Radiation Force Balance Test Compilation

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Last updated on:	August 2, 2023

Introduction

The purpose of this compilation is to document the radiation force balance tests that have been performed up to date. The methods and results are discussed for each test performed. The * next to the experiment date denotes that the experiment yielded results that are used to characterize the temperature dependence of the attenuation coefficient of pork muscle tissue, which is described in the Summary of Results.

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Summary of Results

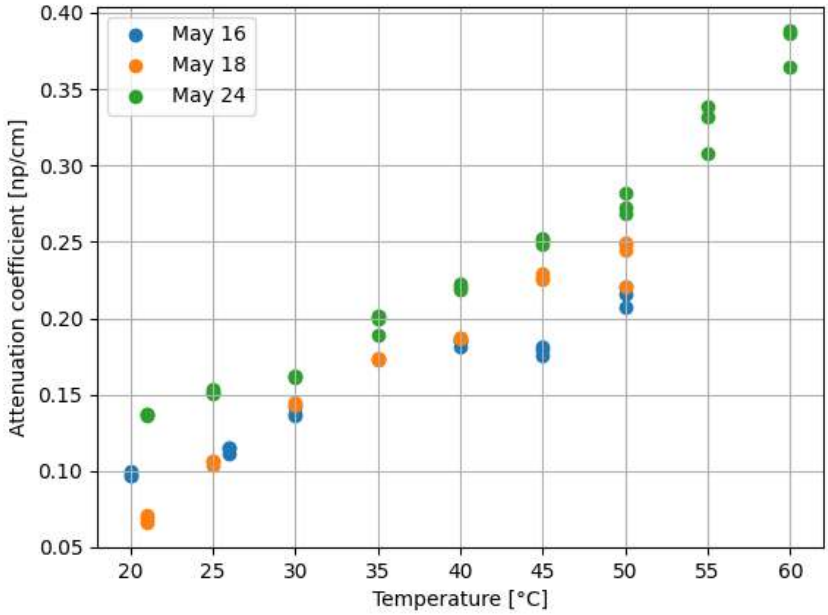


Figure 1: Temperature vs Attenuation at 476 kHz

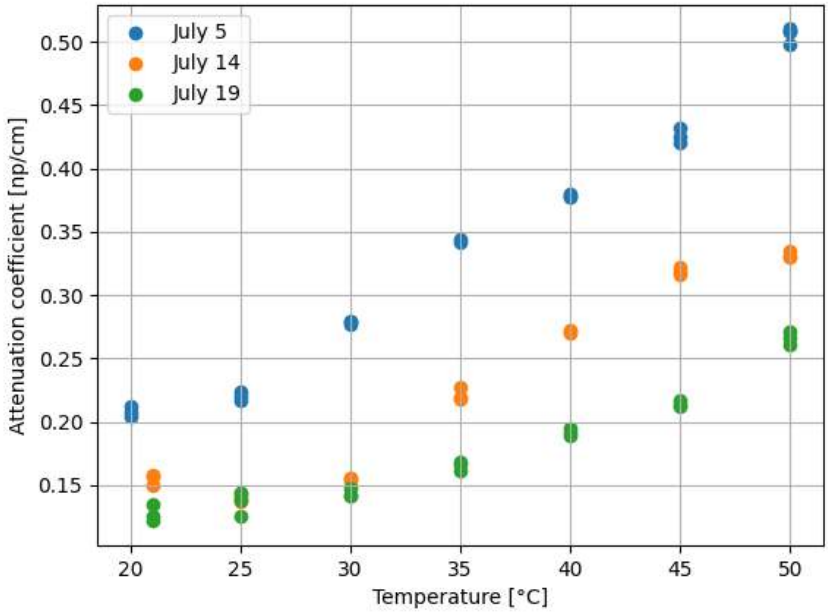


Figure 2: Temperature vs Attenuation at 1.5975 MHz

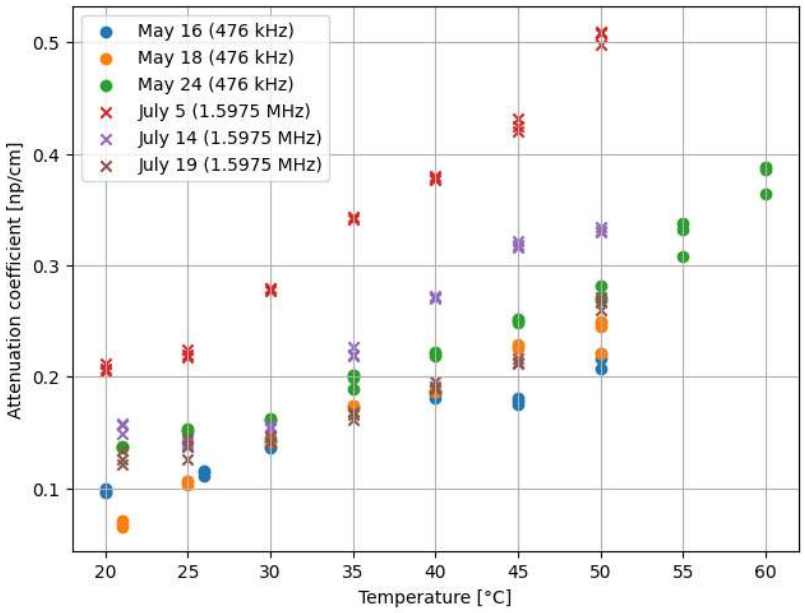


Figure 3: Temperature vs Attenuation

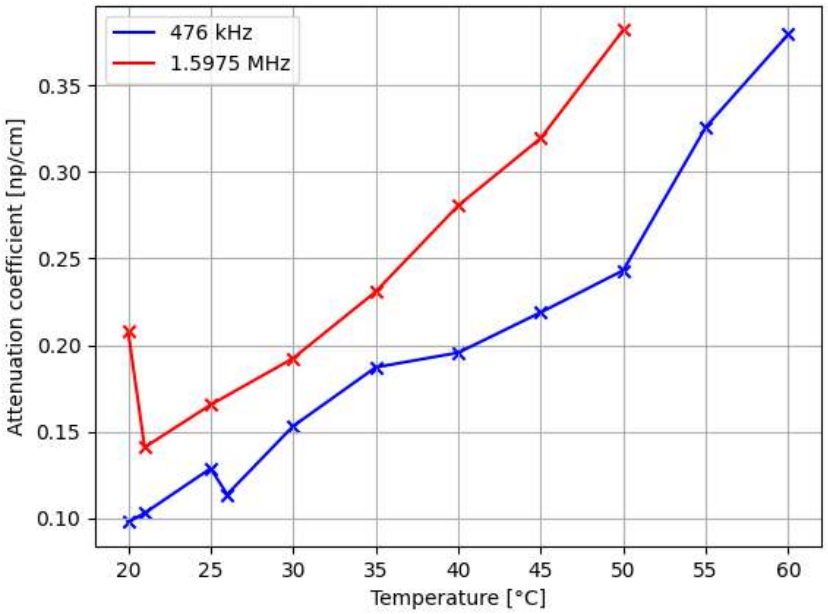


Figure 4: Temperature vs Attenuation (average values)

