Quantification of high temperature stability of stone wool

Jensen, Peter Grouleff; Belmonte, Louise; Yue, Yuanzheng

Publication date:
2022

Document Version
Other version

Quantification of High Temperature Stability of Stone Wool

AALBORG UNIVERSITET

Peter G. Jensen[1,*], Louise Belmonte[2], Yuanzheng Yue[1]

[1]Department of Chemistry and Bioscience, Aalborg University, 9220 Aalborg East, Denmark

[2]ROCKWOOL A/S, 2640 Hedehusene, Denmark

**Presenting author: petergj@bio.aau.dk*

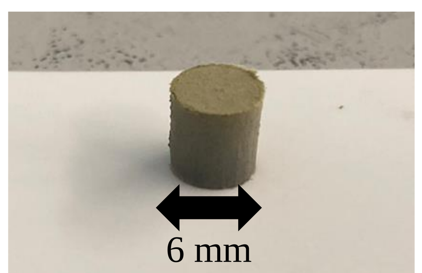
Introduction

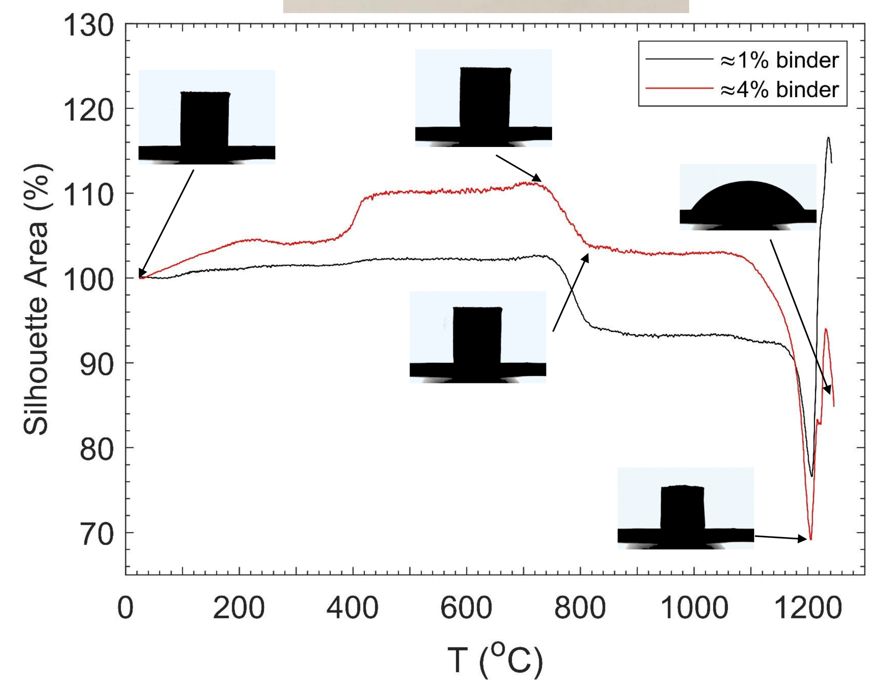
Stone wool is a widely used material for insulation. A key property which sets stone wool apart from other insulation materials is stone wool's ability to maintain its shape at very high temperatures. This high temperature stability (HTS) is important in relation to construction fires where a good HTS of insulation materials slows down the spread of the fire which is critical for saving lives and property. The causes for stone wool's excellent HTS are numerous and complex[1,2]. In order to study and understand the behaviour of stone wool at high temperatures, a method for investigating the dynamic deformation of stone wool at high temperatures in situ is needed. Here we present the preliminary work on such a method. With this method we will be able to shed light on new details of stone wool's HTS and hopefully contribute to improving stone wool's already excellent fire related properties.

