Module 9 - Example Experiment: T_2 of Bound Water in Capillary Tubes

Research Question:

What effect does capillary tubes placed in the sample tube have on the T_2 time of water?

Hypothesis to test:

Water with the capillary tubes inside will have a short T_2 time because there is less molecular mobility. Furthermore, samples with more capillary tubes will have more bound water as opposed to free water, and the T_2 times for these samples will be shorter than samples with less capillary tubes.This experiment is based on experiments which uses NMR to measure T_2 relaxation times in bone and determine bone porosity.[1]

Procedure:

Measure the T_2 time of a sample tube of D_2O and tap water using a repeated Hahn echo experiment (CPMG). Place one capillary tube inside the sample tube and repeat. We used capillary tubes with a 1.0 mm outer diameter and 0.75 mm inner diameter. Repeat with 2, 3, and 4 capillary tubes in the sample tubes (or up to as many as you like).

Prediction:

Because the water bound by the capillary tubes experiences less molecular motion, the sample with the capillary tubes will have a lower T_2 time than that without.

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[1] Barbieri, Marco et al. "Characterization of Structural Bone Properties through Portable Single-Sided NMR Devices: State of the Art and Future Perspectives." International Journal of Molecular Sciences 22.14 (2021): 7318. Available online here.
Wang, Xiaodu, and Qingwen Ni. "Determination of Cortical Bone Porosity and Pore Size Distribution Using a Low Field Pulsed NMR Approach." Journal of Orthopaedic Research 21.2 (2003): 312–319. Available online here.

Data:

T2 Relaxation Times of Water Samples With Capillary Tubes
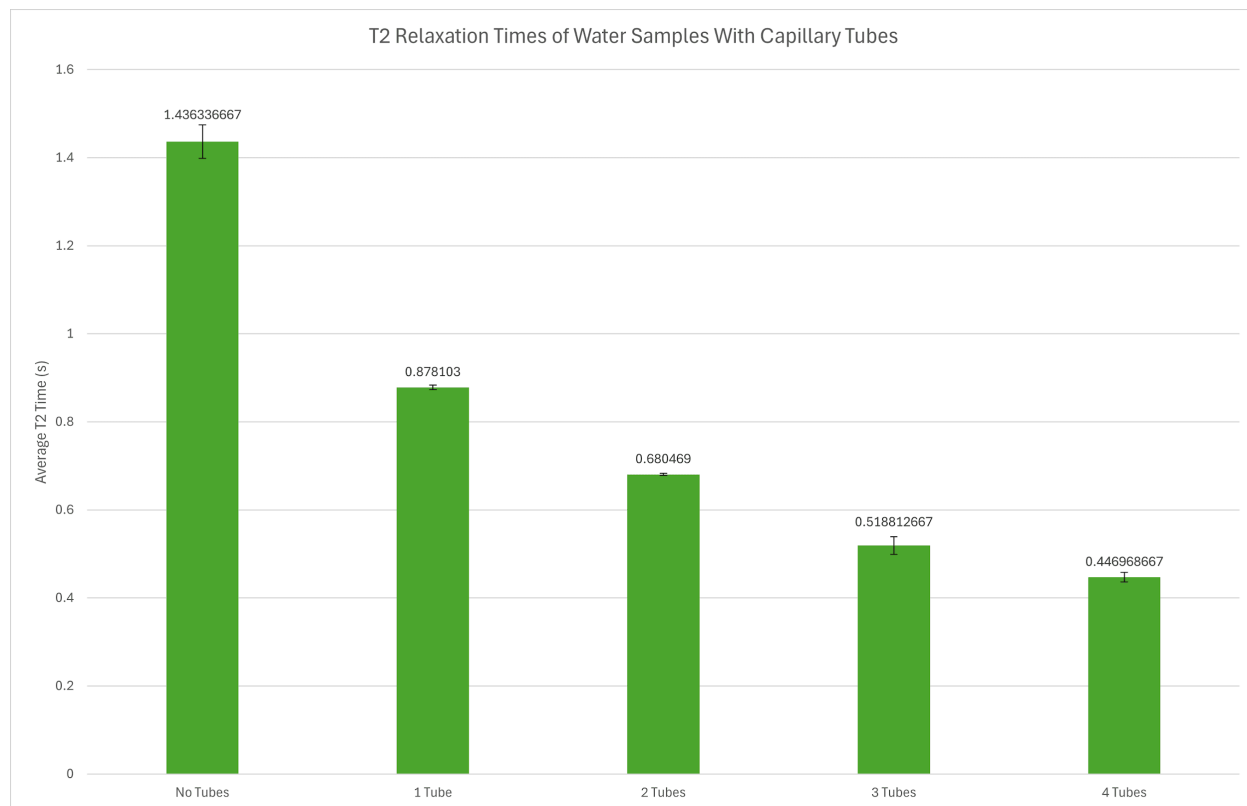
1/T2 versus Number of Capillary Tubes Added

