Heat production of erythrocytes in sickle-cell disease

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Sickle-cell disease (SCD) is a hereditary blood disorder characterized by an abnormality in the oxygen-carrying hemoglobin molecule in red blood cells. Caused by a point mutation in the ß-globin gene, sickle-cell hemoglobin polymerizes into a 14-stranded polymer when in its deoxy state and depolymerizes when it is well oxygenated [1]. This leads to a propensity for the cells to assume an abnormal, rigid, sickle-like shape under certain circumstances. Sickle-cell disease is associated with a number of acute and chronic health problems, such as severe infections, attacks of severe pain, and stroke and there is an increased risk of death.

Proteomics and interatomics can be used to define biomarkers in erythrocytes, leukocytes, blood vessel endothelial cells or plasma which possibly help to predict the severity of SCD for the patients [1]. Abnormalities in sickle-cell blood are also reflected by changes in the metabolic activity of erythrocytes as demonstrated by calorimetric measurements several years ago [2]. Because the catabolism of erythrocytes is mainly determined by the glycolytic pathway their heat production rate is quite low, only few femtowatt per cell. Therefore, calorimetric measurements had to conduct with samples of large cell density which, up to now, requires the application of batch calorimeters which usually are slowly working and of high sample demand. However, newly developed flow-through chip calorimeters operated with the segmented-flow technology [3] allow the fast and continuous calorimetric analysis of small blood samples. This opens up new possibilities to make calorimetry available for personalized medicine for SDC.

In the presented work, we compared the heat production rate of blood samples obtained from SCD patients with those from healthy control persons. We found an increase by factor of two for SCD erythrocytes. Furthermore, the variation of the heat production rate of SCD erythrocytes is considerably higher than in case of the controls. Comparisons with blood analysis data indicate an influence of the concentration of reticulocytes and fetal hemoglobin.

[1] S. R. Goodman, O. Daescu et al., Exp. Biol. Medicine 238 (2013) 509 – 518.

[2] A. E. Boyo and J. A. Ikomi-Kumm, Lancet 299 (1972) 1215 – 1216.

[3] A. Wolf, T. Hartmann, M. Bertolini et al., Thermochim. Acta 603 (2015) 172 – 183.