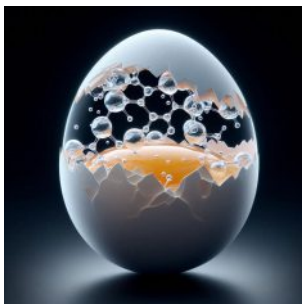
Application Note
Denaturation of Egg Protein

Variable sample temperature setup to measure the denaturation of egg protein in cooking process using T1 & T2 relaxometry



Summary

- Variable Temperature (VT) probe 30 °C - 100 °C
- T1 and T2 measurement during heating
- Observation of the denaturation of specific proteins

Abstract

In this study, the denaturation of proteins in a chicken egg was measured during the cooking process. The measurements were conducted using the Pure Devices Time-Domain Nuclear Magnetic Resonance (TD-NMR) system, which included a variable temperature control of the sample. Significant changes were observed in the T1 and T2 relaxation times, corresponding to the different types of proteins present in the egg. These changes provide insights into the structural transformations that proteins undergo when exposed to heat, highlighting the utility of TD-NMR in monitoring protein denaturation in real-time. The findings contribute to a better understanding of the thermal behaviour of egg proteins, which has implications for both food science and the broader field of protein chemistry. There are more usecases for other industries and research directions.

Used hardware:

- MRI control unit drive-L
- Magnet magspec 20 mm
- VT system 30 °C - 100 °C

Method

The fresh egg was separated into egg white and egg yolk and put into 15 mm glass tubes. Also, a mixture of egg white and egg yolk was created. A vegetable oil sample was used as reference.

The sample has been put into the variable temperature (VT) probe and tempered at 49 °C. For each measurement step, the temperature was increased by 1 °C to a maximum of 90 °C. After that, the temperature was decreases in the same way. After 3 minutes tempering at the target temperature, a T1 inversion recovery measurement and a T2 CMPG measurement was performed. The acquired data was fitted with a single and dual exponential fitting routine.

For further evaluation, the resulting T1 and T2 values as well as the amplitudes of the exponential fit, extrapolated to the point at time $t = 0$ (axis section) were used.

Results

All following figures only show the increasing temperature profile. The descending profile shows no more changes in relaxation times, since all proteins have been denaturated at 90 °C.

Figure 2 and Figure 3 show the T1 and T2 values of the samples at different temperatures. One can clearly see the different denaturation temperature of different proteins which exist in the egg. Interesting is

Figure 1: Egg white, yoke and mixed egg in glass tubes after denaturation experiment.

