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The Mpemba Effect is not valid - Hot Water does not freeze faster than the Cold Water

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Abstract

The Mpemba effect is the name given to the counter-intuitive assertion that it is quicker to cool water of higher temperature than water of relatively lower temperature. In this study, an attempt is made at observing a peculiar effect called "Mpemba effect" on pure water in sealed containers. The available evidence for the Mpemba effect was examined and carried out my own experiment by cooling water in carefully controlled conditions. However, it was observed that cold water freezes faster than the hot water, as common sense would apply. With the help of a simple experiment, this article shows that there is no evidence to support meaningful observations of the Mpemba effect.

Key words: Mpemba effect, Titanium Dioxide

Introduction

The controversial "Mpemba effect" according to which water can sometimes freeze faster than if preheated first, have been discussed since the time of Aristotle. Osborne experimented on the issue back at his workplace and confirmed Mpemba's finding and published the results together in 1969.[1] Several causes for this effect were suggested, including frost melting [2], dissolved gases [1], super-cooling, convection currents [4] and evaporation [2] [5]. Monwhea Jeng proposes a more precise statement: There exists a set of initial parameters, and a pair of temperatures, such that given two bodies of water identical in these parameters, and differing only in initial uniform temperatures, the hot one will freeze sooner. [2]

However, even with this definition it is not clear whether "freezing" refers to the point at which water forms a visible surface layer of ice; the point at which the entire volume of water becomes a solid block of ice; or when the water reaches 0 °C (32 °F).[3] With the above definition there are simple ways in which the effect might be observed: For example, if the hotter temperature melts the frost on a cooling surface and thus increases the thermal conductivity between the cooling surface and the water container.[3] On the other hand, there may be many circumstances in which the effect is not observed. [3]

The aim of this work is to present an investigation of the Mpemba effect, and determine whether the effect actually exists in any meaningful manner.

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Material and Method

Twelve 16 mm wide by 50 mm tall borosilicate glass flasks were used with polythene-lined screw-caps. All flasks were first rinsed several times with triple distillate water.

6 flasks were filled with 5ml of distilled water and the other 6 flasks were filled with 0.0001% suspension of Titanium Dioxide (TiO_2) nanoparticles to provide a support for nucleation and avoid super-cooling. It was purchased from Merck Specialties Private Limited, India. All flasks were then sealed. 6 flasks were placed in an oven at 90°C for 60 minutes; 3 containing pure water, which will be referred to as "PH" (Pure-Hot), 3 containing the suspension of titanium dioxide, which will be referred to as "NH" (Nucleated-Hot).

The other 6 flasks were kept at room temperature (22°C). The three remaining flasks containing pure water will be referred to as "PC" (Pure-Cold) while the three containing the Titanium Dioxide (TIO_2) suspension will be referred to as "NC" (Nucleated-Cold).

All flasks were then transferred to a freezer at -14°C and watched in every once in a while.

Results and Conclusion

At t=23 minutes after introduction into the freezer, all three PC flasks contained liquid water, which instantly froze partly once shaken indicating super-cooling of water. All three NC flasks contained both ice and the liquid. All PH and NH flasks were completely liquid, and remained so when shaken.

At t=37 minutes after introduction into the freezer, all PC and NC flasks were partly frozen. All three PH flasks contained liquid, but partly frozen once shaken, indicating super-cooling. All three NH flasks were partly frozen.

Things stayed the same with all flasks partly frozen until t=153 minutes, where all PC and NC flasks were fully frozen, but PH and NH flasks still contained a little bit of liquid water. By this point of time, the freezer temperature had risen up to -8°C due to frequent opening of its door, and it was decide not to go further in order not to risk ruining every sample it contained.

An attempt was made at observing the Mpemba effect using pure water and sealed containers and despite my best efforts, I was not able to make observations of any physical effects which could reasonably be described as the Mpemba effect. However, it was observed that cold water freezes faster than hot water, as common sense would apply. And this is not just an esoteric finding about a quirk of nature. If the Mpemba effect really did exist, it would have significant implications for thermodynamics. It would mean that water molecules have a kind of memory of their earlier state or states and that would mean having to update thermodynamic tables to include not only what the temperature of the water is but also what it was before. If Mpemba effect exists, it would make thermodynamics a lot more complicated. Hence, there was no observation of any physical effect which could reasonably define the Mpemba effect.

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