C40 Investigation of Illumination State of High- Intensity Discharge Automotive Headlamps

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The goal of this presentation is to establish methodology in determination of illumination state of high-intensity discharge (HID) automotive headlamps.

This presentation will impact the forensic science community by demonstrating the microstructural and chemical condition of lamp fragments after hot and cold fracture.

The forensic examination of tungsten filament headlamps has proven to be very useful for determination of fault and cause of car accidents and has been widely covered in the literature. Automobile manufacturers and customizers have been increasingly moving toward HID headlamps, especially in higher-end automobiles. Analytical techniques such as Scanning Electron Microscopy/Energy Dispersive Spectroscopy (SEM/EDS) and Auger Electron Spectroscopy (AES) have been utilized to determine microstructural condition, elemental composition and degree of oxidation of the tungsten. However, HID lamps have a structure and mixture of compounds completely different from conventional bulbs. While the same analytical techniques can be applied to analysis of the HID lamps, a new interpretation will be necessary due to the potential presence of halide gases and rare earth elements and potential changes in compositional ratios. Forensic analysis of tungsten filament lamps does not apply to analysis of HID lamps due to their vastly different construction and mode of operation. As the popularity of this type of lamp increases, it becomes important to develop suitable methods of forensic evidence collection and analysis. One important issue concerning fracture of HID lamps is the high internal pressure (3 atmospheres in the off [cold] state). In the on state, the temperature of the quartz tube reaches temperatures around 1,000C, raising the internal pressure of the lamp to 30 atmospheres. Clearly, fracture of the lamp in either condition presents evidence collection issues with severe fragmentation of the quartz envelope. Fractured at high temperature, the remnants of the quartz envelope may be anticipated to have differences in structure and residual chemical traces.

A method for controlled fracture and fragment collection was developed. A custom jig was fabricated for safe fracture of the lamps in both off and on state. It was found possible to collect quartz fragments and identify the internal surface of the tube. Analysis of the cold- fractured quartz shards showed the presence of residual halides (bromides and iodides) rare earths (neodymium and dysprosium), as well as cesium and mercury. In the hot fracture condition, the absence of mercury was noted. This may have been anticipated, as this element was the most volatile of those present, and was expected to be the most completely vaporized during operation. Notably the other elements were present as surface deposits on the interior of the quartz, presumably in the form of complex compounds in both the cold and hot condition. The tungsten electrodes that provide the required voltage and current to create and maintain the plasma become red-hot during operation. Despite the temperature at the time of fracture, it was observed that there was very little oxidation of the tungsten, presumably because unlike with a conventional lamp, current is immediately interrupted upon fracture.

The nature and construction of HID lamps presented challenges in distinguishing whether the lamp was on or off at the time of fracture. Although it was possible under controlled circumstances to demonstrate a difference in mercury concentration, experience gained in this study illustrated the difficulties that may be encountered in the field in terms of illumination state and evidence collection.

Automotive, Headlamp, Failure Analysis