July 19, 2023: Pork Loin, 1.5975 MHz

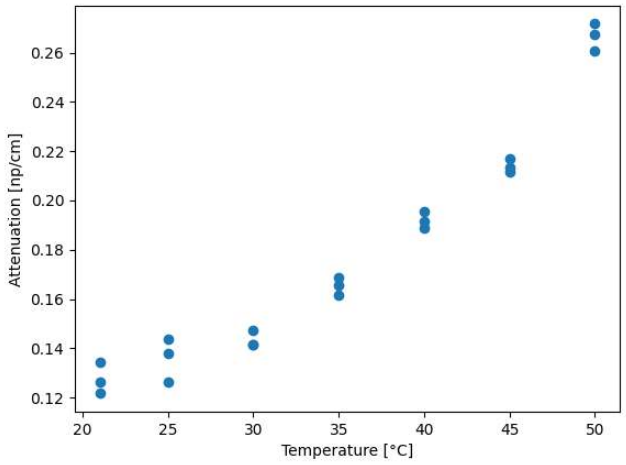
Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. Measurements are taken at 1.5975MHz, which is the 476kHz transducer operating on the third harmonic. Measurements are taken from 20°C (room temperature) to 50°C.

Methods

The test setup is shown in Figure 1. Deionized water was degassed for one hour before measurements were taken. The oxygen level in the water is 5.23ppm at the beginning of the experiment (see Figure 2). The pork phantom was prepared one day before the experiment. The phantom is 2.3cm thick and is packed with porkloin, and also isotonic saline solution is used to fill the air gaps in the phantom.

Results



T[C]	Freq [Hz]	P [W]	A [np/cm]
21	1597.5	50	0.1217
21	1597.5	50	0.1262
21	1597.5	50	0.1344
25	1597.5	50	0.1439
25	1597.5	50	0.1378
25	1597.5	50	0.1262
30	1597.5	50	0.1472
30	1597.5	50	0.1414
30	1597.5	50	0.1417
35	1597.5	50	0.1686
35	1597.5	50	0.1657
35	1597.5	50	0.1615
40	1597.5	50	0.1954
40	1597.5	50	0.1915
40	1597.5	50	0.1888
45	1597.5	50	0.2168
45	1597.5	50	0.2135
45	1597.5	50	0.2118
50	1597.5	50	0.2605
50	1597.5	50	0.2672
50	1597.5	50	0.2717

Figure 1: Temperature [°C] vs attenuation coefficient [np/cm] on July 19, 2023 plot (left) and table (right)

July 14, 2023: Pork Loin, 1.5975 MHz

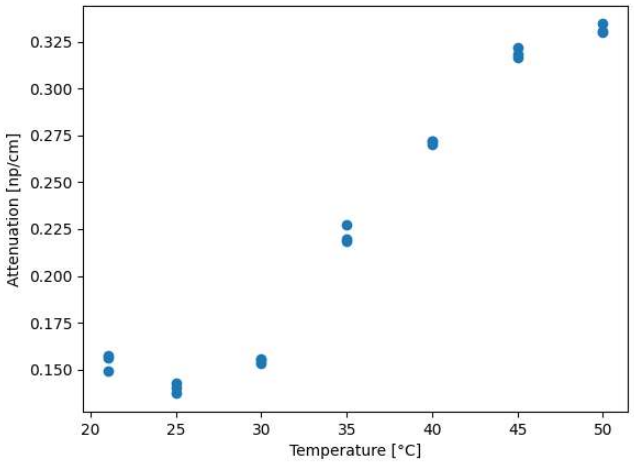
Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. Measurements are taken at 1.5975MHz, which is the 476kHz transducer operating on the third harmonic. Measurements are taken from 20°C (room temperature) to 50°C.

Methods

The test setup is shown in Figure 1. Deionized water was degassed for one hour before measurements were taken. The oxygen level in the water is 5.23ppm at the beginning of the experiment (see Figure 2). The pork phantom was prepared one day before the experiment. The phantom is 2.3cm thick and is packed with porkloin, and also isotonic saline solution is used to fill the air gaps in the phantom.

Results



T[C]	Freq [Hz]	P [W]	A [np/cm]
21	1597.5	50	0.1494
21	1597.5	50	0.1576
21	1597.5	50	0.1565
25	1597.5	50	0.1373
25	1597.5	50	0.1404
25	1597.5	50	0.1426
30	1597.5	50	0.156
30	1597.5	50	0.1533
30	1597.5	50	0.1552
35	1597.5	50	0.2273
35	1597.5	50	0.2186
35	1597.5	50	0.2195
40	1597.5	50	0.2717
40	1597.5	50	0.2722
40	1597.5	50	0.2702
45	1597.5	50	0.3165
45	1597.5	50	0.3185
45	1597.5	50	0.3217
50	1597.5	50	0.3345
50	1597.5	50	0.3303
50	1597.5	50	0.3308

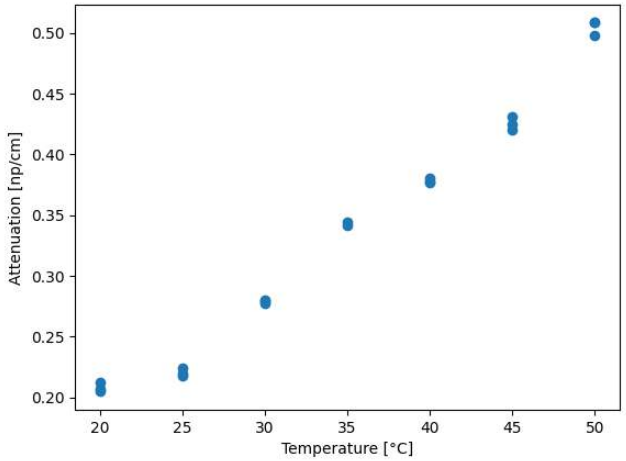
Figure 1: Temperature [°C] vs attenuation coefficient [np/cm] on July 14, 2023 plot (left) and table (right)

July 05, 2023: Pork Loin, 1.5975 MHz

Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. Measurements are taken at 1.5975MHz, which is the 476kHz transducer operating on the third harmonic. Measurements are taken from 20°C (room temperature) to 60°C. In this experiment, the power on the generator is set to 50W instead of 30W, and the pork phantom thickness is reduced from 3.5cm to 2.3cm. This is in an effort to increase the signal to noise ratio in the measurements, since this was an issue in the previous two experiments operating at the third harmonic.

