Sensing Safety: Developing a Flexible, Portable Alcohol Detection Patch for Community Wellness

Project 2526
September 2026

Ava Hedayatipour, PhD   Ryan Huynh   Wahaab Ademola

Introduction

Alcohol-impaired driving continues to be a major transportation safety challenge, contributing to thousands of roadway fatalities and injuries each year. Beyond law enforcement, alcohol monitoring technologies are increasingly used in healthcare, recovery programs, and workplace safety to help reduce alcohol-related risks. However, many existing monitoring systems are expensive, bulky, or impractical for continuous wearable use, limiting their accessibility and widespread adoption.

This research explored whether a low-cost, disposable electrochemical sensor could provide a practical alternative for future wearable alcohol monitoring. The project focused on designing and fabricating a screen-printed electrode using inexpensive conductive inks and integrating it with compact electronic hardware capable of detecting alcohol in a solution that mimics human sweat. By combining printed electronics with established electrochemical sensing techniques, the researchers investigated whether reliable alcohol detection could be achieved using a sensor that costs only about 10 cents to fabricate. The results demonstrate that low-cost manufacturing can produce reliable alcohol sensors and establish a foundation for future wearable technologies that could support transportation safety by helping reduce alcohol-impaired driving.

Study Methods

The research team designed and fabricated a disposable electrochemical alcohol sensor using commercially available conductive carbon and silver inks. The sensor consisted of three screen printed electrodes, a working electrode, counter electrode, and reference electrode, manufactured using a Voltera V-One printed electronics system. The printed electrode was connected to a reusable electronic measurement platform built around the Texas Instruments LMP91000 analog front-end potentiostat and a Seeeduino XIAO microcontroller. Rather than testing alcohol directly on human subjects, the sensor was evaluated using laboratory prepared solutions designed to simulate the chemical composition of human sweat. Artificial sweat solutions containing sodium chloride were mixed with ethanol concentrations ranging from 0% to 30% to represent increasing alcohol levels.

Two standard electrochemical techniques were used to evaluate sensor performance. Cyclic voltammetry measured how electrical current changed as voltage was swept across a predefined range, allowing researchers to identify oxidation and reduction behavior associated with ethanol. Chronoamperometry measured the electrical current produced at fixed voltages over time to evaluate the sensor's ability to distinguish different ethanol concentrations under steady operating conditions. Throughout the study, the researchers focused on demonstrating that inexpensive printed electrodes could produce consistent electrochemical responses while maintaining compatibility with compact, low-power electronics suitable for future wearable applications.

Findings

The fabricated screen-printed electrodes successfully detected ethanol across all tested concentrations. Both cyclic voltammetry and chronoamperometry produced repeatable electrochemical responses that varied systematically with increasing ethanol concentration, demonstrating that the printed electrodes functioned as intended. The study also demonstrated the feasibility of combining inexpensive disposable sensing elements with reusable electronic hardware. Unlike many commercial wearable alcohol monitors that permanently integrate the sensing surface into the wearable device, the proposed architecture allows only the screen-printed electrode to be discarded after use while the electronic measurement system is retained. This significantly reduces replacement cost because each electrode can be manufactured for approximately 10 cents using commercially available conductive inks. Disposable electrodes also provide practical advantages beyond cost. Since the sensing surface comes into direct contact with perspiration, replacing only the electrode eliminates the need to repeatedly reuse sweat-exposed sensing surfaces. This simplifies maintenance, reduces contamination concerns, and minimizes long-term degradation caused by repeated exposure to biological fluids. Although additional work is needed before technology can be deployed in real-world wearable devices, the results demonstrate that low-cost printed electronics can provide reliable electrochemical sensing while significantly reducing manufacturing costs compared with traditional sensor fabrication techniques.

A disposable screen-printed alcohol sensor costing approximately 10 cents demonstrated reliable ethanol detection while enabling reusable electronics for future low-cost wearable alcohol monitoring systems.

Policy/Practice Recommendations

This research demonstrates that printed electronics can substantially reduce the cost of wearable alcohol sensing technologies while improving maintenance and hygiene through disposable sensing elements. Continued investment in low-cost wearable sensing platforms could support future transportation safety initiatives by enabling continuous alcohol monitoring technologies that are affordable, scalable, and practical for widespread deployment

Future research should focus on integrating the disposable electrode into flexible wearable patches capable of monitoring alcohol directly from human perspiration during normal daily activities. Additional studies should also investigate long-term calibration, sensor durability, environmental compensation, wireless communication, and correlations between sweat alcohol concentration and blood alcohol concentration. For transportation agencies and policymakers, continued support for low-cost wearable sensing research aligns with California Senate Bill 1 (SB1) by advancing technologies that improve roadway safety and reduce alcohol-impaired driving. Affordable wearable monitoring systems may eventually complement existing impaired-driving prevention strategies through workplace safety programs, fleet management, rehabilitation monitoring, and early intervention efforts.

About the Authors

Dr. Ava Hedayatipour is a faculty member in the Department of Electrical Engineering with research interests in biosensors, wearable electronics, and biomedical instrumentation.

Ryan Huynh is an undergraduate researcher in electrical engineering focused on printed electronics and electrochemical sensing systems.

Wahaab Amdemola is an undergraduate researcher with interests in sensor fabrication, embedded systems, and biomedical applications.

To Learn More

For more details about the study, download the full report at https://transweb.sjsu.edu/research/2526

MTI MINETA TRANSPORTATION INSTITUTE

MTI is a University Transportation Center sponsored by the US Department of Transportation, the California Department of Transportation, and public and private grants, including those made available by the Road Repair and Accountability Act of 2017 (SB1). The Institute is part of San José State University's Lucas Graduate School of Business.