# A novel concept for optical concentration determination of hemoglobin derivatives in non-hemolyzed human blood

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## Introduction

- Knowing the proportions of hemoglobin derivatives in human blood is important in clinical diagnostics due to possible dysfunctional forms.

**Parameters in blood gas analysis**

typical: pH, pO2, pCO2, **tHb**, lactate, glucose, $K^+$, $Ca^{2+}$, $Cl^-$, $Na^+$

with oximetry unit: HHb, $O_2Hb$ (functional); COHb, MetHb, SHb (dysfunctional)

- Conventionally, hemolysis is necessary in combination with optical measurements to eliminate light scattering effects by red blood cells.
- A novel approach based on optical measurements in non-hemolyzed whole blood and mathematical modeling is currently being developed.
- The nondestructive approach results in a more flexible analysis process and reduces maintenance costs without the need for consumables.

## Objectives

- Design of a measurement setup to determine the optical properties of non-hemolyzed human blood.
- Development of an approach for modeling the dependencies of the optical properties on different condition variables.

## Current status

- Case to protect the setup against unwanted external influences, mainly temperature fluctuations.
- Linear slide to simplify calibration process and to increase the reproducebility of measurements.
- Micro bench part for adjusting unscattered transmission intensity allows easy insertion of further modifications (e.g. filters).

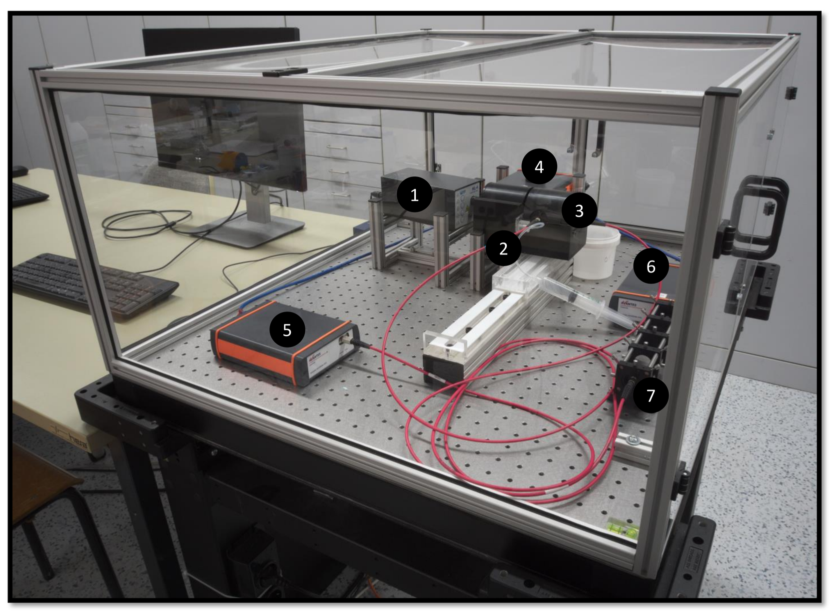


Fig. 3 – Current measurement setup without fluidic circuit components like valves and pump.

1. Light source
2. Flow cell
3. Integrating sphere
4. Spectrometer $R_d$
5. Spectrometer $T_d$
6. Spectrometer $T_u$
7. Micro bench

## Outlook

- Evaluation of the measured data with literature data.
- Creation of a database of $\mu_a$, $\mu_s$ and g at different condition variables.
- Construction of regression model for the determination of functional and dysfunctional hemoglobin concentrations.

## Design concept

- Double-integrating sphere setup with tungsten-halogen light source.
- Measurement of diffuse reflection $R_d$, diffuse transmission $T_d$ and unscattered transmission $T_u$ in the spectral range from 400 to 1000 nm.
- From $R_d$, $T_d$ and $T_u$ the absorption coefficient $\mu_a$, scattering coefficient $\mu_s$ and anisotropy factor g are calculated using the Inverse Adding-Doubling (IAD) method [1, 2].