Results



T[C]	Freq [Hz]	P [W]	A [np/cm]
20	1597.5	50	0.2072
20	1597.5	50	0.2048
20	1597.5	50	0.2121
25	1597.5	50	0.22
25	1597.5	50	0.2174
25	1597.5	50	0.2242
30	1597.5	50	0.2798
30	1597.5	50	0.2771
30	1597.5	50	0.2797
35	1597.5	50	0.344
35	1597.5	50	0.3414
40	1597.5	50	0.3772
40	1597.5	50	0.3802
40	1597.5	50	0.3776
45	1597.5	50	0.4206
45	1597.5	50	0.4247
45	1597.5	50	0.4315
50	1597.5	50	0.5084
50	1597.5	50	0.5084
50	1597.5	50	0.498
50	1597.5	50	0.5101

Figure 1: Temperature [°C] vs attenuation coefficient [np/cm] on July 5, 2023 plot (left) and table (right)

June 30, 2023: Pork Loin, 1.5975 MHz

Introduction

June 13, 2023: Pork Loin, 1.5975 MHz

Introduction

May 25, 2023: Pork Loin, 1.5975 MHz

Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. Measurements will be taken at 1.5975 MHz, which is using the 476 kHz on the 3rd harmonic setting. The purpose of this experiment is to measure the temperature-dependence of the attenuation of porkloin at 1.5975 MHz. Measurements will be taken from room temperature to 60°C.

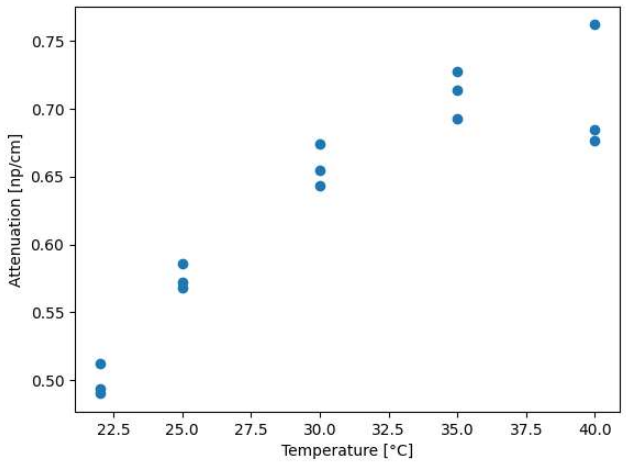
Methods

Deionized water was degassed for one hour before measurements were taken. The oxygen level in the water is 6.32ppm at the beginning of the experiment (see Figure 2). The pork phantom was prepared one day before the experiment. The phantom is 3.5cm thick and is packed with porkloin, and also isotonic saline solution is used to fill the air gaps in the phantom. Two Sous Vides are used to heat up the water in the tank to the desired temperature. The output on the power generator is set to 30W. The transducer used is the 476kHz transducer, operating on the third harmonic frequency. The weight data was collected using the LabVIEW VI.

Figure 1: May 25, 2023 image of porkloin phantom used (left) and oxygen level in water (right)

Results

The figure below shows the results from this experiment.



T[C]	A [np/cm]
22	0.4902
22	0.494
22	0.5127
25	0.5682
25	0.5726
25	0.5856
30	0.6546
30	0.6431
30	0.674
35	0.7278
35	0.714
35	0.6924
40	0.6767
40	0.762
40	0.6843

Figure 2: Temperature [°C] vs attenuation coefficient [np/cm] on May 24, 2023 plot (left) and table (right)

Discussion

After measurements were taken at 40°C, the experiment had to stop because the data was so noisy (see figure 3). When the transducer was powered on, the signal is almost indistinguishable through the pork phantom. So, although a trend is somewhat visible in this data, it cannot be trusted due to the measurement uncertainty. Another experiment should be performed in these same configurations to determine if something similar happens again.

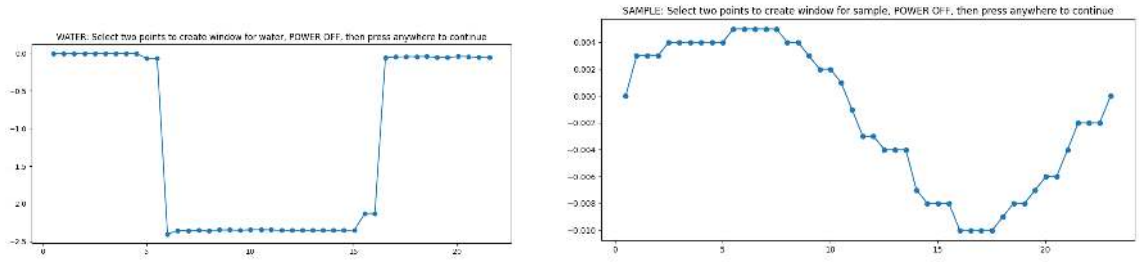


Figure 3: Raw signal at 40°C through water phantom (left) and through pork phantom (right). The axes numbers are not very visible in these figures: on the left, the mass ranges from 0 to -2.5g. On the right, the mass ranges from 0 to -0.010g

May 24, 2023: Pork Loin, 476kHz

Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. The experiment today is performed with the same test configurations as the test on May 16, 2023 and May 18, 2023, and the purpose of this experiment is to see how similar the results are to the test done on those two days. The only difference is that with this experiment, measurements will be taken from 21°C up to 60°C, instead of only up to 50°C as has been done in previous experiments.

Methods

The test setup is shown in Figure 1. Deionized water was degassed for one hour before measurements were taken. The oxygen level in the water is 5.23ppm at the beginning of the experiment (see Figure 2). The pork phantom was prepared one day before the experiment. The phantom is 3.5cm thick and is packed with porkloin, and also isotonic saline solution is used to fill the air gaps in the phantom.

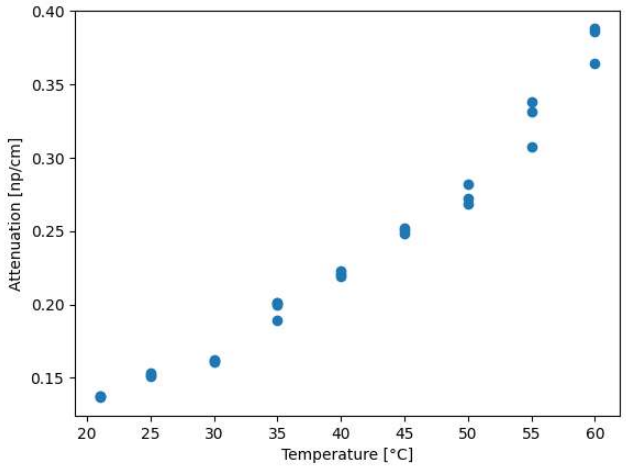
Figure 1: May 24, 2023 experiment setup plot (left) and image of porkloin phantom used (right)

Figure 2: Oxygen level in water for May 24, 2023 test

Two Sous Vides are used to heat up the water in the tank to the desired temperature. The output on the power generator is set to 30W. The transducer used is the 476kHz transducer, operating on the fundamental frequency. The weight data was collected using the LabVIEW VI.

Results

The figure below shows the plot of the attenuation coefficient of porkloin measured as a function of temperature ranging from 20°C to 60°C, and a table including all of the measured values.



