

Demo: Got Under Your Skin? Light-Based Detection of Plastic Particles Using Biological Skin Phantoms

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1 Introduction

Despite estimates that humans ingest between 0.1 and 5 g of plastic per week and emerging evidence of plastics in multiple organs and tissues [1], their health impacts remain poorly understood. One key limitation is the lack of accessible, non-invasive monitoring tools, as existing detection techniques are often invasive and cost-prohibitive. To address this gap, we first develop biological skin phantoms that replicate the optical and structural properties of human tissue, enabling controlled investigation of subcutaneous plastic particle detection. Building on this foundation, we use SWAN [2], a spectrometry-based wearable light-sensing platform, to evaluate the feasibility of detecting plastic particles beneath the skin. Through experiments on these tissue-mimicking testbeds, we demonstrate detection of plastic particles and highlight the challenges introduced by pulsatile flow in physiologically realistic conditions.

Demo video link: <https://tinyurl.com/swan-123>

2 Plastic particle detection

Wearable prototype: SWAN is built from off-the-shelf components, combining an ESP32-WROOM-32E microcontroller with an AS7265X spectrometer. Illumination is provided by three LEDs: white (LUXEON 3014), infrared (SIR19-21C/TR8), and ultraviolet (SMD PLCC-2). SWAN cost is \approx \$105 and is designed to detect plastic particles (polymer type PET, PP, and PS) of about 1 mm (1000 μ m) – size to a grain of salt.

Biological phantoms: Wearable sensing systems are typically evaluated in phantoms prior to human trials. We advance this practice by introducing biologically grounded skin phantoms to assess whether light-based sensing can detect plastic particles beneath the skin. Following established protocols, we employ gelatin-based skin phantoms and ex vivo porcine skin as tissue proxies.

3 Experiments

Goal: We evaluate light-based plastic particle detection using biological skin phantoms in two testbeds: a static setup and a dynamic flow model that simulates pulsatile blood flow via a syringe-driven vessel embedded in a mannequin arm.

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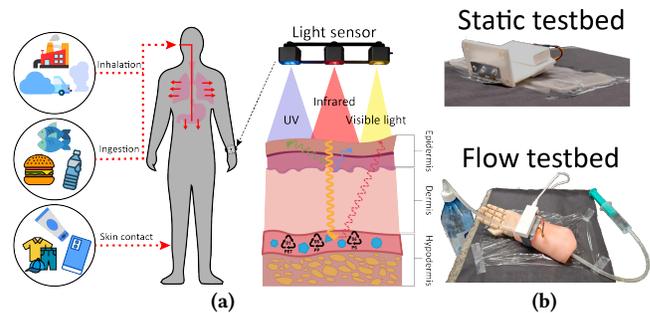


Figure 1: (a) SWAN overview (b) testbeds.

Results: Light values showed attenuation trends correlated with plastic particle size, with distinct spectral fingerprints across different polymer types in the static testbed. However, the flow testbed proved challenging, with changes in light intensity below the system's lower limit of detection.

Room for improvement: To enhance fidelity, multi-layered phantoms could be incorporated to emulate human tissue structures, phantoms tuned with optical additives to emulate skin tones, and manual delivery replaced with cardiovascular waveform pumps.

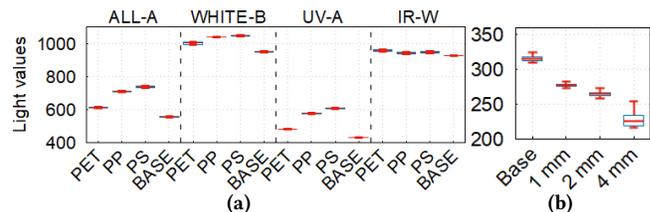


Figure 2: Light performance - plastic (a) types, (b) sizes.

Acknowledgments

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Ethics

Ethical approval was consulted with the Institutional Review Board (IRB) of the University of Tartu and the Estonian Research Council. Both bodies issued a formal statement confirming that the study does not require ethics committee approval.

References

- [1] D. Barceló, Y. Picó, and A.H. Alfathan. 2023. Microplastics: Detection in human samples, cell line studies, and health impacts. *Environmental toxicology and pharmacology* 101 (2023), 104204.
- [2] K. Post et al. 2026. SWAN: Spectrometry-based Wearable Biosensing for Monitoring Plastic Particles in the Human Body. In *The 27th ACM HotMobile 2026*.