more slowly and allowed to rest (aged) for various amounts of time from one hour to three days. For the quenched sample the simple step is observed at T_g. The T_g value is typically taken as the midpoint value, which is about 40 ºC in our example.

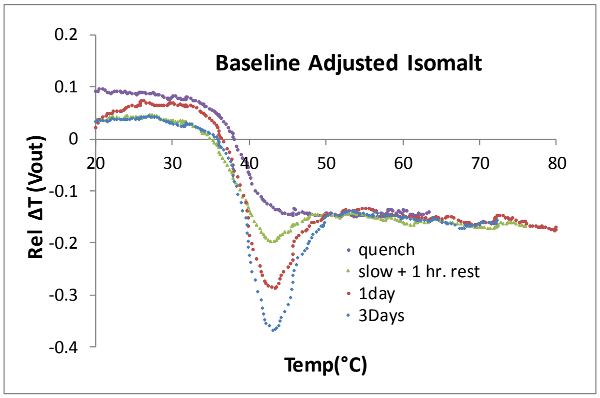

Figure 4. Baseline flattened data for the same sample of Isomalt under four different thermal histories.

In contrast, the non-quenched samples all show the emergence of a post-T_g endothermic peak, associated with the varying amounts of relaxation which took place in the glassy structure both during and after cooling. The occurrence and association of these endothermic peaks was originally observed by Tool [7] in 1946. The detailed quantitative understanding of the dynamics took place over the next three decades.

In short, the peak arises because the aged glass has relaxed to a lower enthalpy state with an associated increase in its inherent relaxation time. On reheating the more relaxed structure of the aged material responds more sluggishly to the ramped temperature change than an unaged sample. When the sample's relaxation rate is slow relative to the heating rate, its enthalpy change can lag and fall below the metastable equilibrium state of the supercooled liquid. On further heating, this enthalpy undershoot eventually reverts back to the equilibrium condition accompanied by an endothermic event. The size of the peak reflects the amount of relaxation that has taken place. This interesting topic certain warrants a much longer discussion than can be provided here. A good review of both the history and the technical understanding of this topic can be found in a text by Scherer [8]. The phenomena and analysis remain widely used tools today in the study of relaxation and aging in both glass and polymers.

SUMMARY

In this paper we have highlighted the importance of glass to our modern technologies and the significant questions it raises concerning our understanding of matter. Central to understanding glass are the glass transition and its underlying relaxation phenomena. To facilitate an empirical approach to this understanding we have designed and described a low-cost, home-built DTA capable of measuring the glass transition phenomena in simple low temperature glasses made from sugar and artificial sweeteners. We demonstrate how the apparatus can be used to engage in serious, quantitative experiments to examine the effect of thermal history and aging in glassy materials using this very accessible system. This apparatus provides a hands-on, intuitive path to engage the student in glass science and experimental design. In addition the apparatus could also provide a resource for deeper, open-ended and independent study of relaxation phenomena, especially appropriate for an advanced undergraduate laboratory.

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