T[C]	Freq [Hz]	Eff [%]	A [np/cm]
21	476	86.06	0.1377
21	476	85.72	0.1366
21	476	85.82	0.1377
25	476	80.16	0.1508
25	476	80.08	0.1533
25	476	79.61	0.1521
30	476	91.24	0.1612
30	476	91.34	0.1619
30	476	91.19	0.1624
35	476	86.11	0.1996
35	476	85.73	0.2016
35	476	85.46	0.2015
35	476	85.38	0.1895
40	476	91.01	0.2192
40	476	91.06	0.2211
40	476	91.21	0.2226
45	476	83.23	0.251
45	476	82.98	0.2486
45	476	82.98	0.2525
50	476	95.67	0.2689
50	476	95.68	0.272
50	476	96.56	0.2819
55	476	80.92	0.3383
55	476	80.9	0.3078
55	476	80.36	0.3316
60	476	81.49	0.3641
60	476	79.86	0.3863
60	476	78.16	0.3881

Figure 3: Temperature [°C] vs attenuation coefficient [np/cm] on May 24, 2023 plot (left) and table (right)

Discussion

Once again, the attenuation coefficient of pork inceeases approximately linearly from 20°C to 60 °C. The measurements at 55°C and 60°C are not as closely grouped as the measurements are at lower temperatures. This is reflective of how difficult it is to control these experiments in the higher temperature regimes.

When compared to the experiments performed on May 16, 2023 and May 18, 2023, the attenuation coefficient values are different across experiments at the same temperatures (which can be attributed to biological variability). However, the temperature-dependence trend is similar across those experiments.

May 18, 2023: Pork Loin, 476kHz

Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. Measurements will be taken from room temperature (20 °C) to 50°C. The experiment today is performed with the same test configurations as the test on May 16, 2023, and the purpose of this experiment is to see how similar the results are to the test done on the 16th.

Methods

The test setup is shown in Figure 1. Deionized water was degassed for one hour before measurements were taken. The oxygen level in the water is 4.89ppm at the beginning of the experiment (see Figure 2). The pork phantom was prepared one day before the experiment. The phantom is 3.5cm thick and is packed with porkloin, and isotonic saline solution is used to fill the air gaps in the phantom.

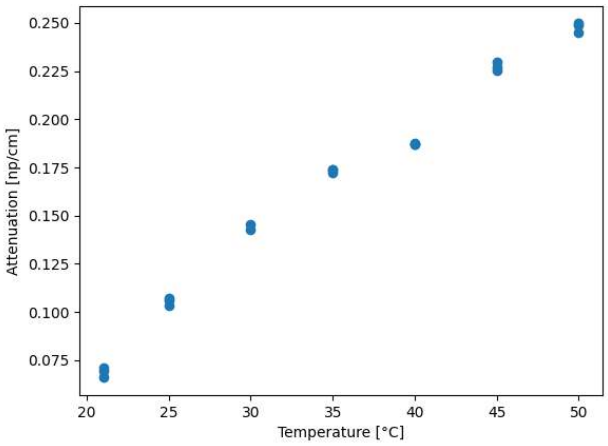
Figure 1: May 18, 2023 experiment setup plot (left) and image of porkloin phantom used (right)

Figure 2: Oxygen level in water for May 18, 2023 test

Two Sous Vides are used to heat up the water in the tank to the desired temperature. The output on the power generator is set to 30W. The transducer used is the 476kHz transducer, operating on the fundamental frequency. The weight data was collected using the LabVIEW VI.

Results

The figure below shows the plot of the attenuation coefficient of porkloin measured as a function of temperature ranging from 20°C to 50°C, and a table including all of the measured values.



Temperature[C]	Frequency [Hz]	Efficiency [%]	Attenuation [np/cm]
21	476	74	0.0659
21	476	74.5	0.0692
21	476	74.24	0.0708
25	476	87.72	0.1033
25	476	87.38	0.1063
25	476	87.4	0.1069
30	476	87.7	0.1427
30	476	89.22	0.1453
35	476	89.33	0.1723
35	476	89.4	0.1739
35	476	89.19	0.1741
40	476	79.41	0.1872
40	476	79.43	0.1875
40	476	79.07	0.1868
45	476	79.28	0.2253
45	476	79.56	0.2269
45	476	79.46	0.2296
50	476	85.12	0.2448
50	476	85.05	0.2497
50	476	85.31	0.2489

Figure 3: Temperature [°C] vs attenuation coefficient [np/cm] on May 18, 2023 plot (left) and table (right)

Discussion

The attenuation coefficient of pork increases approximately linearly from 20°C to 50°C. In addition, all of the attenuation measurements are precise and closely grouped to each other at the same temperatures.

This experiment is the second time in a row that the pork phantom was prepared using isotonic saline solution instead of deionized, degassed water. This also corresponds to the second experiment in a row where the results show a clear, consistent trend across the entire temperature range. This suggests that using isotonic saline solution makes a big difference when preparing the sample phantoms.

May 16, 2023: Pork Loin, 476kHz

Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. Measurements will be taken from room temperature (20 °C) to 50°C. The experiment today is performed with the same test configurations as the test on May 9, 2023, with one exception. In this test, the phantoms are prepared with porkloin and isotonic saline solution, as opposed to porkloin and degassed, deionized water.

Methods

The test setup is shown in Figure 1. Deionized water was degassed for one hour before measurements were taken. The oxygen level in the water is 0.37ppm at the beginning of the experiment.The pork phantom was prepared one day before the experiment. The phantom is 3.5cm thick and is packed with porkloin, and isotonic saline solution is used to fill the air gaps in the phantom. This marks a difference between this experiment and previous experiments, since phantoms were previously prepared by filling the air gaps with degassed, deonized water instead of saline solution.

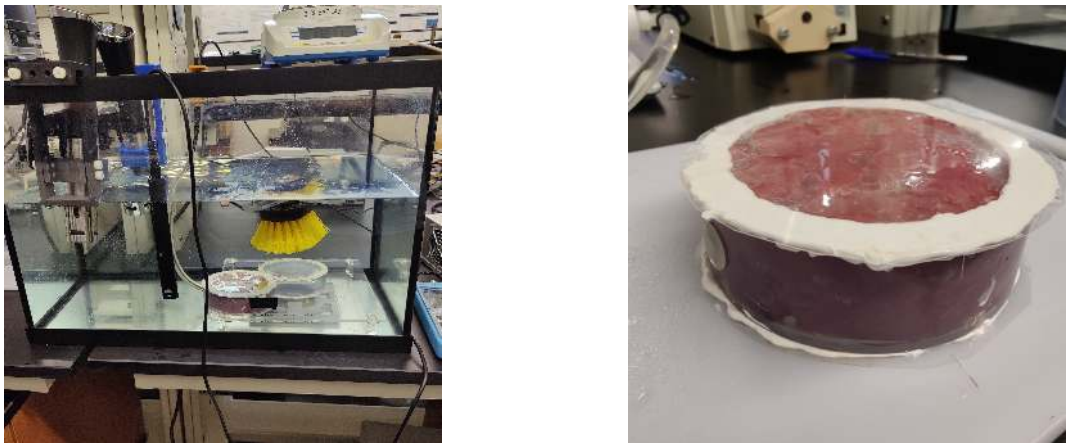


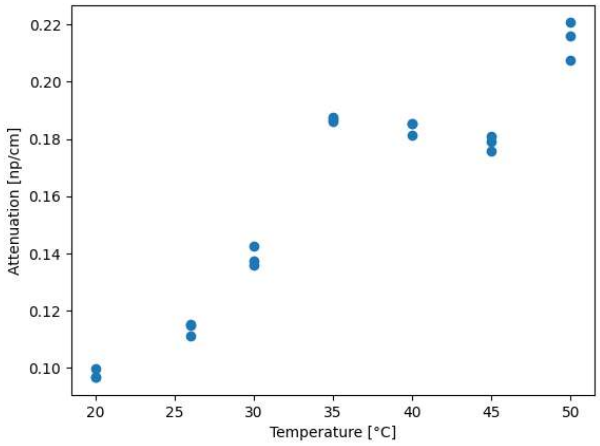
Figure 1: May 16, 2023 experiment setup plot (left) and image of porkloin phantom used (right)

