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Optothermal Measurement of Haemoglobin and Glucose in Blood

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ABSTRACT

Prototype instruments are developed for determing haemoglobin and glucose content of blood based on optothermal spectroscopy. The optothermal instrument is described. The results of clinical haemoglobin and glucose tests show good agreement with standard methodes. For haemoglobin a method reproducibility of better than $\pm 2\%$.

INTRODUCTION

Optothermal spectroscopy has been shown to be very useful for determinig the light absorption properties of opaque or powdered substances which are difficult or impossible to analyse using transmission spectroscopy. One such substance is whole blood, where the high absorption and light scattering make transmission spectroscopy inappropriate. Helander and Lundström -82 (1) McQueen -83 (2).

THE OPTOTHERMAL INSTRUMENT

A schematic representation of the optothermal instrument for haemoglobin analysis is shown in figure 1. The optical system consists of a light source, lens system, optical filter and light chopper. The open cell provides an electrical signal to the electronic system which consists of preamplifiers, lock-in amplifiers, electronic logic and a digital display.

A quartz halogen lamp is used with a reflector to direct the light through the collimating and focusing lenses. The color filter transmits light in the visible region. The mirror reflects the light upward toward the cell. Between the mirror and the cell the light is chopped at a frequency of 32 Hz using a mechanical chopper.

The electrical signals from the cell are amplified in lock-in amplifiers, using the chopper frequency and phase as reference. Following that the amplified signals are linearized in electronic logic circuits and the final output is transmitted to a digital display calibrated in haemoglobin or glucose concentration units. The instrument can be calibrated absolutely using a black sample, and a sample adjustment of the final amplifiers can be made routinely. The instrument requires about ten seconds to produce the measured value of the haemoglobin content on the digital display. Glucose is measured in forty seconds.

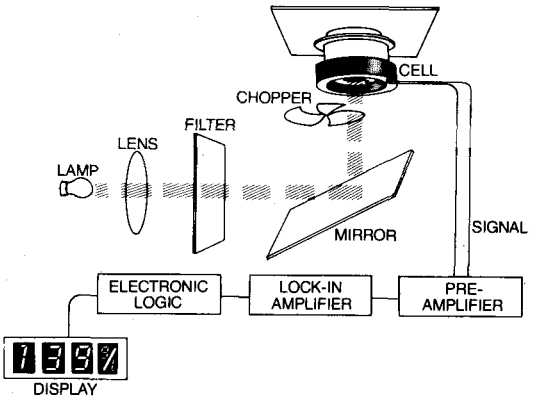

Figure 1. Schematic presentation of the optothermal instrument. Showing the components of the optical and mechanical systems and the optothermal cell.

CLINICAL RESULTS

Hemoglobin

For optothermal determination of haemoglobin in blood there is no need for reagents or dilution of the blood. The instrument can clearly identify the haemoglobin peak in the absorption spectrum. One drop of blood is all required for measurement of clinically interesting concentration.(3)

A comparison test of the optothermal instrument against the standard method (Van Kampen - Zijlstra) was carried out. Fresh samples of whole blood with EDTA, citrate or heparin as anti-coagulant were analysed for hemoglobin content after one to six hours storage.

Sampels were first sent for haemoglobin test using routine methodes with photometric instruments calibrated against haemoglobin standards. Each sample was numbered and had a separate protocoll with the measurement results.

The haemoglobin content of the samples was then determined using the optothermal instrument in such a way that the previous results from the standard photometric analysis were not known to the laboratory personnel performing the analysis (blind test). In order to study the reproducibility of the optothermal instument results twenty determinations of the haemoglobin content of each sample were made. 616 sample were studied in this way between May and August 1983. The optothermal instument was adjusted using a black sample daily. The results of this study are shown in figure 2.

Using the twenty determinations of each sample the reproducibility of the optothermal instrument results was determined to be better than $\pm 2\%$. Since no dilutions or reagents are required, this is the same as the method reproducibility.

Analysis of the 616 data points shown in figure 2 shows a 100% correlation between the standard cyanmethaemoglobin method and the optothermal method. No statistical difference

could be detected between the two methods. There is no detectable dependence on storage time (one to six hours) or storage temperature (10°C to 30°C). Thus the method accuracy is at least as good as that of the standard cyanmethaemoglobin method.

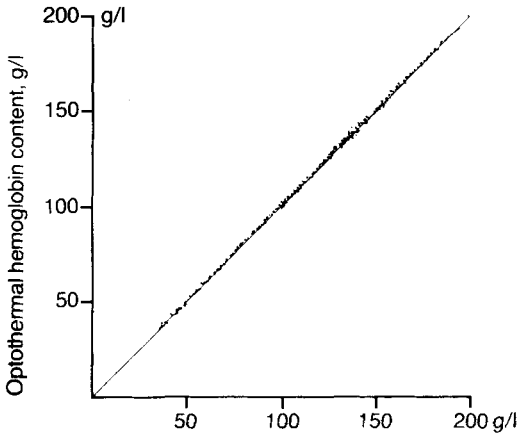

Figure 2. Standard method haemoglobin content, g/l

GLUCOSE

Besides haemoglobin other analyses can be carried out using optothermal spectroscopy. We have tested blood glucose. Comparisons were made to study the accuracy in a clinical study useing hexokinase as reference method. 480 samples were measured.

One drop of blood was added to reagent on the optothermal cell. In 40 to 50 seconds the result could be read on the optothermal prototype instrument.

Results:
We found a good correlation between results of the routine method and the optothermal one. Table 1.

N=480

METHOD	MEAN VALUE
OPTOTHERMAL	4.3 m mol/L
HEXOKINASE	4.1 m mol/L

Table 1. Comparison of a standard method and the optothermal

DISCUSSION

We have investigated the use of the optothermal method in determing haemoglobin and blood glucose in a clinical contex. Some advantages of this method compared with routine practice in middle-sized and small laboratories have been confirmed.

They are:
- no quantification of the sample is needed
- haemoglobin is measured without any adding reagents
- the method can be performed in closed systems
- operators with diverse backgrounds are able to produce equivalent results

Further parameters sutable for "open care" are under development. Clinical studies an triels continue.

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