

UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Heat capacity of polystyrene from 275 to 315 K¹

By

Bruce S. Hemingway² and Richard A. Robie³

Open-file Report 94-671

¹ This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey editorial standards.

² U.S. Geological Survey, 959 National Center, Reston, VA 22092

³ 220 Meadow Lark Lane, Boalsburg, PA 16827

Abstract

The heat capacity of polystyrene was measured between the temperatures of 275 to 315 K by quasi-adiabatic low-temperature calorimetry. The experimental data were fit to the equation

$$C_p = -362.39 + 0.88904T + 3910.9T^{-0.5}$$

with an average deviation of about 0.1%. The heat capacity of the polystyrene was required for corrections to the thermal terms for an absorbed-dose-rate calorimeter.

Introduction

A portable absorbed-dose-rate calorimeter was constructed by Steve R. Domen (National Institute of Standards and Technology (NIST), Gaithersburg, MD) and Wei-Zhen Ba (Xinjiang Institute for Physics, Academia Sinica, China). The calorimeter was constructed by embedding a calibrated thermistor on the axis of a polystyrene rod. The polystyrene rod was positioned on the axis of a cylindrical array of ^{60}Co rods. Knowledge of the heat capacity of the polystyrene as a function of temperature was necessary to calculate the dose of ionizing radiation reaching the calorimeter. Assuming that the energy absorbed by the calorimeter was converted to heat, then the absorbed dose, D , is equal to the specific heat capacity ($\text{J}\cdot\text{g}^{-1}\cdot\text{K}$) times the observed temperature rise, ΔT .

Experimental data

A sample of polystyrene was provided by Steve Domen (NIST). The sample weighed 23.832 g and was cut from a 50 mm thick slab from which the calorimeter was fabricated. The density of the sample was 1.05 g/cm^3 . No information was provided on the molecular weight distribution of the polystyrene. The molar weight of the polystyrene is 104.15 g.

Heat capacities in the temperature interval 275 to 315 K were measured using a quasi-adiabatic low-temperature calorimeter. The calorimeter has been described previously (Hemingway and Robie, 1984). The experimental values (T in Kelvins and C_p in $\text{J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$) are:

<u>T</u>	<u>C_p</u>	<u>T</u>	<u>C_p</u>	<u>T</u>	<u>C_p</u>
299.6	130.03	278.9	119.67	300.3	130.13
301.7	130.97	282.1	121.44	303.3	132.02
303.8	131.46	285.2	122.70	306.2	133.42
305.9	133.48	288.4	124.16	309.2	135.51
307.9	134.04	291.4	125.79	312.1	136.34
309.9	134.95	297.4	129.00		

The experimental data were fit with a three term equation,

$$C_p = -362.39 + 0.88904T + 3910.9T^{-0.5},$$

with an average deviation of about 0.1%. At 298.15 K the heat capacity calculated from the equation is $129.2 \pm 0.3 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$. Smoothed values of the heat capacity calculated from the equation are:

T	C _p	T	C _p
275	117.9	298.15	129.2
280	120.3	300	130.1
285	122.7	305	132.7
290	125.1	310	135.3
295	127.6	315	138.0

Gaur and Wunderlich (1982) provided recommended values for the heat capacity of polystyrene based on measurements of 29 samples reported in the literature. Their recommended value at 298.15 K is $126.5 \pm 0.6 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$. The value reported here is 2.1% larger. Various processes associated with the production of polymers (e.g., extrusion and rolling) can cause small changes in the heat capacity (e.g., Furukawa, 1952). That is a likely cause for the difference observed here.

References

- Furukawa, G.T., McCoskey, R.E., and King, G.J. 1952, Calorimetric properties of polytetrafluoroethylene (Teflon) from 0° to 365°K. U.S. National Bureau of Standards Journal of Research, v. 49, p. 13-114.
- Gaur, Umesh and Wunderlich, Bernhard, 1982, Heat capacity and other thermodynamic properties of linear macromolecules. V. Polystyrene. Journal of Physical and Chemical Reference Data, v. 11, No. 2, p. 313-325.
- Hemingway, B.S., Robie, R.A., Kittrick, J.A., Grew, E.S., Nelen, J.A., and London, D., 1984, The thermodynamic properties of two natural chlorites to 500 K, the heat capacities of osumilite from 298.15 to 1000 K, and the thermodynamic properties of petalite to 1800 K. American Mineralogist, v. 69, p. 701-710.