Heat-Sensing Electrical Outlets With Thermochromic Paint for Early Hazard Detection

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Electrical outlets can overheat due to faults or overloading, often without any visual warning before failure or fire. While thermochromic materials have been widely applied in temperature indicators, and fire safety applications, their use in electrical safety — particularly within outlet systems — remains largely unexplored. This project aims to integrate thermochromic pigments into outlet designs as a passive, energy-free heat detection system. A custom outlet model was designed using Fusion 360, featuring an embedded alumina component to transfer internal heat efficiently to a visible surface coated with thermochromic pigment. This structure enables the outlet to provide an early visual warning of abnormal heat buildup without relying on sensors or electronics. To evaluate heat conduction, thermal transfer tests were conducted on alumina using a Peltier module, logging temperature changes every second at 70 °C. The behavior of thermochromic pigments was also tested to determine the ideal activation temperature for both early fading and full color change. The results showed that a pigment with a 60 °C activation temperature began fading at approximately 55 °C and completely changed color in 74 seconds, with fading starting in just 35 seconds. These values were chosen for optimal safety response, and the alumina component was kept as small as possible to minimize heat transfer time. This project presents a novel, low-cost, and visually intuitive method to improve outlet safety, helping fill a gap in fire prevention technology by enabling earlier detection and user response.

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