



A117 Characterization of Selected Solid and Liquid Products From the Pyrolysis of Cotton Fabrics

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After attending this presentation, the attendee will learn to recognize and characterize particulate and liquid residues that result from cotton pyrolysis and apply this information to casework situations involving burnt cotton and cellulosic clothing.

An amber viscous liquid and microscopic spheroids produced during combustion of cotton fabrics can be used as markers of a burn event when observed microscopically and characterized by elemental and organic analysis. This provides a tool for linking a person or object with a fire event if such residues are found on the person's clothing.

When cotton fabrics are burnt or exposed to high heat, the non-gaseous reaction products include char, ash, mineral residues, and an amber-to-brown viscous material. The ash progresses from black to brown to white, each stage exhibiting greater loss of mass. The amber-brown material appears as a viscous residue. When the residues are examined microscopically, tiny viscous amber beads are observed adhering to individual fibers, and microscopic hollow black spheroids shaped like the amber beads are observed on the burnt fabric and in loose debris from the burn. The amber beads appear to be a condensate; they are found on less damaged portions of fabric protected by folds, yet appear after the fabric is heated past the initial charring stage. This corresponds with descriptions in the cellulose pyrolysis literature describing cotton "tar" resulting from the breakdown of cellulose during combustion above 300°C and reported to comprise levoglucosan, its isomers and condensation products.

This interest in microscopically observed burn residues is twofold:

(1) the types and ratios of the several types of residues vary with burn conditions and may be able to provide information about burn conditions such as rapid high heat versus slow smoldering char. The question is complicated by the effect of fire retardants on the pyrolysis product ratios (inhibition of levoglucosan formation) and will be the subject of further study; and, (2) a finding of readily observed residues such as amber viscous deposits and microscopic black spheroids on the clothing or artifacts of a person who was exposed to a fire or other high heat may provide a link between the person and an event such as an arson fire. To be used as markers of proximate exposure to the pyrolysis of cotton or other cellulosic fabrics, the microscopic spheroids must be distinguishable from microscopic spheres found as residues from pyrotechnics, from the discharge of black powder weapons, from incinerator residues, and from the thermal decomposition of non-fabric cellulosic materials such as wood. The viscous amber residue must be distinguishable from tree sap, mastics, and other sticky residues. The focus of this paper is the chemical characterization of the amber residue and the spheroids via elemental analysis and organic analysis, optical characterization via light microscopy, and their production during exposure to high heat and flame.

The black spheroids, analyzed using a scanning electron microscope equipped with energy-dispersive X-ray (SEM-EDX), can be characterized by trace elements, that despite a range of variation between samples are readily distinguishable from trace elements from spheres produced in black powder discharge and pyrotechnic residues (the latter as reported by Kosanke, et. al.). A smaller number of white spheres were also observed in burn residues and appear to be mostly carbonate. The amber viscous residue from several samples were analyzed using Fourier transform infrared spectroscopy (FTIR), gas chromatography-mass spectrometry (GC-MS) of aqueous extracts and polarized light microscopy (PLM) and SEM-EDX of particulates. The particulates include tiny carbonate crystals that form in the viscous residue and may form from dissolved carbonates. These crystals have not been observed in samples of tree sap examined to date and if the environment does not account for other sources of carbonate crystals, may suggest combustion.

Summary: A finding of amber viscous residues, microscopic amber viscous beads and microscopic black spheroids that result from the burning or heat exposure of cotton fabrics can be considered markers of burn events and can be distinguished from materials of similar appearance that result from different processes or different materials. Such residues are forensically significant materials that can be used to link an object found elsewhere with a fire event.

Burn Debris, Pyrolysis, Trace Evidence