Two Sous Vides are used to heat up the water in the tank to the desired temperature. The output on the power generator is set to 30W. The transducer used is the 476kHz transducer, operating on the fundamental frequency. The weight data was collected using the LabVIEW VI.

Figure 2: Oxygen level in water for May 9, 2023 test

Results

The figure below shows the plot of the attenuation coefficient of porkloin measured as a function of temperature ranging from 20°C to 50°C, and a table including all of the measured values.



Temperature [C]	Frequency [Hz]	Efficiency [%]	Attenuation [np/cm]
20	476	74.42	0.0967
20	476	73.83	0.0969
20	476	73.71	0.0998
26	476	75.86	0.1153
26	476	75.54	0.1148
26	476	74.05	0.1112
30	476	77.66	0.1425
30	476	77.27	0.1374
30	476	76.81	0.136
35	476	79.13	0.1878
35	476	78.12	0.1869
35	476	78.7	0.1863
40	476	91.75	0.1855
40	476	92.04	0.1853
40	476	91.63	0.1815
45	476	81.02	0.1811
45	476	81.04	0.1757
45	476	80.28	0.1793
50	476	76.39	0.2075
50	476	76.22	0.2162
50	476	75.79	0.2207

Figure 3: Temperature [°C] vs attenuation coefficient [np/cm] on May 16, 2023 plot (left) and table (right)

Discussion

The results from this experiment are promising, as a more visible trend is apparent between temperature and attenuation. As the temperature increases from 20 °C to 50 °C, the attenuation increases approximately linearly. It seems that using saline solution instead of degassed, deionized water in preparing the phantoms makes a difference. Futher tests should be done with these experiment configurations to see if a similar trend is observed.

May 9, 2023: Pork Loin, 476kHz

Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. Measurements will be taken from room temperature (20 °C) to 50°C. Since the experiment performed on March 28, 2023 did not produce meaningful results, the experiment today is an attempt to perform the same test and eliminate the experimental error. Last time, air bubbles formed in the pork phantom after a short amout of time. This time, better care was taken during the phantom preparation to prevent air bubbles from occurring in the phantom.

Methods

The test setup is shown in Figure 1. Deionized water was degassed for one hour before measurements were taken. The oxygen level in the water is 0.60ppm (7.4%) at the beginning of the experiment (see Figure 2).

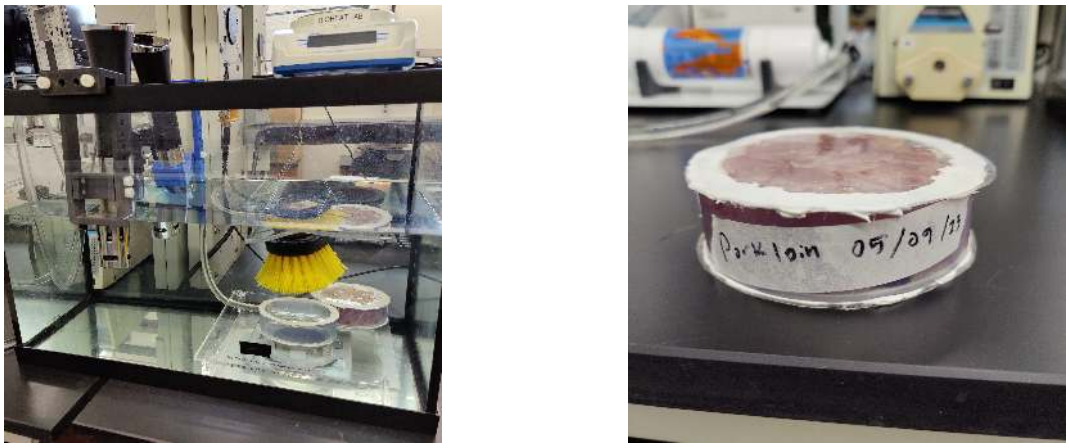


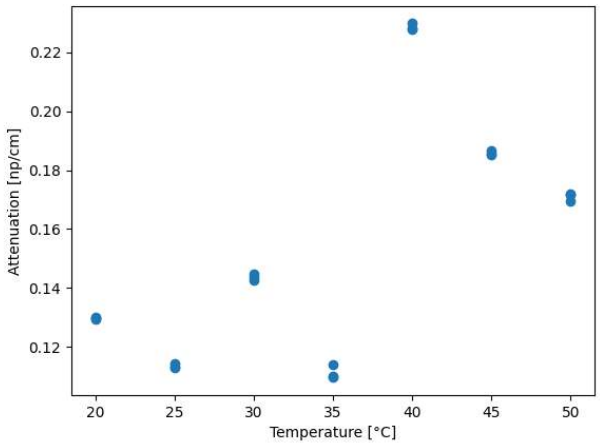
Figure 1: May 9, 2023 experiment setup plot (left) and image of porkloin phantom used (right)

Figure 2: Oxygen level in water for May 9, 2023 test

Two Sous Vides are used to heat up the water in the tank to the desired temperature. The output on the power generator is set to 30W. The transducer used is the 476kHz transducer, operating on the fundamental frequency. The weight data was collected using the LabVIEW VI.

Results

The figure below shows the plot of the attenuation coefficient of porkloin measured as a function of temperature ranging from 20°C to 50°C, and a table including all of the measured values.



Temperature [C]	Frequency [Hz]	Efficiency [%]	Attenuation [np/cm]
20	476	89.1	0.130
20	476	88.7	0.130
20	476	89.0	0.130
25	476	88.8	0.114
25	476	88.0	0.114
25	476	87.7	0.113
30	476	76.7	0.143
30	476	76.9	0.142
30	476	76.6	0.145
35	476	89.2	0.114
35	476	89.1	0.110
35	476	89.1	0.109
40	476	87.7	0.230
40	476	88.1	0.228
40	476	87.6	0.228
45	476	96.5	0.186
45	476	96.1	0.185
45	476	95.9	0.186
50	476	90.0	0.170
50	476	89.9	0.172
50	476	90.1	0.172

Figure 3: Temperature [°C] vs attenuation coefficient [np/cm] on May 9, 2023 plot (left) and table (right)

The plot below shows how the mass difference for the water sample and the pork sample changes with respect to temperature.