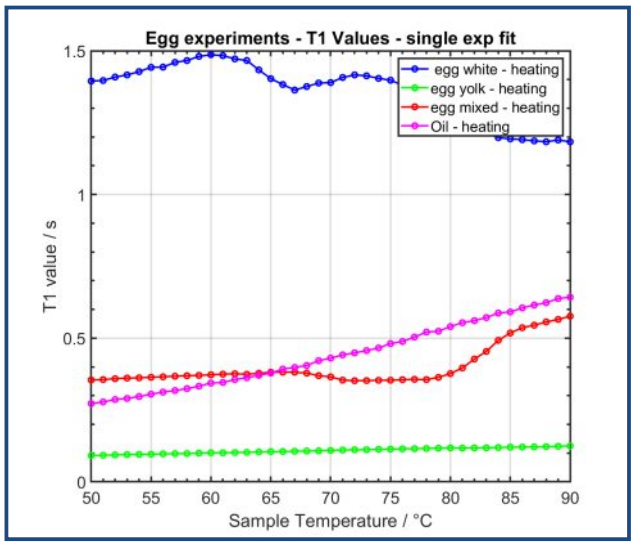


Figure 2: T1 values during increasing temperatures

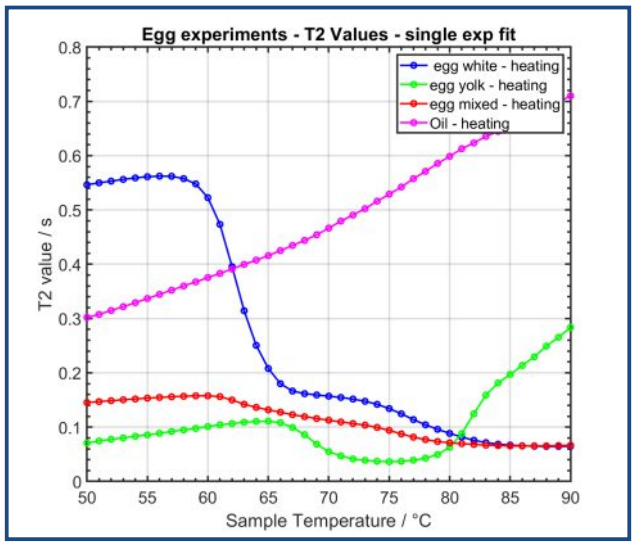


Figure 3: T2 values during increasing temperatures

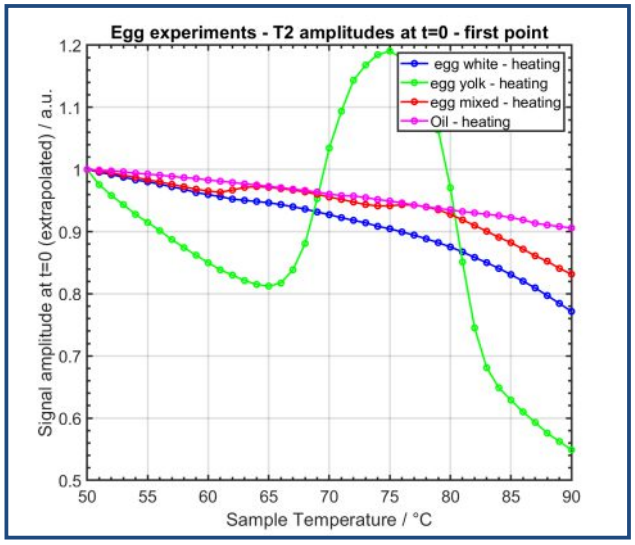


Figure 4: T2 amplitudes at t = 0 (axis section); normalized to the first measurement at T = 50 °C

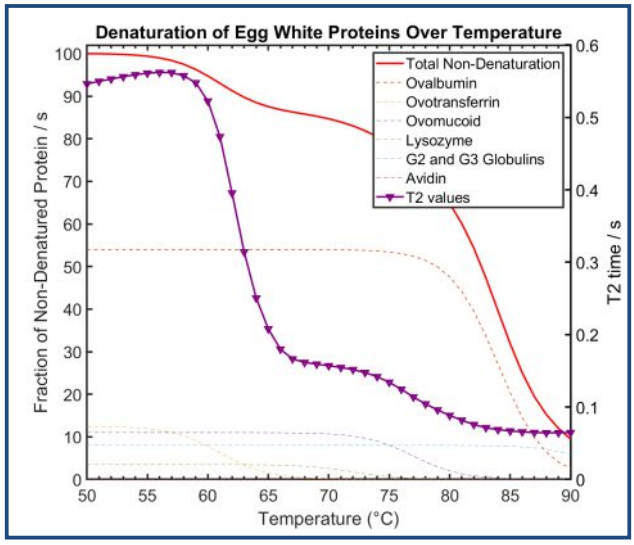


Figure 5: Fraction of the non-denaturated proteins compared to T2 values

the fact that the egg white and yoke behave clearly different than the mixture of both.
Figure 4 shows the T2 amplitudes at t = 0 which were normalized to the first point at T = 50 °C.
Figure 5 shows the calculated fraction of non-denaturated proteins for each protein as well as the total non-denaturated amount at a specific temperature (in red). The change of the T2 value for egg white is shown in purple. One can clearly see the change of the T2 values corresponds to the denaturation of specific proteins, especially Ovalbumin and Ovomucoid.

Conclusion

Both the relaxation times itself as well as the extrapolated amplitudes at t = 0 show interesting effects at different temperatures. The effects can be correlated to the denaturation temperatures of specific proteins existing in the egg.

Advantages

The Pure Devices Variable Temperature setup is a flexible tool to investigate the temperature dependency of materials during heating as well as cooling. The possibility of running arbitrary temperature profiles enables the researcher to study a wide variety of materials and effects.
The measurement is not limited to relaxation time measurements and can be combined with any MR sequence resulting in endless possibilities.

Possible further applications

- Temperature dependency of plastic materials
- Denaturation of biological samples
- Food industry
- Investigation of the viscosity at different temperatures
- many more...

pure devices
Pure Devices GmbH
Kettelerstr. 5-11
97222 Rimpar
GERMANY
www.pure-devices.com
info@pure-devices.com
Tel.: +49 (0) 9365 2069490
Fax: +49 (0) 9365 2069486