Efficacy of a Low-Cost UV Sensor for In Vitro Sunscreen Testing

Eliana Miao

Erin Angell, Palo Alto High School, AAR

INTRODUCTION

1 IN 5 Americans develop skin cancer before 70 years old due to exposure to UV light (Zou et al., 2022). To prevent skin cancer, sunscreen protection is crucial. Currently, ISO 24444:2019 is the gold standard in vivo method used to test the efficacy of sunscreen by applying sunscreen to human skin (Osterwalder et al., 2020). However, testing on human skin is:

- **inconsistent**
- **unequitable**
- **unethical**
- **does not fully account for UVA protection**

In fact, many zinc oxide sunscreens were found to test at half of its labeled SPF value (Andrews et al., 2021). To address these challenges, scientists are developing lab-based tests, though these also have their own limitations. Instead, this study aims to explore the potential of simple, low-cost UV sensor tests that focus on comparing sunscreens relative to one another rather than finding the true accuracy of one sunscreen—providing more practical information for consumers. How accurate are low-cost UV sensors for comparing the protection of different sunscreens?

RESEARCH METHODOLOGIES

In a series of tests, a UVA flashlight emitted UVA light on different concentrations of zinc oxide cream spread on a quartz slide, where a $15 UVM30A sensor, chosen for its flexible range and circular diffuser, detected how much UV penetrated through the cream. The UVM30A sensor was connected to an Arduino MKR Wifi 1010 that could upload data to the cloud.

In this context, accuracy is how well the UV sensor compares the protection of different sunscreens. In order to test the accuracy of the UV sensor, the protection of the sunscreens should be known. Consequently, the test used different concentrations of zinc oxide (ZnO) cream as the "sunscreen." It is known that the higher the concentration of ZnO, the more UV will be blocked. From 0% to 20% concentration cream, the UV sensor should detect decreasing amounts of UVA if accurate.

15 baseline tests using just the quartz slide were performed to accurately average the total amount of UV light that reached the sensor. Then, 5 variable tests were each performed 3x:

- **0% ZINC OXIDE**
- **5% ZINC OXIDE**
- **10% ZINC OXIDE**
- **15% ZINC OXIDE**
- **20% ZINC OXIDE**

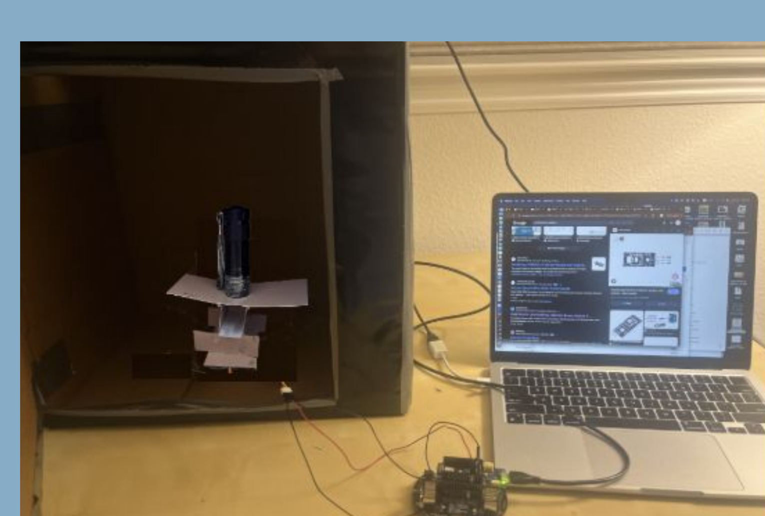

Fig 1. Test setup

DATA AND FINDINGS

The below quantitative data was gathered from 15 baseline tests and 15 variable tests, with 10 raw data points collected for each test.

Average UVA (mV) Detected for Each of 15 Zinc Oxide Cream Tests.