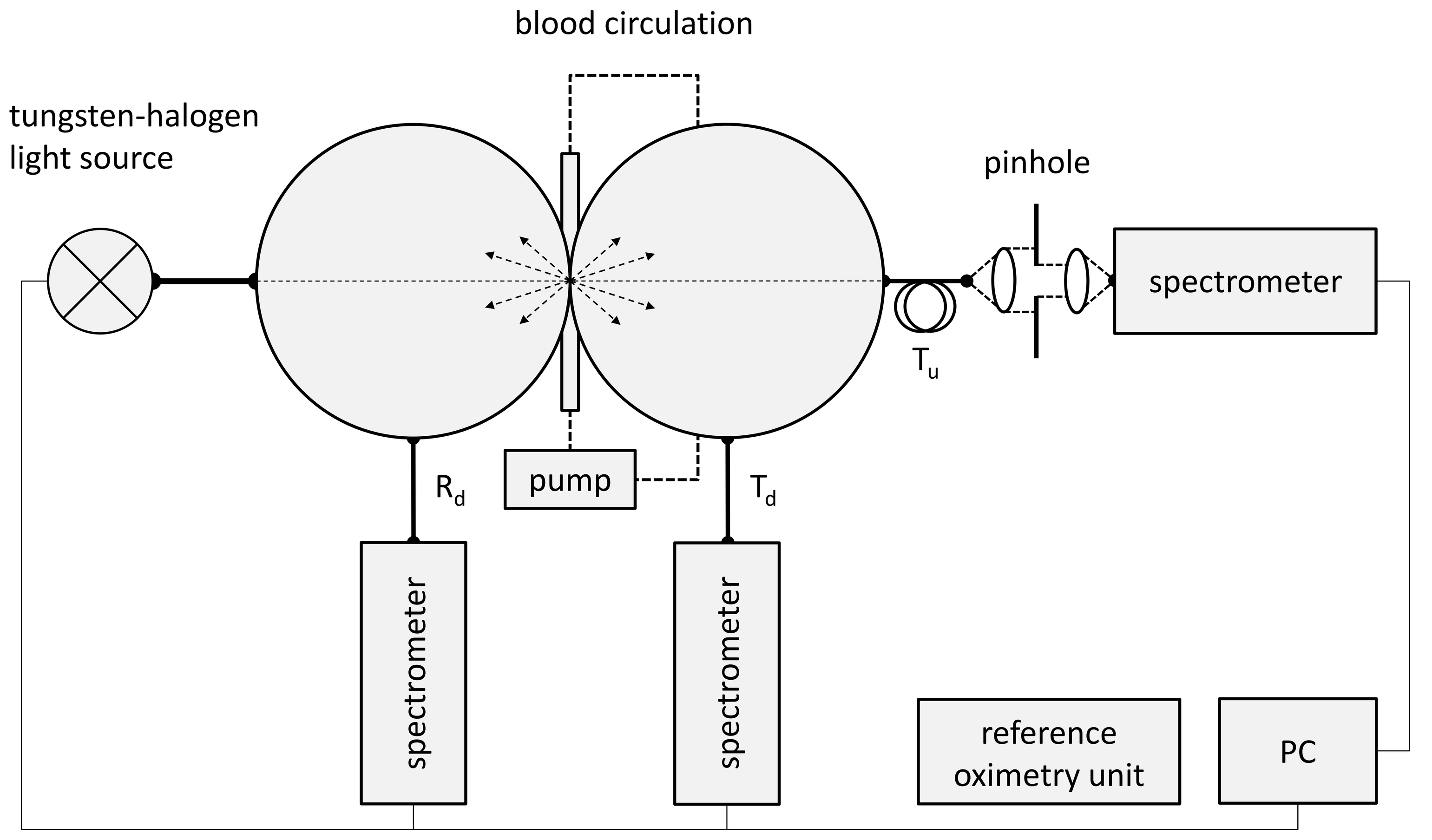


Fig. 1 – A tungsten-halogen light source irradiates a blood sample which continuously flows through a 100 µm optical path length cuvette that is placed between two integrating spheres. Back-scattered and transmitted radiation intensities are measured by spectrometers.

- Determination of optical parameters at sequential variation of condition variables (hematocrit, osmolarity, hemoglobin derivatives and more) through optical measurements on non-hemolyzed human blood [3].
- Shear rate and temperature will be kept at constant values.
- Selection of spectral ranges with good correlation and low cross sensitivity to other variables.
- Construction of a regression model, which combines suitable spectral changes at different optical parameters.

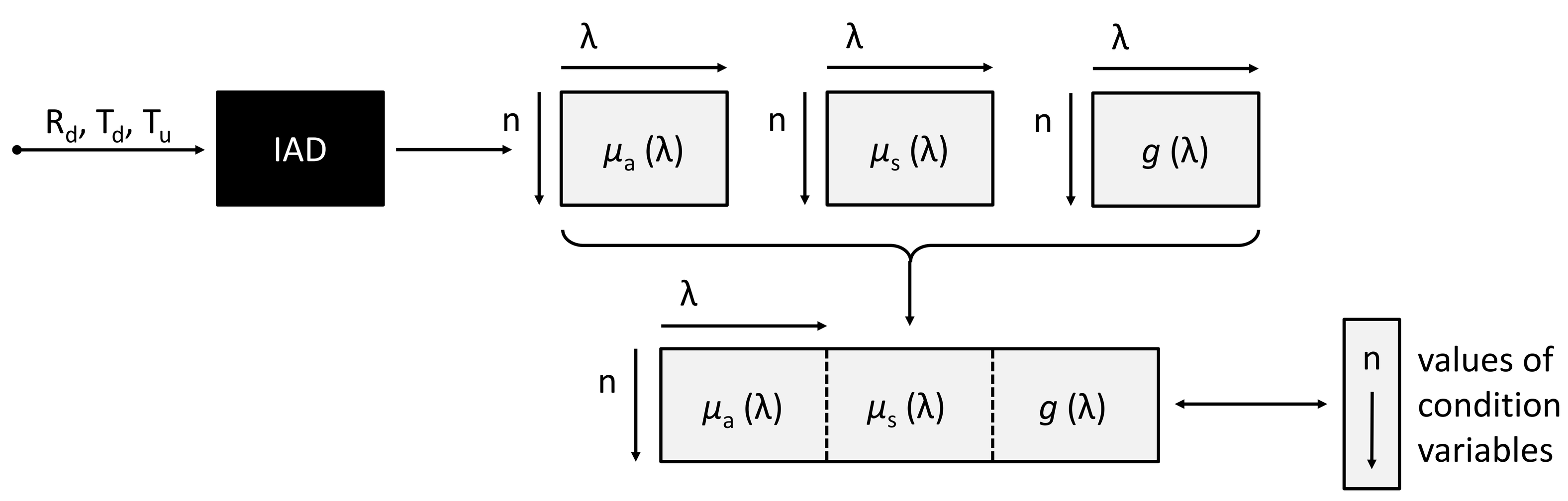


Fig. 2 – Changes in all three optical parameters $\mu_a$, $\mu_s$ and g are used to build the regression model.

- Relative quantities provide a well transferable model, e.g. to different measurement geometries.

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