



J15 Research on the Mechanism of Paper Burning by Thermal-Gravimetry and the Handling Methods for Charred Documents

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After attending this presentation, attendees will understand the mechanism of paper burning, which can be summarized by four stages. Additionally, a new handling method with softening and flattening solutions will be introduced.

This presentation will impact the forensic science community by increasing knowledge regarding charred document examination, especially on the use of suitable handling methods based on the stage of the charred paper.

In questioned document examination, a charred document is a piece of burned paper or its fragments containing a message. The examination of such a document and deciphering the writing thereon are important for gaining information, usually demanding a careful application of certain scientific methods and techniques because of its unstable property. To address this issue, the mechanism of paper burning needs to be studied in order to discover the essential and key factors. Here, Thermal-Gravimetry (TG) was applied to investigate five types of paper with their TG and Derivative Thermo-Gravimetric (DTG) curve observed at different atmospheric conditions. The results demonstrated that the shape of curves, albeit similar, varied with the physical and chemical composition of paper. In the burning process, dehydration and de-polymerization are the two main pathways for cellulose — the major ingredient of paper. The heating rate indicated little influence on the curves while the type of atmosphere was strongly influential. The reason is due to the lack of tar oxidation when nitrogen is used as the atmospheric environment. At a moderate temperature, de-polymerization prevails and the tar can be observed. With increasing temperatures, the tar and cellulose are further decomposed, leading to products of a high boiling-point. According to the results, the charred document can be classified as one of dehydrated, tarred, charred, and ashed: (1) Dehydrated — below 100°C, paper is slightly yellow. In this stage, water absorbed in cellulose is gradually lost, and the basic physical property stays intact; (2) Tarred — from 150°C to 250°C, paper color changes from yellow to brown, the edges become curly, and the dimension diminishes. In this stage, although cellulose is not completely decomposed, tar is obtained through de-polymerization; (3) Charred — from 250°C to 350°C, paper changes from dark brown to black and becomes much curlier. In this stage, residual tar continues to oxidize, thus solid char can be observed; and, (4) Ashed — above 350°C, paper color turns from gray-white to ash. In this stage, char continues to oxidize, leaving the high boiling-point products, mainly the filler materials (mostly Calcium Carbonate (CaCO₃)).

Except for the ashed document, the other three can be handled and deciphered to collect information. A new softening solution (glycerinum-water) and flattening solution (polyvinylpyrrolidone-ethanol) with a new handling method can be used for subsequent examinations. The results of this study may provide a fundamental method for examining and deciphering charred documents.

Charred Document, Thermal-Gravimetry, Handling Method