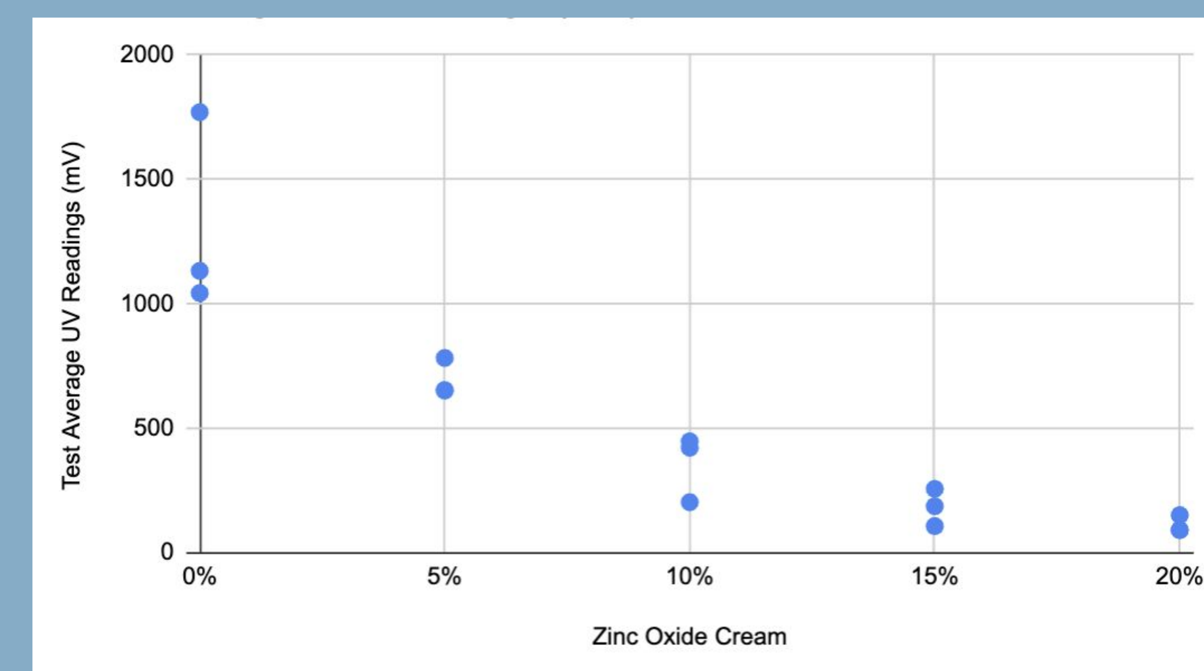

***Fig. 2.** This scatterplot graph shows the amount of UV that penetrated through the cream for each variable test.*

Percent UV Blocked Based on Different Percent Zinc Oxide Cream

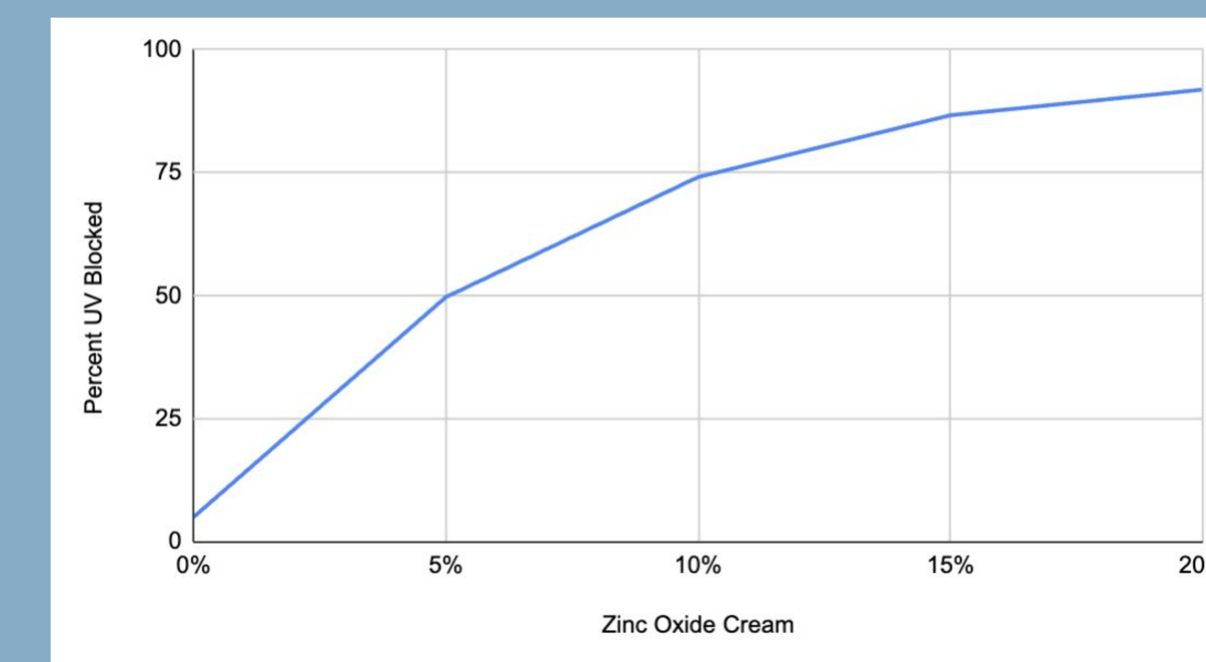

***Fig. 3.** This line graph shows the percent UV blocked by each percent zinc oxide cream.*

CONCLUSIONS AND ANALYSIS

The data collected from this study supports the accuracy of a UVM30A sensor to compare the UV protection of different sunscreens. As