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Coefficient of Thermal Expansion of Pressed PETN Pellets

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The PETN single crystal coefficient of thermal expansion (CTE) values were measured and reported by Cady in 1972 [1] over the temperature range of -160 to 100°C. Measurements were made in the (001) and (100) crystallographic directions, see Figure 1 (a replicate of Figure 1 from the Cady paper). Cady used his single-crystal data to calculate the linear CTE for a randomly-oriented multi-crystal pressing of PETN, and his values ranged from 76.5 με/°C (at 20°C) to 89.9 5 με/°C (at 90°C). In 1967, Roth and Blackburn [2] measured the linear CTE of a multi-crystal compaction as 113.0 με/°C in the range of room temperature to 110°C.

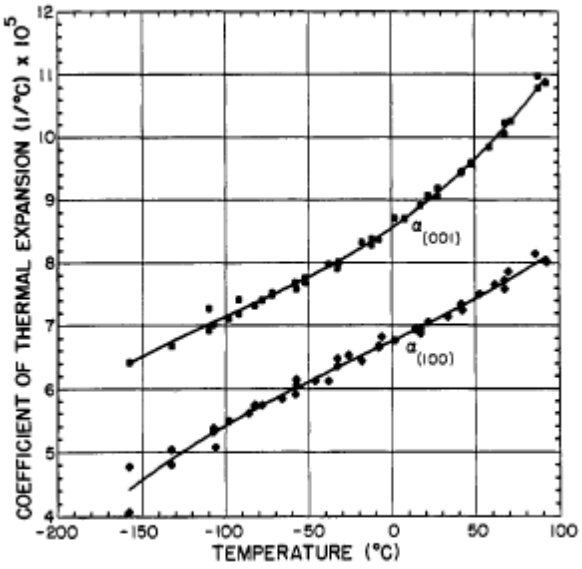


Figure 1. Linear coefficients of PETN

Figure 1: From ref[1], Howard Cady's single-crystal PETN linear expansion data in the two crystallographic directions.

We have used a TA Instruments thermal mechanical analyzer (TMA) to measure the linear CTE of die-pressed cylinders of dry PETN, 2.99 mm diameter by 2.5 mm long. The instrument is located at TA-9, Bldg 48, Room 102 (WX-7, High Explosives Science and Technology), and is calibrated per manufacturer's recommendation, with validation using an aluminum standard.

Two different PETN specimens were tested and the data are plotted in Figures 2 and 3. In these tests, the temperature is ramped according to the programmed procedure, and the axial strain response is measured. A load of 0.3 N (0.067 lbs) is applied to the top of the specimen by the strain probe, in order to maintain contact as the temperature is varied. In these tests, we were interested to look at the effect of thermal cycling on the axial strain of the PETN, specifically to look for signs of irreversible growth (i.e. the "ratchet growth" of TATB-based compactions and composites). All temperature ramps were 1°C/min, a slow rate used to ensure thermal equilibrium and minimize thermal gradients. The test was initiated at 23°C and ramped to -52°C, held for 10 minutes, ramped to 75°C and held for 10 minutes, then ramped to 23°C and held for 10 minutes. This STS cycle was repeated a total of three times. The full data sets are plotted versus time in Figure 2.

