A thermal conductivity standard for organic phase change materials around ambient temperature

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The interest in materials that undergo a phase change within a temperature range relevant to the built environment has been stimulated by the need to find means of regulating the temperature in buildings in ways that make the most efficient use of available energy in the face of climate change. In particular in any heat transfer or storage process, phase-change materials (PCM's) that undergo a melting transition bring the latent heat of fusion into the storage process as well as sensible heat and so can be more effective. For near-ambient temperature applications some organic materials have attracted particular attention. For such materials the thermal conductivity in both the solid and liquid phases is of importance for design purposes. Unfortunately, in the solid phase for such materials there are no widely accepted standard reference material or standard reference values with an accuracy better than 5% which can aid the development of data on such materials over the relevant temperature range. In part this is a result of the absence of an absolute methodology for the measurement of the thermal conductivity of solids that can be demonstrated unequivocally to be free of systematic errors, not least those caused by heat transfer resistances at the surfaces of the sample tested.

In an effort to ameliorate this situation we have developed the absolute transient hot-wire instrument in a manner that allows the study of solid materials near ambient temperatures and eliminates entirely the contact resistance between the thermal sensor and the test material. The technique has a rigorous theory which enables comparisons between the observed temperature rise in the thin-wire heater/sensor and that evaluated from the absolute theory of the instrument. Such comparisons lead to the conclusion that the new development allows measurements of the thermal conductivity of solid materials free from systematic error on an absolute basis with an uncertainty of 1%. The paper will describe the experimental arrangements and the operation of the instrument and demonstrate its correct operation.

New measurements of the thermal conductivity of hexadecan-1-ol and octadecan-1-ol, in both solid and liquid phases will be presented. The values obtained could be the first step in formulating new standard reference data for the thermal conductivity of solids near ambient temperatures.