



CASCADE 2027 NON-CONFIDENTIAL SUMMARY »

Smartphone-Enabled Optical pH Imaging for Cavity Prevention

Overview

Tooth decay affects billions of people worldwide, yet dentists and consumers currently lack an easy, reliable way to measure the acidity of the bacterial plaque that causes cavities before damage occurs. Existing approaches, such as pH test strips, microelectrodes, or salivary pH testing, are qualitative, invasive, expensive, or too imprecise to guide everyday preventive care. This University of Washington innovation, called O-pH, is a fluorescence-based optical imaging platform that uses an FDA-approved, inexpensive pH-sensitive dye (fluorescein) and blue LED illumination to generate quantitative, color-coded maps of plaque acidity directly on teeth and gums. The platform has been demonstrated clinically to visualize enamel plaque pH and is being engineered toward an affordable smartphone-based attachment that could bring dentist-office-quality biofilm monitoring into the home.

- **Problem:** dental caries is one of the most common and expensive chronic diseases, yet it is the only one not routinely and quantitatively monitored by clinicians or patients.
- **Solution:** a patented, non-contact optical method uses ratiometric or AI-assisted analysis of fluorescein fluorescence to calculate plaque pH from captured images.
- **Impact:** the technology could enable earlier detection of at-risk sites, better patient education, and objective tracking of the effectiveness of remineralization or hygiene interventions over time.

Description

The O-pH platform applies a known concentration of fluorescein dye to the oral biofilm (plaque) covering teeth and gums, then illuminates the tissue with blue light (approximately 404-430 nm, with a preferred wavelength of 420 nm). Fluorescein exists in different ionized forms (anion and dianion) whose fluorescence emission spectra shift depending on the local pH. The platform captures the resulting fluorescence at two wavelength bands (approximately 515-525 nm and 545-555 nm) using bandpass filters and image sensors, and calculates pH using a ratiometric equation ($\text{Measured Spectrum} = A1 * (\text{Anion Spectrum}) + A2 * (\text{Dianion Spectrum})$) that is largely insensitive to dye concentration, excitation intensity, and photobleaching. A second, related innovation trains a computational (deep learning) model on labeled fluorescence images so that pH can be estimated on a pixel-by-pixel basis from a single filter or standard RGB smartphone image, removing the need for specialized multi-band optics.

COMOTION REFERENCE »

BDP 7425

INNOVATION MANAGER »

Judy Bridges

SECTOR »

Medical Device

LEAD INVESTIGATOR »

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Modality: Diagnostic / Digital Health imaging device. **Indication:** Dental caries (tooth decay) risk assessment; the underlying pH-sensing principle has also been evaluated in the literature for relevance to gum disease (gingivitis and periodontitis) risk. Clinical demonstrations to date have visualized enamel plaque pH in vivo, and a peer-reviewed clinical study (Sharma et al., IEEE Trans. Biomed. Eng. 2022) validated the underlying optical pH monitoring approach for assessing oral biofilm acidity and enamel health.

- **Current development status:** Benchtop and probe-based prototypes (including a wand-style device) have been demonstrated and clinically evaluated; a smartphone-attachment prototype is in the design stage.
- **Low-cost design:** The dye costs a few pennies per use, and the target device/attachment cost is under \$20 in volume using an LED-and-filter smartphone accessory or software-only RGB-image processing.
- **Workflow:** A user rinses briefly with a fluorescein solution, images the mouth with an attached device, and the resulting image is processed (via ratiometric calculation or a trained AI model) into a color-coded pH heat map that can be tracked over time.

Technology Readiness Level (TRL)

TRL 5 — System or subsystem components have been validated in a relevant environment. The core optical pH sensing method has been demonstrated and clinically piloted using benchtop and wand-style probes, with peer-reviewed clinical data visualizing enamel plaque pH; a low-cost, smartphone-compatible imaging attachment and an AI-based single-image analysis approach are in active development but have not yet been integrated into a full consumer prototype.

Value Proposition

- **Low cost, high accessibility:** Fluorescein dye costs only a few pennies per use, and the target device cost is under \$20 in volume, well below existing chairside pH electrodes.
- **Non-invasive and non-contact:** The platform images the whole tooth/gum surface optically rather than requiring a probe to contact each site, unlike pH microelectrodes.
- **Quantitative and trackable:** Unlike color-based test strips, the platform produces a quantitative, pixel-level pH map that can be stored and compared over time to monitor hygiene, diet, or treatment changes.
- **Fits existing consumer and clinical workflows:** The design is intended to attach to a standard smartphone camera, enabling both at-home use and potential dental-office adoption without specialized capital equipment.
- **Built on approved, familiar materials:** Fluorescein is an FDA-approved dye already used in other clinical and consumer contexts, supporting a lower-risk path to market.

Intellectual Property Position

- [US12241901B2](#) – Patent issued/granted March 4, 2025.
- [US20190328234A1](#) – Patent issued/granted January 30, 2024.
- [US10888230B2](#) – Patent issued/granted January 12, 2021.
- [US20260030746A1](#) – Patent application pending.

Market Opportunity

- **Underserved chronic disease category:** Dental caries is reported by interviewed clinicians to be among the most expensive chronic diseases yet remains the only one not routinely and quantitatively medically managed.
- **Dual clinical and consumer pathways:** Customer discovery interviews with ten academic, clinical, and industry experts (including UW, UCSF, and Colgate-Palmolive/Philips Oral Healthcare researchers) indicated interest in both chairside caries-risk assessment tools for dental practices and take-home monitoring for consumers.
- **Industry validation signals:** Colgate-Palmolive has been developing a plaque-sensing toothbrush and expressed interest in adding pH measurement as a "logical next step," and Philips Oral Healthcare has expressed interest in optical, non-contact oral pH measurement relevant to its Sonicare product line.
- **High-need patient segments:** Interviewed experts identified pediatric caries risk, dry-mouth patients, orthodontic patients, and patients undergoing cancer treatment or radiotherapy as populations that could particularly benefit from localized, trackable acidity monitoring.
- **Unmet need for specificity:** Clinicians noted that current caries-risk tools (e.g., salivary pH tests, visual/tactile exams) have low specificity and high false-positive rates, creating an opening for a more localized, quantitative, and reproducible measurement approach.

References

1. Sharma M, Lee LK, Carson MD, Park DS, An SW, Bovenkamp MG, Cayetano JJ, Berude IA, Xu Z, Sadr A, Patel SN, Seibel EJ. "O-pH: Optical pH Monitor to Measure Oral Biofilm Acidity and Assist in Enamel Health Monitoring." IEEE Transactions on Biomedical Engineering. 2022;69(9):2776-2786.
<https://doi.org/10.1109/TBME.2022.3153659>