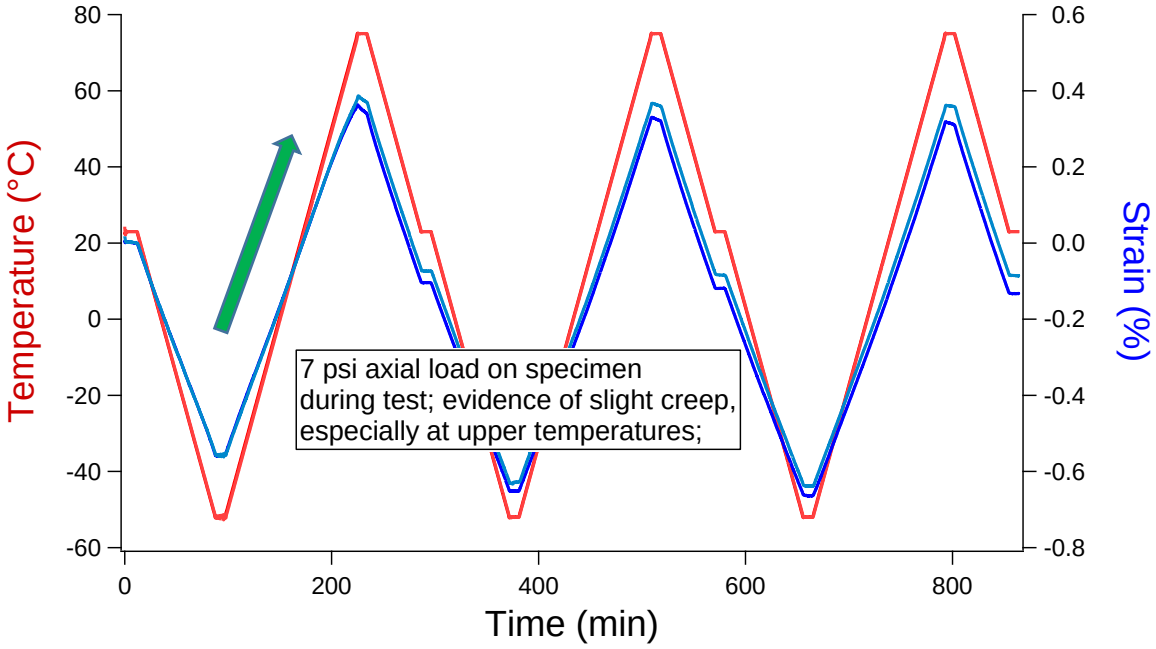
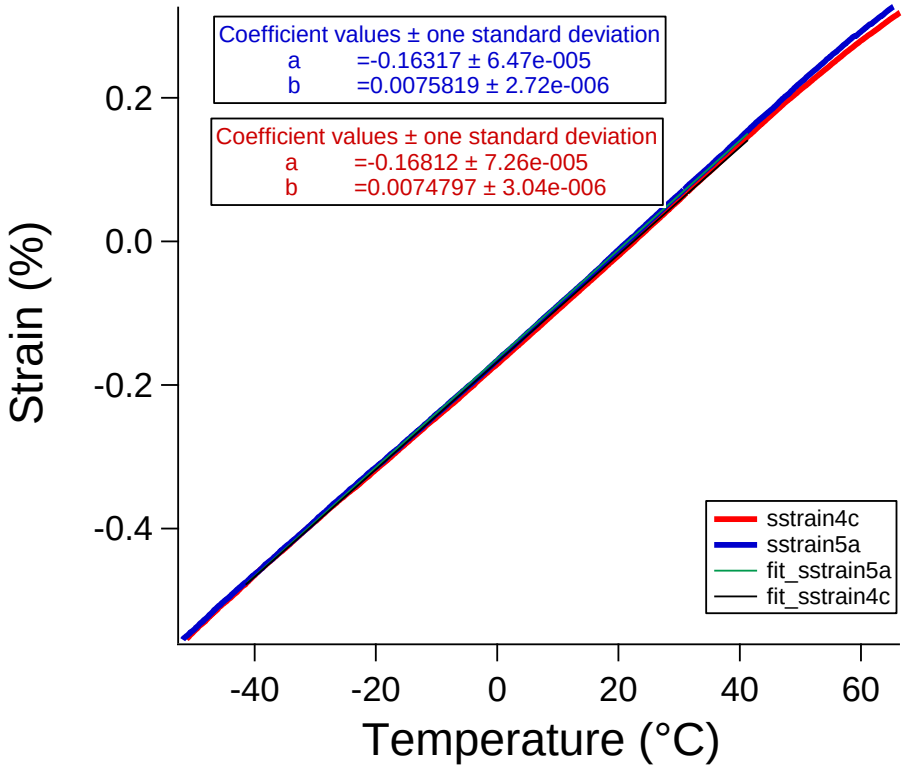


Figure 2: TMA Data, Temperature and Strain plotted versus Time for two different PETN pellets. The green arrow shows the data ramp section that is plotted in Figure 3.

Instead of seeing irreversible volume expansion upon thermal cycling, Figure 2 shows signs of slight compressive creep, especially during the 75°C isothermal hold. The 0.3 N of load on the probe corresponds to a pressure (stress) of 7 psi or 0.05 MPa on the specimen. The creep magnitude over the course of the test is 0.1%.

In Figure 3 is plotted the strain versus temperature of the first increasing thermal ramp (indicated by a green arrow in Figure 2). We use these data to obtain the axial CTE by fitting a straight line to the data between -41 and +41°C. For the two specimens measured, we obtained values of 74.797 and 75.819 με/ε°C, with an average of 75.308 με/ε°C. This value agrees well with that predicted by Cady (1). Note a slight decrease in the slope of the data (CTE) at the higher temperatures. Because it appears that the

material has the tendency to creep under load at high temperatures, more accurate high-temperature CTE data could be repeated with probe loads smaller than the 0.3 N value typically used.



References:

[1] "Coefficient of Thermal Expansion of Pentaerythritol Tetranitrate and Hexahydro-1,3,5-trinitro-s-triazine (RDX)," Howard H. Cady, J. Chem. Eng. Data, 1972, 17(3), 369-371.

[2] "The Effect of Initial Temperature on the Shock Sensitivity of Granular Explosives," J. Roth and J. H. Blackburn, Sandia Corp. Report SC-CR-67-2805, 28 August 1967.