A Conductivity Probe for the Determination of Carbon Dioxide Tension at the Oxygenator Exhaust Outlet during Extracorporeal Membrane Oxygenation (ECMO)

B. van der Weerd, Regensburg/D, F.-M. Matysik, Regensburg/D, R. Bierl, Regensburg/D

University of Regensburg, Institute of Analytical Chemistry, Chemo- and Biosensors
Universitätsstrasse 31, 93053 Regensburg/D

A veno-venous extracorporeal membrane oxygenation (ECMO) is a mature clinical treatment for an acute respiratory distress syndrome (ARDS). ECMO is applied to patients with severe lung failure. It can be understood as an artificial lung realizing oxygenation and carbon dioxide elimination. During a veno-venous ECMO venous blood is pumped through a membrane oxygenator before the oxygenated blood flows back into the patient's vein [1]. There is a need for reliable, accurate and instant determinations of the arterial blood CO_2 tension (p_aCO_2) to guarantee a physiological therapy. A well known method for an indirect determination of the p_aCO_2 is the analysis of the partial pressure of CO_2 (pCO_2) in the exhaust gas outlet from the membrane oxygenator [2].
A new concept for the determination of pCO_2 in the exhausted gas volume was studied. The electrochemical detection is based on a commercial thin-film microelectrode. Interdigitated platinum electrodes are structured on a 750 µm Pyrex substrate (10 x 6 mm), in detail 15 pairs of 10 µm width, separated by gaps of 10 µm, form the interdigital structure. The whole chip is protected by a SU-8 layer. The key idea of the present sensor concept is, to have a membraneless device which measures the pCO_2 dependent conductivity in a thin film of water in direct contact with the gas phase. There is no need for a separating membrane as the measured medium in the oxygenator exhaust gas analysis consists only of oxygen, carbon dioxide and water vapor. The fact to have a sensor without any membrane is promising in terms of attractive response characteristics.
An impedance-phase analyzer was utilized for the investigation of the electrochemical characteristics of the sensor. Impedance spectra were measured to study the frequency behavior of the electrochemical sensor. The sensor was mounted into various flow cells with different geometries and materials. The performance was characterized using the gas test bench. For preliminary studies the microelectrode was completely immersed into the electrolyte solution. Signal stability and reproducibility, calibration curves and response characteristics were studied. A hydrogel covered electrode was prepared and integrated into the sensor configuration. First experiments with the gas sensor show promising results.

[1] T. Müller, Extrakorporale Lungenunterstützungsverfahren beim ARDS des Erwachsenen: Eine Standortbestimmung, Intensivmedizin und Notfallmedizin, **46 (2009), 109-119**. [2] K. C.Potger, Membrane oxygenator exhaust capnography for continuously estimating arterial carbon dioxide tension during cardiopulmonary bypass, J Extra-Corpor Technol., **35 (2003), 218-23**.