the concentration of zinc oxide increased, the amount of UV light the sensor detected decreased.

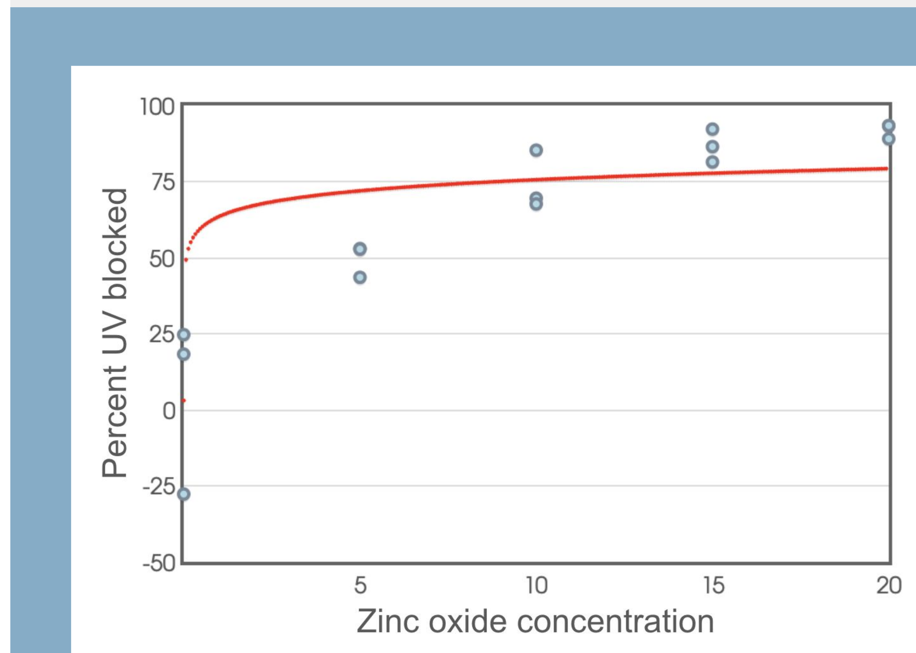

***Fig. 3.** This graph shows a logarithmic line of best fit for the amount of UV percent blocked for each of 15 variable tests.*

The data from the average percentage of UV blocked shows a strong correlation coefficient of r = 0.8693. A stronger correlation means that there is less deviation from expected values, and supports the consistency and accuracy of the UV sensor.

