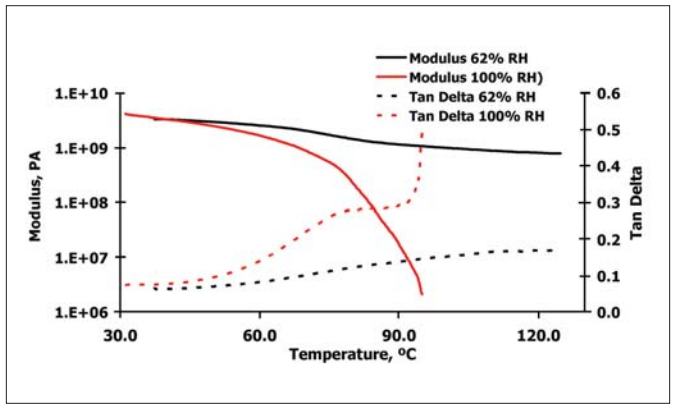

Figure 2. Modulus and tan δ from two temperature scanning experiments.

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