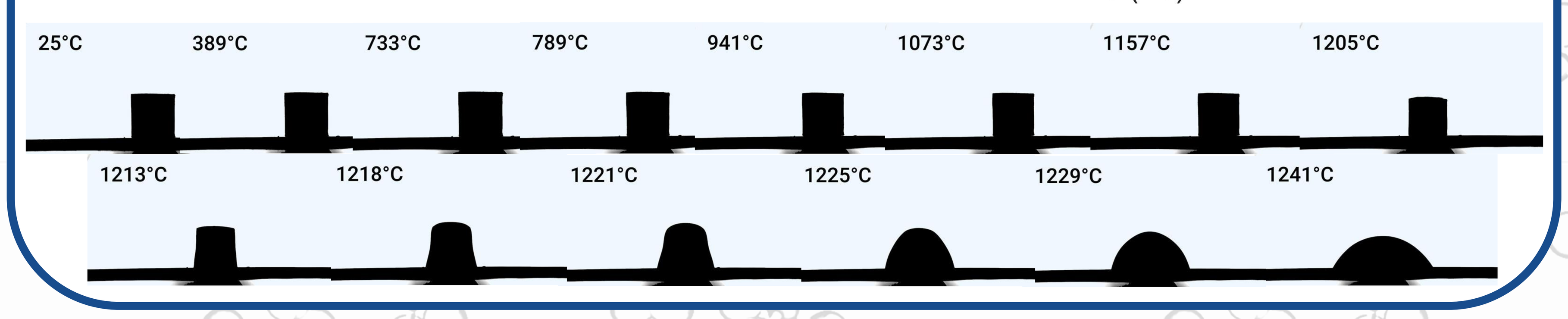
Dynamic measurements of stone wool's high temperature behavior

Experimentally

- Stone wool is sieved and pressed into a pellet
- The pellet's silhouette area is measured as function of temperature in a hot stage microscope (in atmospheric air)
- STA is measured to get a better understanding of the chemical mechanisms responsible for deformations of the stone wool observed in the high temperature microscope

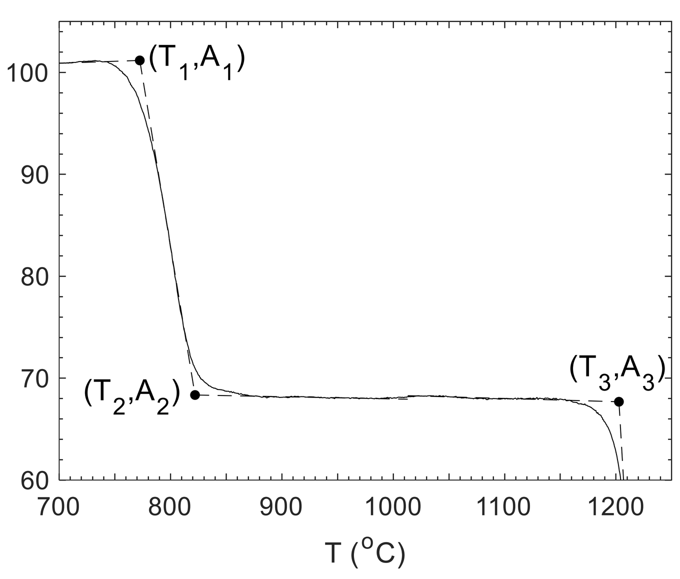






What is HTS?

- HTS is an object's ability to retain its shape at high temperatures



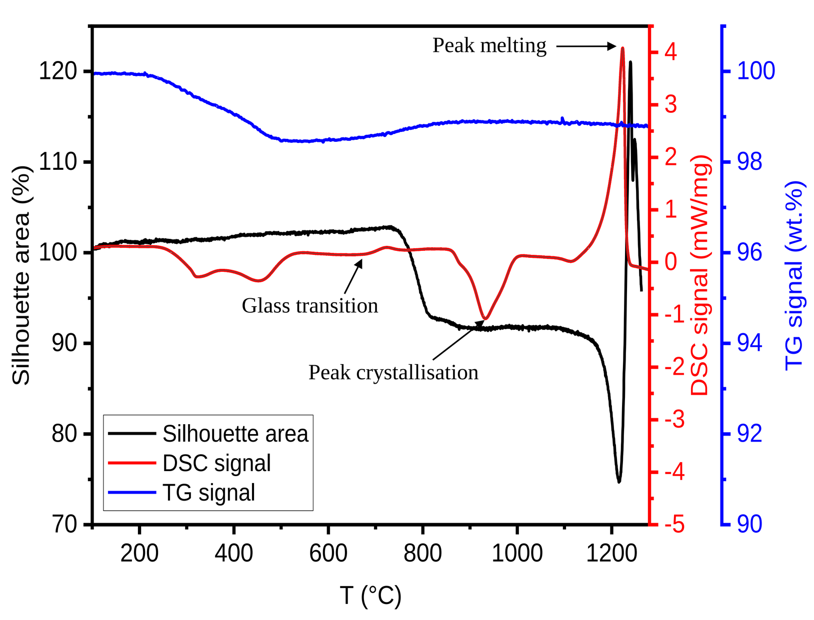
HTS of stone wool consists of several aspects:

- At which temperature does the stone wool sample start to shrink (T_1)?
- At which temperature does the shrinkage stop? (T_2)
- How much does the stone wool sample shrink? (shrinkage=A_1- A_2)
- At what temperature does the sample melt and collapse completely? (T_3)

Why does stone wool begin to shrink?

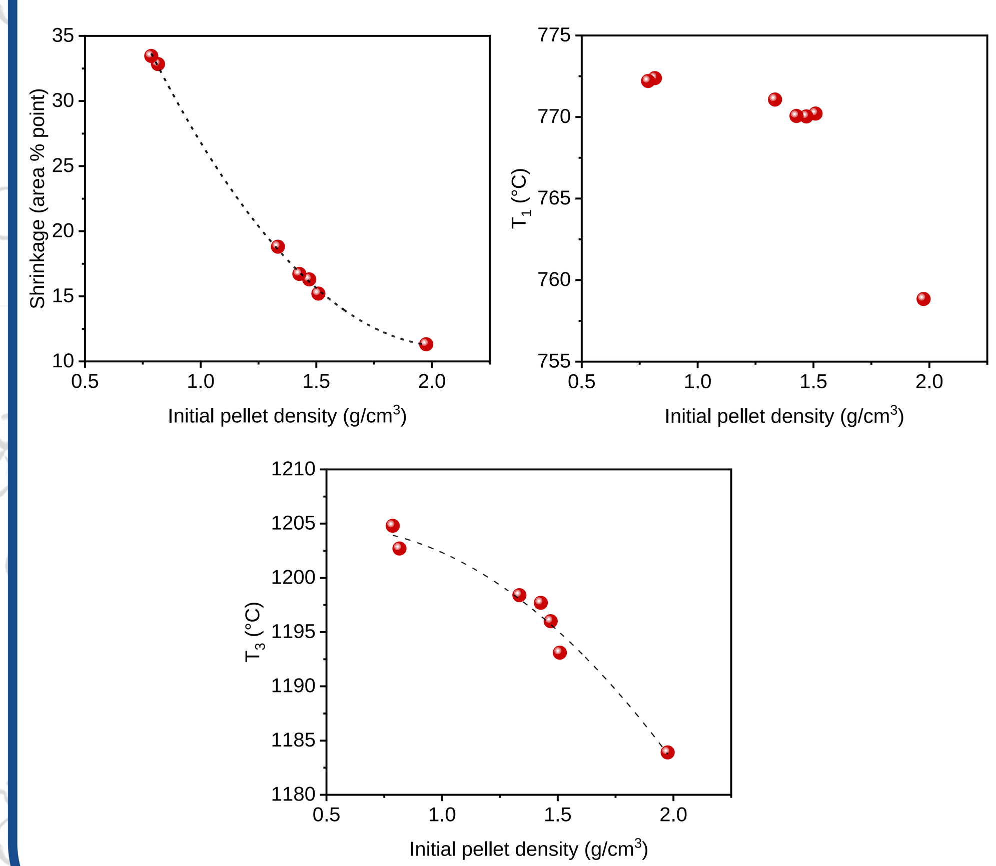
As temperature increases the viscosity of the glass decreases. When a certain critical viscosity is reached the stone wool can no longer uphold its own weight and it begins to shrink.

Why does stone wool stop to shrink?