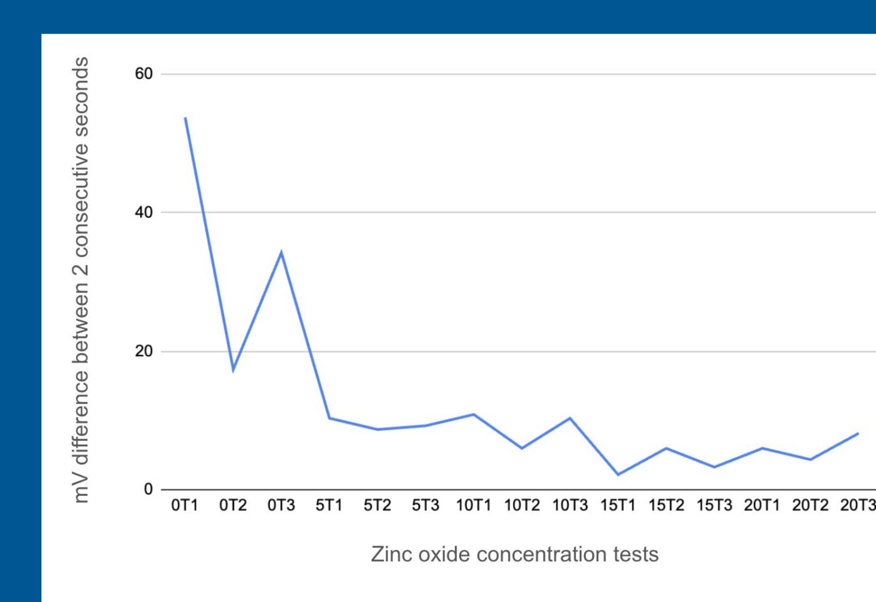

Fig. 11. *The average difference between consecutive sensor readings for each test.*

There are also observations that show the sensor's flaws. Fig. 11, indicates that either the UVM30A sensor is least accurate at more intense UV levels, or the UVM30A sensor has trouble sensing and differentiating between lower levels of light.

IMPLICATIONS AND NEXT STEPS

The UVM30A sensor accuracy shows potential to impact the field of in vitro sunscreen tests. It is small and efficient, fast, and low-cost. While the purpose of these tests is not to replace other professional in vitro tests, these tests could be used to supplement and verify a sunscreen's SPF value, and could be recreated by consumers, companies, or influencers to verify the SPF of different sunscreens and educate the public.

Evident next steps include testing the accuracy of the UVM30A to detect UVB light, and testing the accuracy of different types of UV sensors, including the VEML6075 and ML8511. Additional tests that thoroughly study reasons for the flaws of UVM30A would help provide a more comprehensive understanding of the accuracy of UV sensors.

ACKNOWLEDGEMENTS/REFERENCES

Andrews, D. Q., Rauhe, K., Burns, C., Spilman, E., Temkin, A. M., Perrone-Gray, S., Naidenko, O. V., & Leiba, N. (2021, October 19). Laboratory testing of sunscreens on the US market finds lower in vitro SPF values than on labels and even less UVA protection. *Photodermatology, photoimmunology & photomedicine*.

Osterwalder, U., Uhlig, S., & Colson, B. (2020, April). Good as gold. Cosmetics & Toiletries.

Zou, W., Ramanathan, R., Urban, S., Sinclair, C., King, K., Tinker, R., & Bansal, V. (2022, June 22). Sunscreen testing: A critical perspective and future roadmap. *TrAC Trends in Analytical Chemistry*.

Special thanks to Ms. Angell and my family for valuable guidance and support!
This project would not have been possible without them.