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Transient Hot Bridge

Thermal analysis of space food

THB-100

Introduction

In modern ages, space travel gets more and more interesting due to possible access to extraterrestrial resources and colonization projects. But of course, there are many problems that have to be solved and investigated first. Having access to enough good quality food is not as easy as it might seem as there are many circumstances in space that make it way more difficult than on earth. A lot of researchers and research methods are therefore trying to optimize that problems.

Experiment and methods

In the given example, a couple of space food packages (syringes with food gel) were investigated using a Linseis THB-100 instrument to determine the thermal conductivity of the gels. As a consequence of the limited amount of mass a rocket can carry into space, the food for space travel is usually compressed into liquid or gel form, containing all ingredients that are necessary, like salts, proteins, sugars, vitamins and others. Another advantage of the gel is that it can be “eaten” out of a syringe and is not flying around in the low gravity zone of free space.

However, the storage and transport within a spaceship is sometimes not ideal due to the low amount of space. It is often stored close to electrical parts or hot or cold parts that can affect the temperature of the gel and syringe. For that reason, the thermal conductivity of the food syringe gel was investigated at several temperatures. The results were taken over in calculations and simulations to optimize the storage and transport.

As a good method for testing the thermal conductivity of liquids in a temperature range close to room temperature, the THB-100 is the right choice. It can directly determine the thermal conductivity within some minutes quite easily without need of any further necessary sample preparation. The Sensor with a heating wire is just applied into the liquid, a definite amount of heat is transferred to the sample and at the edges of the sensor, the heat spread is measured, similar to a hot wire technique.

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Table 1. Experimental Conditions

Instrument	Linseis THB-100
Sensor Type	THB-K metal frame
Sample volume	100 ml food gel
Setup	Measurement in open glass, hanging sensor setup
Atmosphere	Air; Heated air in oven
Settings:	70 mW heating 60 s duration for single measurement

Results

Table 1 shows the THB results of the measurement of the food gel at several temperatures. The gel was put into a 150 ml glass and the THB-100 sensor was applied hanging from the top using a clamp construction, to make sure the sensor touches the liquid only and not the bottom or side of the glass. The measurement was then performed by heating the sensor with definite power for several times at each temperature step. The results are then taken from the average value at each temperature.

The result shows that the thermal conductivity is only slightly lower than water (water: 0.609 W/mK at 25°C). This makes sense as the main component is water, however the viscosity is much higher. Over temperature from RT to 100°C, the thermal conductivity is slightly decreasing from 0.588 W/mK to 0.548 W/mK because of the loss of water content. At around 90°C, the sample formed bubbles of evaporating water, however it did not start cooking at 100°C.

Temperature in °C	Lambda in W/(m·K)
24.6 +/- 0.5	0.588 +/- 0.003
50.1 +/- 0.5	0.579 +/- 0.003
74.9 +/- 0.5	0.565 +/- 0.003
99.7 +/- 0.5	0.548 +/- 0.003

Table 1: Results for thermal conductivity direct measurement for nutrition gel at several temperatures

Experimental

All samples were provided by a pharmaceutical company which may not be named here. The samples were final products as used as food for space travel and for nutrition of patients in critical state.

The measurements were performed using a THB-100 with type K sensor with metal frame.

The whole setup was placed in a drying oven to be able to heat it as the THB sensor can only apply local heat for measurement but not heat the sample in total. Before the measurement at each target temperature, it was waited for around 30 min to minimize convection within the sample.

Summary

The thermal conductivity of the special space food has shown to be slightly lower than water. This is an important result, as the right value can now be taken for simulations and calculations to optimize storage and transport. The value of water which was used before, is definitely higher and would lead to wrong results of calculations and therefore could in the worst case cause damage to the syringes or food packs.