Analysis of Propellants by HyperDSC and TGA

Introduction
Explosives, propellants and gun powders are often classed as highly energetic materials and are a special subset of thermal analysis. Differential Scanning Calorimetry (DSC) is normally used to study these materials. In this note, we investigate the application of HyperDSC™ and Thermogravimetric Analysis (TGA) techniques to slow-burn and fastburn gun powders. The instruments used are the Diamond DSC in its HyperDSC mode and Pyris™ 1 TGA, shown in Figure 1.

HyperDSC is a technique that involves heating and cooling samples at rates from 150 to 500 °C/min. Several papers have already addressed its applications. This work looks at its application to propellants as well as more traditional techniques.

Standard DSC
When gun powders or other energetic materials are run in the DSC, small sample weights (1-2 milligrams) are normally run at 10-20 °C/min. Figure 2 shows the results of such a run. It is important to keep sample size small and consistent in order to get reproducible results. On the below, for 5 runs, the temperature range was ±4 °C. Enthalpy varied about 5% on repeated runs.
The high sensitivity of the Pyris 1 TGA and its ability to also heat quickly gave interesting results when running the two powders. Heating at 50 °C/minute gave the curves shown in Figure 4. The slow-burn powder shows more weight loss below 200 °C and both materials exhibit an abrupt weight loss at 209 °C. Both materials left a residue in the pans that did not burn off at elevated temperatures (1000 °C).

**Conclusion**

For quicker and improved analysis of propellants and other materials, HyperDSC allows dramatic improvement in turnaround time and the Pyris 1 TGA provides a more complete characterization.
Acknowledgements
Thanks to A. Brehms and S. Camp of the North Texas Shooters Association, who donated the samples of commercial gun powders.

References