Developing a Colorimetric Patch and Toxicity Index for Detecting Components in Secondhand Smoke

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Secondhand smoke (SHS) is a major public health concern, causing over 1.3 million deaths globally each year. Despite its links to cancer and respiratory disease, SHS is difficult to detect in real time because it is often invisible at low concentrations. This project addressed this challenge by developing a low-cost, colorimetric patch to detect five primary SHS toxins: nicotine, formaldehyde, volatile organic compounds (VOCs), carbon monoxide (CO), and PM2.5. The final prototype consisted of a 3D-printed, five-compartment housing containing chemical reagents: potassium permanganate ($KMnO_4$) for VOCs, Schiff's reagent for formaldehyde, palladium chloride ($PdCl_2$) for CO, glass fiber filters for PM2.5 deposition, and Zinc-organic nanotubes for nicotine, which were synthesized at a university laboratory to act as a gasochromic indicator for nicotine. SEM/EDS analysis of Zinc Nanotubes confirmed successful synthesis, with an elemental composition of 8.0% zinc and 11.7% oxygen. Testing of the patches with clean air and cigarette smoke was performed in a controlled smoke chamber, with patch responses recorded via smartphone while electronic sensors provided numerical concentrations. Color changes were quantified using Euclidean distance in RGB space, and correlated to numerical sensor data. Results showed strong precision, with Pearson correlation coefficients (r) between the sensor data and color change from 0.948 to 0.990. A 0–100 Toxicity Index was created, weighting more hazardous pollutants more heavily. The patch reliably identified hazardous conditions within 5 minutes, demonstrating its potential as an accessible tool for personal health monitoring, wearables, and studies in public health impact, for both public and industrial settings.

Awards Won:

Third Award of $1,200

NC State College of Engineering: Alternates (not read aloud)