A CONDUCTIVITY PROBE FOR THE DETERMINATION OF CARBON DIOXIDE TENSION AT THE OXYGENATOR EXHAUST OUTLET DURING EXTRACORPOREAL MEMBRANE OXYGENATION (ECMO)

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Introduction

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 instantaneous determinations of the arterial blood CO\(_2\) tension (p\(_{CO_2}\)) to guarantee a physiological therapy. The current state of the art is the manual collection of blood samples followed by a separate determination of p\(_{CO_2}\) by means of a blood gas analyzer. This approach delays the optimal regulation of the system and suffers from many unwanted manual steps.\(^2\) A well known method for an indirect determination of the p\(_{CO_2}\) is the analysis of the partial pressure of CO\(_2\) (pCO\(_2\)) in the exhaust gas outlet from the membrane oxygenator.\(^3\)

New Sensor Concept

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. The key idea of the present sensor concept is, to have a device which measures the pCO\(_2\) dependent conductivity in a thin water film. This water film is separated to the gas phase by a gas permeable membrane. The fact to have a sensor with a thin membrane and a small water volume is promising in terms of response characteristics and signal stability.

Experimental Data

The miniaturized sensor is based on a thin-film microelectrode, a micro cavity, a CO\(_2\) permeable PDMS membrane and a sensor package. A cavity with a diameter of 2 mm and a height of 100 µm was processed on top of the electrode via known photolithographic SU-8 structuring methods. PDMS was spin coated to form a membrane with auspicious diffusion characteristics as PDMS shows good permeability properties to CO\(_2\).\(^4\) A drop of clean water was placed into the cavity before the whole sensor was stacked together with the help of a 3D printed sensor housing.

Classical Conductivity Measurements

The relation of electrolytic conductivity and the gaseous carbon dioxide concentration was determined by the use of a classical conductivity electrode and a measuring cell shown in figure 3.

![Diagram of a classical conductivity electrode and measuring cell.](image)

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![Diagram of a miniaturized sensor with a thin-film electrode and cavity.](image)

Literature