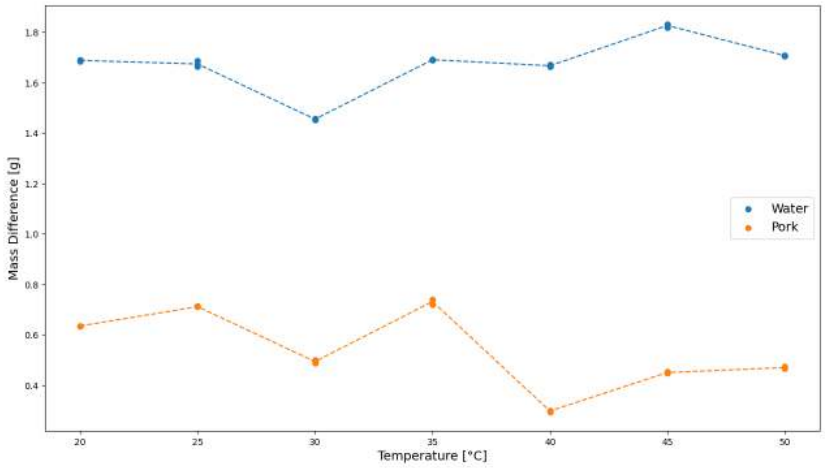


Figure 4: Temperature vs change in mass reading on scale for water and pork

The image below shows the pork phantom after the experiment. After heating up to 50°C, the pork appears cooked. Also, although there are air bubbles apparent closer to the sides of the phantom, there are, more importantly, no apparent air bubbles in the middle.

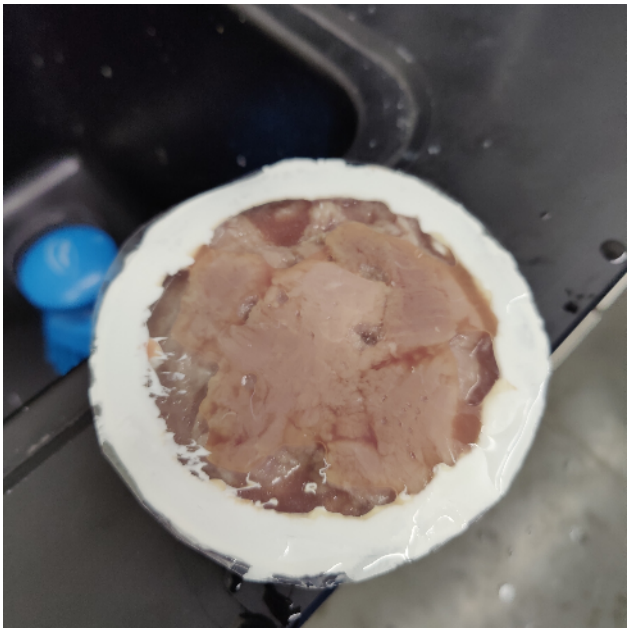


Figure 5: Pork phantom after experiment. Appears cooked, and no apparent air bubbles in the center of the phantom

Discussion

The results from this experiment are interesting for a couple of reasons. First, one promising observation from this test is the precision of the measurements. At any given temperature, the measurements are very closely grouped together. It is also worth noting that the oxygen level did not change significantly during the experiment (0.60ppm to begin and 0.65ppm to end).

However, the results do not show any conclusive relationship between the temperature of the water bath and the attenuation coefficient of the porkloin. This prompted an investigation into how the measured mass difference raw data changed with respect to temperature. Figure 4 shows that even the mass differences measured in the water phantom are not consistent with temperature. Further investigation should be done to conclude the significance of this observation.

March 28, 2023: Pork Loin, 476kHz

Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. Measurements will be taken from room temperature (21 °C) to 50°C. This experiment is an attempt to replicate the results obtained on December 20, 2022. The reason that there is such a long time in between experiments is because

1. The 3-D sample holder used in the previous experiment melted during the test, so a new sample holder needed to be manufactured out of acrylic.
2. The python code used to process the data needed various modifications to make it more robust. The new data processing method is captured in the radiation force balance lab manual.

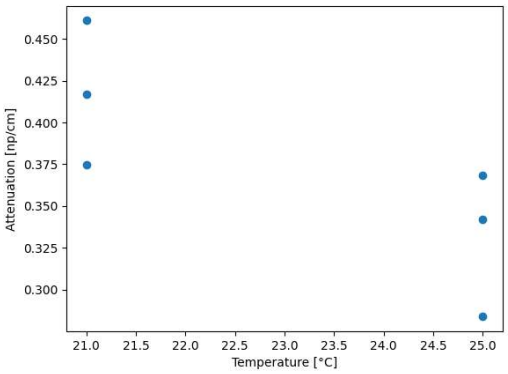
Methods

Deionized water was degassed for one hour before measurements were taken. Two Sous Vides are used to heat up the water in the tank to the desired temperature. The output on the power generator is set to 30W, and the signal is turned on for 10 seconds for every measurement using REALTERM. The transducer used is the 476kHz transducer, operating on the fundamental frequency. The weight data was collected using the LabVIEW VI.

Figure 1: March 28, 2023 experiment setup plot (left) and image of porkloin phantom used (right)

Results

The results of this experiment did not go as planned. The attenuation measurements do not match expectations, and are notably imprecise. Beginning at 30°C, the attenuation measurements are ”nan.” Obviously, something is wrong with the experimental setup.



Temperature [C]	Frequency [Hz]	Efficiency [%]	Attenuation [np/cm]
21	476	81.71	0.4609
21	476	81.78	0.417
21	476	81.02	0.3745
25	476	83.77	0.3684
25	476	83.55	0.3421
25	476	83.08	0.2839
30	476	85.37	nan
30	476	85.03	nan
30	476	-0.1	nan

Figure 2: Temperature [°C] vs attenuation coefficient [np/cm] on March 28, 2023 plot (left) and table (right)

The raw signals with the water phantom look normal; however, the raw signals for the power measurements with the pork phantom show that there is something wrong with the pork phantom.

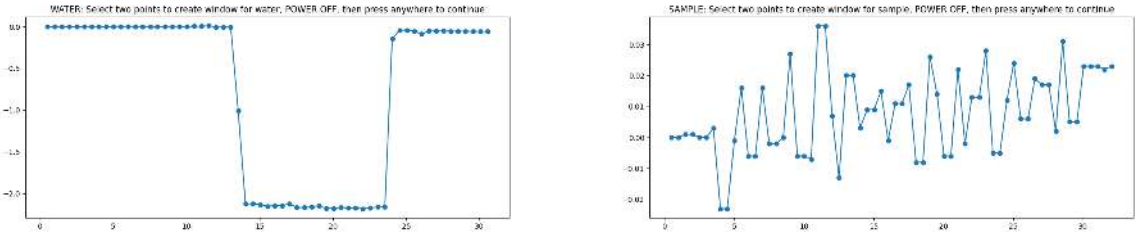


Figure 3: Temperature [°C] vs attenuation coefficient [np/cm] on March 28, 2023 plot (left) and table (right)

Discussion

The figure below shows images of the pork phantom used in this test. One problem is that although at there did not appear to be any air in the phantom at the beginning of the test, air bubbles were apparent in the phantom by the end of the test. This could be a result of not properly sealing the phantom with degassed water to fill the gaps between the pork. Also, the mylar became detached during the test.

