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2020

Thulya, C. P., Adegoke, J., Edler, K., de Bank, P., Kochan, K., Heraud, P., & Wood, B. R. (2020). Proof of concept study for the detection and quantification of low molecular weight human serum proteomes using a miniature near-infrared spectrometer. Proc. Of the 7th Asian Spectroscopy Conference (ASC 2020). doi:10.32655/ASC_8-10_Dec2020.52

<https://hdl.handle.net/10356/144313>

https://doi.org/10.32655/ASC_8-10_Dec2020.52

Proof of Concept study for the detection and quantification of low molecular weight human serum proteomes using a miniature near-infrared spectrometer

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Abstract

Detection of serum proteomics is regarded as a laborious analytical exercise due to the complexity of serum samples, which have a dynamic range of high molecular weight fractions (HMWF) including albumin, immunoglobulins, transferrin, and lipoproteins and low molecular weight fractions (LMWF) such as cytokines, chemokines, and peptide hormones. Serum possesses biomarkers from several organ-specific pathological events, which leads to the variation in serum biochemistry. The LMWF often contains several disease-specific biomarkers, which are usually neglected in detection due to the high abundance of HMWF in serum. Here, we present a novel near-infrared spectroscopy (NIR) approach to detect low molecular weight serum biomarkers using the simplest and smallest amino acid unit, glycine as a reference molecule. Glycine was chosen because of its extremely low molecular weight (i.e., 75 Da) compared to other LMWF proteins such as cytokines (6-70 kDa) and chemokines (8 – 10 kDa). Furthermore, removal of the HMWF of the serum proteome by centrifugal ultrafiltration can improve detection of LMWF analytes. A Partial Least Squares – Regression (PLS-R) model was built by spiking glycine into serum and recording NIR spectra of the LMWF of the serum obtained by ultracentrifugation. The root mean square error of prediction (RMSEP) value of 0.174 mg/mL and an R² value of 0.963 was achieved with the glycine spiked ultrafiltered serum. Hence, the miniature NIR device was shown to identify specific glycine bands (at 2092, 2133, 2254, and 2333 nm) and quantify LMWF biomarkers using centrifugal ultrafiltration. The handheld NIR spectrometer is cost-effective, portable, low power and convenient compared to the traditional laboratory - based NIR spectrometers and hence has the potential to become a rapid high throughput screening tool for both dedicated clinics and remote villages where road travel and power can be problematic.

Fig. 1: Concept of study

Keywords: Serum proteomics, Biomarkers, NIR spectroscopy

References:

- [1] Franck Bonnier, Guillaume Brachet, Romain Duong, Tobiloba Sojinrin, Renaud Respaud, Nicolas Aubrey, Matthew J. Baker, Hugh J. Byrne, and Igor Chourpa, "Screening the low molecular weight fraction of human serum using ATR-IR spectroscopy," *Journal of Biophotonics*, **9**, 1085–1097 (2016).
- [2] Franck Bonnier, Hélène Blasco, Clément Wasselet, Guillaume Brachet, Renaud Respaud, Luis Felipe C. S. Carvalho, Dominique Bertrand, Matthew J. Baker, Hugh J. Byrne and Igor Chourpa, " Ultra-filtration of human serum for improved quantitative analysis of low molecular weight biomarkers using ATR-IR spectroscopy," *Analyst*, **142**, 1285–1298 (2017).