B84 Evaluation of the Self-Heating Tendency of Vegetable Oils by Differential Scanning Calorimetry

Amélie Baylon, BS, Olivier Delémont, PhD, and Eric Stauffer, MS, School of Criminal Sciences, University of Lausanne, Batochime, Lausanne, CH-1015, SWITZERLAND*

The goal of this presentation is to demonstrate the use of differential scanning calorimetry to determine the self-heating tendency of vegetable oils. event defines the end of the induction period. This event was followed by a second peak, which was attributed to the decomposition of hydroperoxides. Finally, a third peak likely represented the termination phase, which constitutes the polymerization of the oil.

This technique can bring one more piece of information in a fire investigation where a vegetable oil is suspected to have caused a fire. While vegetable oil residues analyses are useful, DSC brings a complementary answer. As such, this presentation will impact the forensic science community by demonstrating how laboratories may start using DSC to improve the information provided to the fire investigator.

Spontaneous ignition is a common cause of fire. Different reactions of biological or chemical origin can lead to such a phenomenon. Among chemical reactions, the self-heating of vegetable (and animal) oils is well known and has been reported in the literature as the cause of many fires.

When determining the cause of a fire, the fire investigator must rely upon the application of thermodynamics to develop and test the different hypotheses regarding the production of the initial activation energy. Fire investigators must also comprehend the chemistry and physics of the self-heating process of vegetable oils in order to properly assess suspicions of spontaneous ignition. In any case, hypothesis testing must include the evaluation of the oil as a source of energy and its configuration in the particular scenario.

Similarly to regular fire debris analysis, from which the presence of ignitable liquid residues is determined, it is possible to analyze fire debris samples for the presence of vegetable oil residues (VOR). However, the determination of the presence of VOR does not imply in any manner that a phenomenon of spontaneous ignition took place: It merely answers the question of whether residues of a vegetable oil are present in the debris. When comparison samples of an oil are available, gas chromatographic- mass spectrometric (GC-MS) analysis provides the investigator with the composition of the oil in terms of its fatty acid content; however, it does not take into account additives that may be present in the oil and that can significantly influence its self-heating capacity. Therefore, in these instances, the investigator typically relies on laboratory reconstruction experiments that evaluate the self-heating propensity of an oil. Laboratory-scale calorimetric tests, such as the Mackey test, are standardized and often used; however, they are long and cumbersome to perform, and they require a substantial amount of oil.

The development of a faster and simpler technique to evaluate the self-heating propensity of a vegetable oil is interesting to the fire investigator. As a result, he or she would be much more inclined to test the different hypotheses, thus guaranteeing a more thorough scientific investigation. One such technique that appears very promising is differential scanning calorimetry (DSC). In the current research, DSC is evaluated as a technique to determine the thermodynamics associated with different vegetable oils and, more particularly, their propensity toward self-heating.

Five different vegetable oils were tested in this study: edible linseed oil, boiled linseed oil, safflower oil, corn oil, and peanut oil. These different types of oils were selected based on their saturation degree, which is often linked to their propensity toward self-heating. For each type of oil, a small amount (between 2 and 5 mg) was introduced into a 40-µl aluminum cup and weighed. A Mettler-Toledo (Greifensee, Switzerland) differential scanning calorimeter, DSC 25, equipped with a TA4000 ceramic sensor was used for the analyses.

The DSC curves allowed for the observation of the induction period, characterized by the consumption of natural and/or artificial antioxidants present in the oil. The presence of the first exothermic event defines the end of the induction period. This event was followed by a second peak, which was attributed to the decomposition of hydroperoxides. Finally, a third peak likely represented the termination phase, which constitutes the polymerization of the oil.

The use of DSC allowed for the observation of the differences in induction times between oils composed of different inhibitor/drying agents. This information can be very helpful to the fire investigator during his or her reconstitution of the events and hypothesis testing.

Fire Investigation, Spontaneous Ignition, Fatty Acids

** Presenting Author*