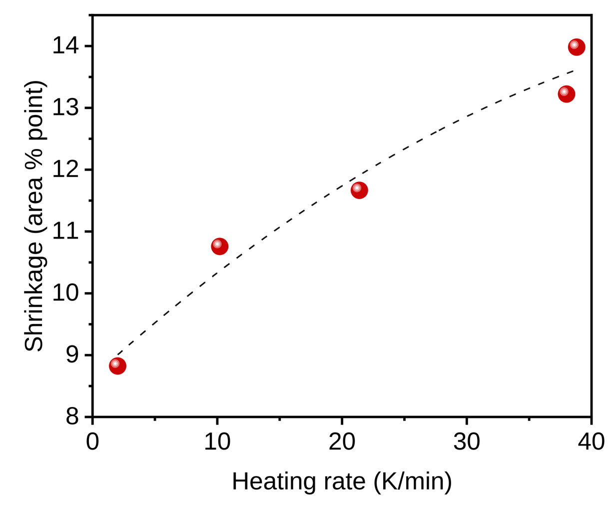
- The shrinkage ends before bulk crystallization begins
- When the shrinkage ends does not correlate with sample density – spatial constraints are not the main control
- A potential explanation is the formation of a nanocrystalline layer which has been shown to be important for HTS[3,4]

Controls on HTS 1: Density



- Experiments with varying densities of the stone wool pellets show that higher density results in less shrinkage
- The experiments also show that a higher density results in a lower temperature of both shrinkage initiation (T_1) and the melting-related collapse (T_3)
- The critical viscosity must be higher for stone wool pellets of higher densities as the sample collapses under its own weight

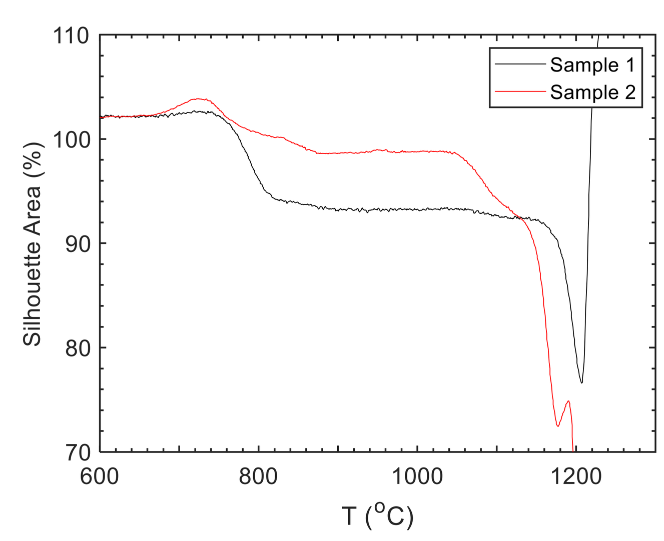
Controls on HTS 2: Heating rate



- Experiments with varying heating rates and a constant density show that a higher heating rate results in more shrinkage.
- A possible explanation for this is the time dependent formation of a stabilizing nanocrystalline layer[3,4]

Controls on HTS 3: Chemistry

Once the effects of experimental parameters (density and heating rate) are known, the influence of chemistry can be investigated. However, stone wool consists of a mixture of 10 metal oxides and numerous trace elements. This makes stone wool an extremely complex material where deriving correlations is difficult. Lab-scale production of simplified glasses will in the future hopefully help elucidate the complex chemical controls on HTS of stone wool.



Example of two different stone wool compositions with very different HTS measured under the same experimental conditions. Sample 2 shrinks very little (5.5 % point) compared to sample 1 (11.3 % point), but the final collapse temperature is much lower for sample 2 (T_3=1055°C) than for sample 1 (T_3=1184°C).

Conclusions

We have studied the effects of experimental conditions on the HTS of stone wool. We have found that the density of the stone wool samples controls when the shrinkage begins (T_1) and the total amount of shrinkage. Another important control on the amount of shrinkage is the heating rate. The results of these experiments highlight important conditions to control and monitor in future investigations on how the chemical composition of stone wool affect the HTS of stone wool.

References: [1]Moesgaard, M., Pedersen, H. D., Yue, Y. Z., & Nielsen, E. R, *Journal of non-crystalline solids*, *353* (2007); [2]Yue, Y., Korsgaard, M., Kirkegaard, L. F., & Heide, G., *Journal of the American Ceramic Society*, 92(1) (2009); [3]Smedskjaer, M. M., Solvang, M., & Yue, Y., *Journal of the European Ceramic Society*, 30(6), (2010); [4]Cooper, R. F., Fanselow, J. B., & Poker, D. B., *Geochimica et Cosmochimica Acta*, 60(17) (1996)

Acknowledgments

The authors acknowledge the help from Tobias, Simon, Cecillie, and Nanna (2nd semester group B358) for carrying out HSM measurements at different heating rates.