● 1/T2 ━ 0.387*x + 0.72 R² = 0.996
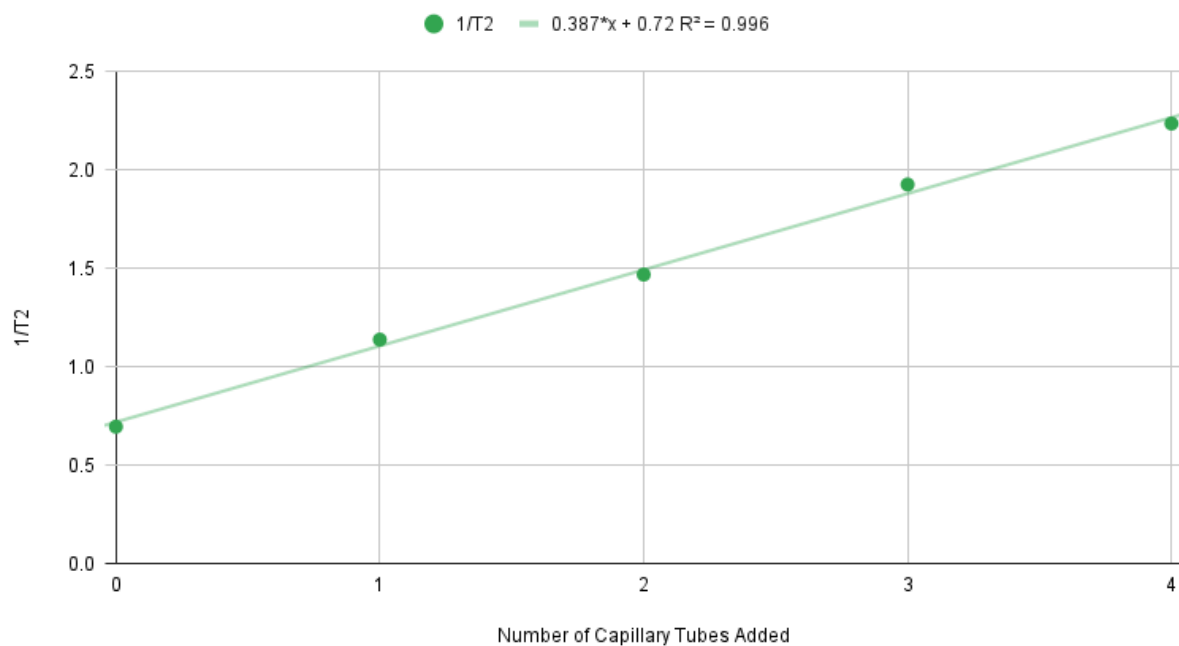
Analysis:

The T_2 relaxation time of the samples with the capillary tubes is significantly lower than that of the sample without the capillary tubes. The T_2 time decreases with the amount of capillary tubes in the sample. The data also shows a positive, linear relationship between the number of capillary tubes in the sample and the reciprocal of the T_2 relaxation time.

Conclusions:

We have confirmed our hypothesis that the water with the capillary tubes will have a lower T_2 time than the sample without the capillary tubes, and that more capillary tubes placed in the sample will lower the T_2 time.