Figure 4: Air bubbles formed in the pork phantom (left) and mylar becomes detached from acrylic (right)

The results from this experiment are **not meaningful**. A better job needs to be done next time to make sure the pork phantom is well prepared for the experiment in order to obtain meaningful results.

Raw Data

The raw data for this experiment can be found at: raw data 03-28-2023

December 20, 2022: Pork Loin, 476kHz

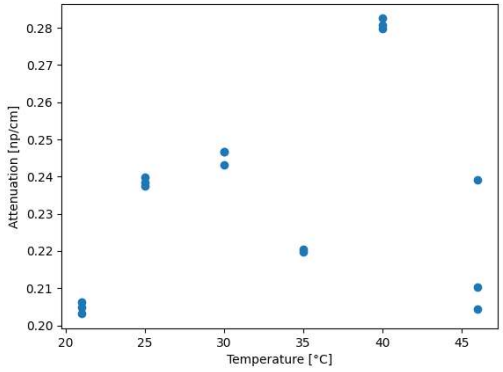
Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. Measurements will be taken from room temperature (21 °C) to 50°C.

Methods

This test was the first test run with degassed water. Deionized water was degassed for one hour before measurements were taken. This eliminated air bubbles from appearing in the tank, which was a problem in the test performed on December 16, 2022. Two Sous Vides are used to heat up the water in the tank to the desired temperature. The output on the power generator is set to 30W. The transducer used is the 476kHz transducer, operating on the fundamental frequency. The weight data was collected using the LabVIEW VI.

Results



Temperature [C]	Frequency [Hz]	Efficiency [%]	Attenuation [np/cm]
21	476	75.9	0.2031
21	476	76.04	0.2049
21	476	76.77	0.2062
25	476	75.8	0.2374
25	476	76.38	0.2384
25	476	76.12	0.2399
30	476	67.35	0.2466
30	476	67.61	0.2468
30	476	67.29	0.2431
35	476	69.68	0.2198
35	476	68.42	0.2204
40	476	64.41	0.2807
40	476	60.49	0.2798
40	476	59.88	0.2825
46	476	62.46	0.239
46	476	63.73	0.2103
46	476	64.18	0.2043

Figure 1: Raw signal plots for the water phantom (left) and pork phantom (right)

Discussion

On the test performed on December 16, 2022, one of the observations was that air bubbles formed in the tank at high temperatures. Degassing the water prior to the test eliminated this issue, even at high temperatures. Other issues observed on the December 16th test was that the porkloin started to cook at high temperatures, and that the measurements are much less precise at these temperatures. This happened again on this test. The pork cooked in the same way, and the data points are more spread out at 45°C than they are for the rest of the experiment. Also, the 3-D printed sample holder used in the experiment began to melt at high temperatures. So, a new sample holder will be made out of acrylic before the next test.

Again, a positive relationship is observable between the temperature of the water and the attenuation coefficient of the porkloin. The relationship becomes less clear around 45°C. Also, at 35°C, the measured attenuation coefficient appears to be a bad measurement. Further tests should be performed in the higher temperature regions (35°C to 50°C) to better characterize the relationship between temperature and attenuation.

Raw Data

The files for the raw data and the raw signal plots can be found at:

- Raw data 12-20-2022
- Raw signal plots 12-20-2022

December 16, 2022: Pork Loin, 476kHz

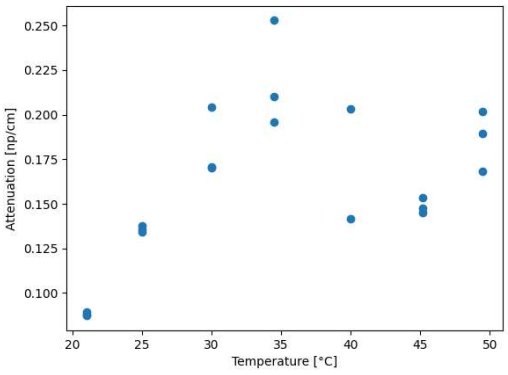
Introduction

The purpose of this experiment is to measure the attenuation coefficient of porkloin as a function of temperature. This test marks the first time that a temperature-dependent test will be performed from room temperature up to 50°C. Also, this test marks the first time that pork loin is used instead of pork shoulder. Pork shoulder is laced with fat, and therefore is not a good sample to use in radiation force balance tests. Pork loin, on the other hand, is much more homogenous and represents human tissue better than pork shoulder.

Methods

The water in the tank is deionized water. Two Sous Vides are used to heat up the water in the tank to the desired temperature. The output on the power generator is set to 30W. The transducer used is the 476kHz transducer, operating on the fundamental frequency. The weight data was collected using the LabVIEW VI.

Results



Temperature [C]	Frequency [Hz]	Efficiency [%]	Attenuation [np/cm]
21	476	85	0.0877
21	476	84.16	0.0872
21	476	84.18	0.0896
25	476	78.93	0.1343
25	476	79.53	0.1359
25	476	79.06	0.1378
30	476	83.63	0.1709
30	476	83.68	0.1702
30	476	84.3	0.2041
34.5	476	82.8	0.1957
34.5	476	82.66	0.2102
34.5	476	83.37	0.2529
40	476	90.48	0.1417
40	476	84.95	0.2031
45.2	476	52.27	0.1476
45.2	476	49.83	0.1534
45.2	476	47.17	0.1452
49.5	476	53.48	0.2017
49.5	476	48.24	0.1682
49.5	476	46.56	0.1892

Figure 1: Temperature [°C] vs attenuation coefficient [np/cm] on December 16, 2022 plot (left) and table (right)

Discussion

There appears to be a linear correlation between temperature and attenuation at lower temperatures (approximately room temperature to 35°C). Howeveer, in higher temperature regions (¿35°C), the relationship between temperature and attenuation is less predictable. Some observations from the test include:

- The pork is beginning to cook at higher temperatures (See figure 2). At this point it is unclear how this affects the attenuation measurements, and if meaningful conclusions can be drawn from this experiment.
- Air bubbles form in the water tank at higher temperatures. This definitely affects attenuation measurements and can be the cause of imprecision.
- The scale readings are much more unstable at higher temperatures. This is most likely because the temperature of the water decreases more rapidly at higher temperatures, so the scale readings are fluctuating more chaotically.

