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NIR “matchbox size” spectrometer can quantify and detect malaria infection in *Plasmodium falciparum* infected red blood cells

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Abstract

New point-of-care diagnostic approaches for malaria that are highly sensitive, portable and affordable are urgently needed to meet the World Health Organization’s objective of reducing malaria cases and related life losses by at least 90% globally on or before 2030.¹ In this study, an ultra-cheap matchbox size near-infrared (NIR) spectrophotometer was used for the first time to detect and quantify malaria infection in vitro from isolated dried red blood cells using a fingerpick volume (15 μ l) of blood, down to 0.0001% parasitemia. This technique relies on detecting distinct changes associated with the NIR spectroscopic signatures of both infected and control RBCs spectra. The approach requires minimal sample preparation that entails a centrifugation step to isolate the RBCs. The spectrum is acquired within 3 s thus can be transferred with Global Position Satellite coordinates for epidemiological surveillance. Prior to its application for malaria detection, we first characterized the major biomarkers associated with infected and uninfected red blood cells in the near infrared region including hemozoin, hemoglobin and lipids. We then applied Principal Component Analysis and achieved an excellent separation between the infected and uninfected RBCs. Using Partial Least Squares Regression Analysis, a Root Mean Square Error of Prediction of 0.446 and 0.001 for the PLS- R models were achieved. Thus, we introduce a high-throughput alternative to Polymerize Chain Reaction DNA amplification and rapid diagnostic antibody test strips that can be established using inexpensive substrates and an affordable, highly portable and low power instrument. Moreover, data can be uploaded via a smartphone and analysed online from anywhere in the world, highlighting the potential of this approach for field deployment in remote villages where road access can be problematic.

Fig. 1: A simple straight forward approach for malaria diagnosis using a cheap miniature NIR spectrometer

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Keywords : Near Infrared spectroscopy, Chemometrics, Hemozoin.

References:

- [1] N. Tangpukdee; C. Duangdee; P. Wilairatana; S. Krudsood, “Malaria diagnosis: a brief review,” *Korean J Parasitol* 47, 93-102 (2009) 47 (2), 93-102.