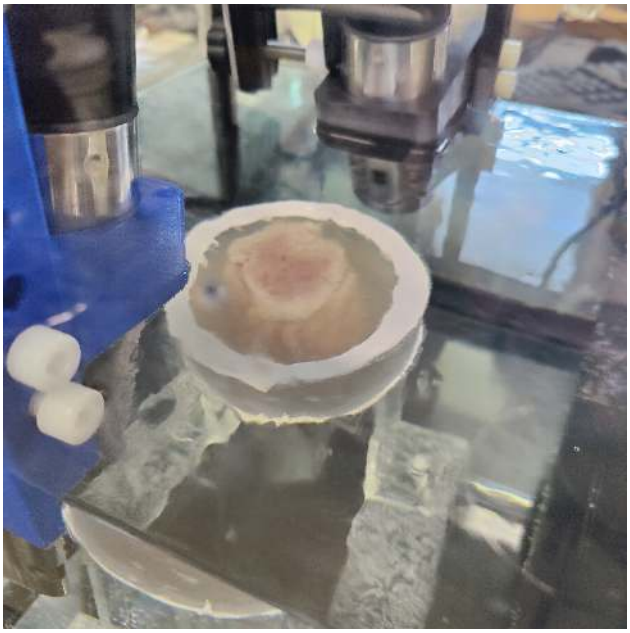


Figure 2: The porkloin cooks at higher temperatures, potentially negatively affecting the attenuation measurements

Going forward, attempts will be made to minimize the discussed experimental error.

Raw Data

The files for the raw data can be found at: raw data 12-16-2022

December 2, 2022: Pork Shoulder, 476kHz

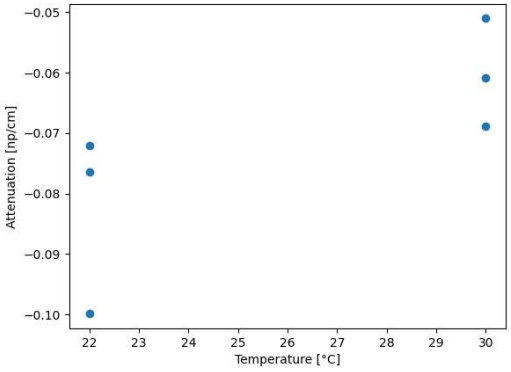
Introduction

The purpose of this experiment is to measure the attenuation coefficient of pork shoulder at room temperature (21°C) and at 30°C. This marks the first attempt at measuring the relationship between the temperature of the water tank and the attenuation coefficient of the sample.

Methods

A sample phantom was created using pork shoulder. The temperature of the water tank is changed to the desired temperature using a Sous Vide. The output on the power generator was set to 30W. Three attenuation measurements are taken at each temperature. The transducer used is the 476kHz transducer, operating on the fundamental frequency. The weight data was collected using the LabVIEW VI.

Results



Temperature [C]	Frequency [Hz]	Efficiency [%]	Attenuation [np/cm]
22.0	476	130.15	-0.0999
22.0	476	132.2	-0.0764
22.0	476	131.03	-0.0721
30.0	476	133.15	-0.051
30.0	476	146.39	-0.0608
30.0	476	151.25	-0.0689

Figure 1: Temperature [°C] vs attenuation coefficient [np/cm] on December 2, 2022 plot (left) and table (right)

Discussion

The absolute value of the attenuation coefficient measurements decreases from 22°C to 30 °C, which does not reflect expectations. Also, the measurements at both temperatures are not precise. This is the third test in a row where measurements of pork shoulder are not precise. This leads me to believe that pork shoulder is not a good tissue surrogate, and another sample needs to be identified for future tests.

Raw Data

The raw data for this experiment can be found at: raw data 12-02-2022

December 1, 2022: Pork Shoulder, 476kHz

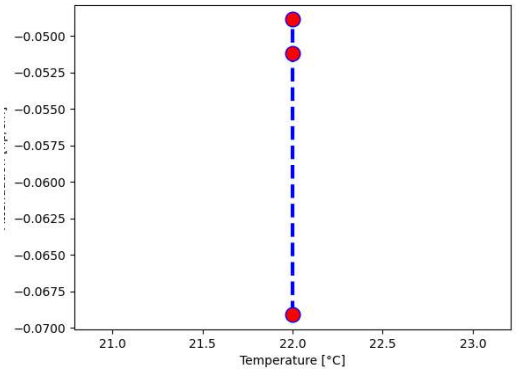
Introduction

The purpose of this experiment is to measure the attenuation coefficient of pork shoulder at room temperature (21°C). The intention is to replicate the results obtained on November 7, 2022

Methods

A pork phantom was prepared with pork shoulder. The output on the power generator was set to 30W. The transducer used is the 476kHz transducer, operating at fundamental frequency. The weight data was collected using the LabVIEW VI.

Results



Temperature [C]	Frequency [Hz]	Efficiency [%]	Attenuation [np/cm]
22.0	476	86.09	-0.0691
22.0	476	75.68	-0.0512
22.0	476	75.71	-0.0489

Figure 1: Attenuation coefficient of pork shoulder [np/cm] measured on December 1, 2022 plot (left) and table (right)

Discussion

The values for the attenuation coefficient of pork shoulder vary between -0.0691 and -0.0489 np/cm at room temperature for the three measurements. Again, these measurements are not very precise. Also, the attenuation values do not reflect the results obtained on November 7, 2022, which was a test performed under the same conditions. Further tests should be done to see if the values for attenuation can be repeated.

Raw Data

The raw data for this experiment can be found at: raw data 12-01-2022

November 7, 2022: Pork Shoulder, 476kHz

Introduction

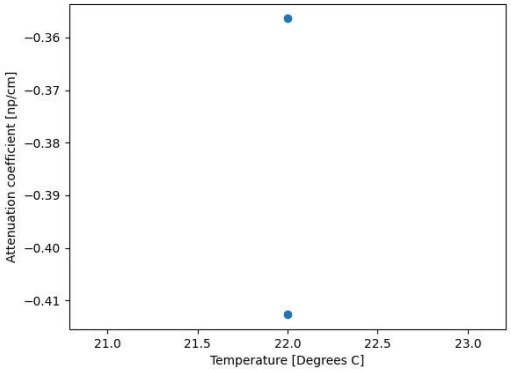
The purpose of this experiment is to measure the attenuation coefficient of pork shoulder at room temperature (21°C). The test conditions are a major improvement from the previous test conditions because:

1. The data collection is done on LabVIEW instead of by observing the scale and manually recording weight values
2. A python program was developed to process the data instead of processing it manually using Excel.

Methods

A pork phantom was prepared with pork shoulder. The output on the power generator was set to 30W. The transducer used is the 476kHz transducer, operating at fundamental frequency. The weight data was collected using the LabVIEW VI.

Results



Temperature [C]	Frequency [Hz]	Efficiency [%]	Attenuation [np/cm]
22.0	476	95.45	-0.4127
22.0	476	85.26	-0.3564

Figure 1: Attenuation coefficient of pork shoulder [np/cm] measured on December 1, 2022 plot (left) and table (right)

Discussion

The values for the attenuation coefficient of pork shoulder vary between -0.3564 and -0.4127 np/cm at room temperature for the two measurements. These measurements are not very precise. Further tests should be done to see if the values for attenuation can be repeated in the same conditions.