MED DEVICE ONLINE

Article | March 29, 2023

# Membranes Allow Oxygen-Dependent Sensors To Function Longer And More Accurately

Source: DSM Biomedical

By Andre Martinez, PhD, DSM Biomedical

*Design Considerations In Developing A Glucose Limiting Membrane*

Wearable biosensors are one of the most promising areas in the medical device industry, inspiring major investments from device manufacturers and a strong focus on research and commercialization from both universities and start-ups. One of the first areas of medicine to fully embrace this field is diabetes management. Continuous glucose monitors (CGMs) have simplified life for millions of patients, allowing real-time blood-glucose monitoring without the need to prick one's finger and apply blood to a test strip.

CGMs work by adhering a transmitter to the skin, typically on the arm or abdomen. Leading from the transmitter, a thin sensor penetrates the subcutaneous layer. An outermost, rate-limiting membrane on the sensor regulates the permeation of glucose and oxygen to an enzyme layer below. This layer is composed of crosslinked glucose oxidase. When glucose and oxygen permeate to the enzyme layer, glucose oxidase catalyzes the oxidation of glucose to gluconic acid using molecular oxygen as an electron acceptor, generating hydrogen peroxide in the process. Hydrogen peroxide then permeates another layer to reach the anode of the device where it is oxidized, releasing electrons that generate a current that the device monitors.[1]

The outer rate-limiting membrane, known as a glucose limiting membrane (GLM), is necessary to balance the permeation of glucose and oxygen to the enzyme layer. To achieve this throughout all usage conditions of the device, a properly designed GLM should target a permeability ratio such that permeability of oxygen relative to glucose is greater than the maximum glucose concentration relative to minimum oxygen concentration expected during use. [2]

$$\text{Target Permeability Ratio for GLMs: } (P_O / P_G) > ([\text{Glucose}]_{max} / [\text{Oxygen}]_{min})$$

The current generated by the device thus remains linear with respect to glucose concentration and the concentration of blood-glucose can be accurately measured over the naturally occurring physiological range.

DSM Biomedical has developed the Sparsa platform of amphiphilic polyurethanes designed to regulate analyte permeation and allow simplified fabrication of biosensor devices such as CGMs. The Sparsa platform is a thermoplastic polyurethane (TPU) combining hydrophilic and hydrophobic polyols into a single chain. These two segments allow transport of both polar, water-soluble molecules, and non-polar molecules and there is no need to blend a second material to achieve desired transport properties of glucose and oxygen in the case of a CGM. This also means that there is no risk of phase separation of multiple components upon forming the membrane, and less stringent process control is required.

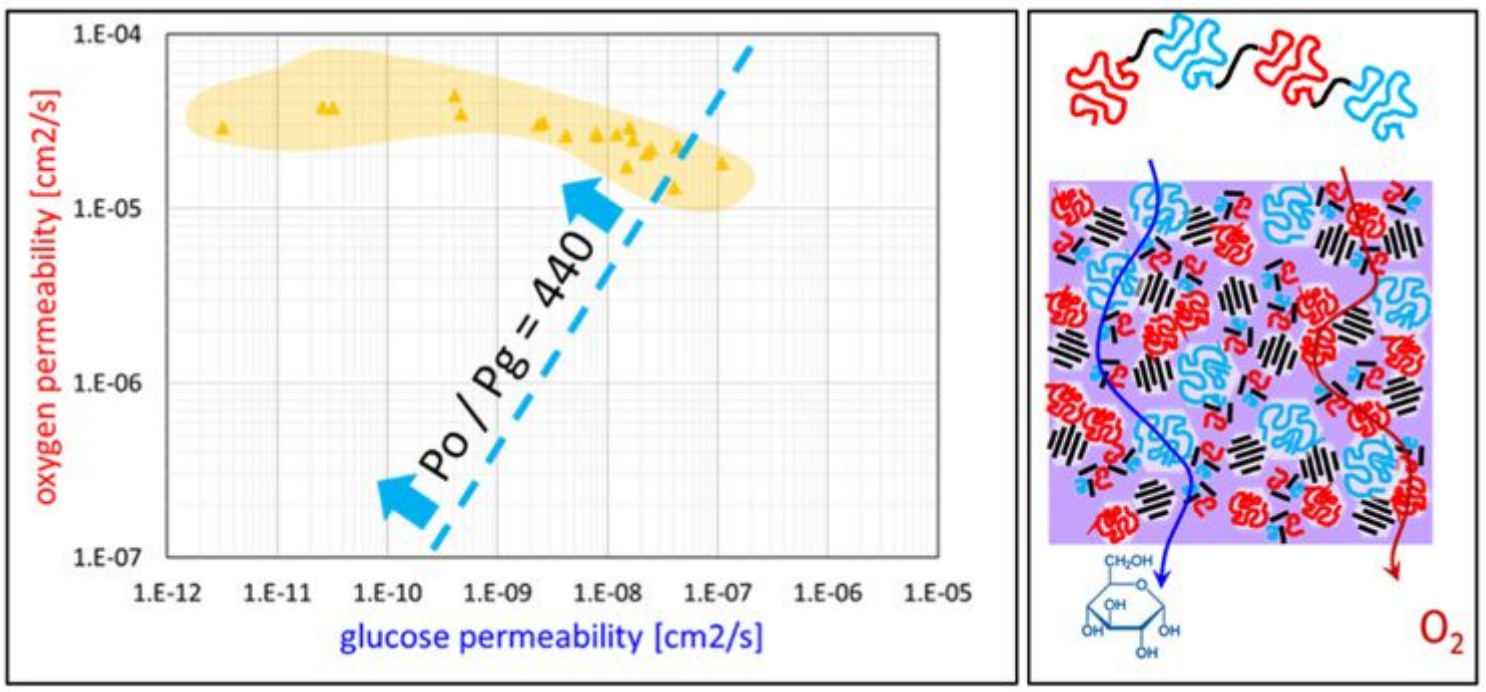


*Figure 1: Left - The Sparsa platform allows a range of permeability ratios. Glucose permeability is highly tunable via formulation balance. Right - The Sparsa polymer contains hydrophobic and hydrophilic blocks. When cast*

*into a membrane, hydrophilic blocks allow glucose permeation, while hydrophobic bolcks are primarily responsible for oxygen permeation.*

An additional benefit to surfaces coated with Sparsa formulations are that they show far greater resistance to non-specific protein adhesion than conventional TPUs[3]. This may be considered non-fouling behavior, with the potential to reduce fibrous capsule formation and extend implanted sensor lifetimes.

The Sparsa platform is adaptable, allowing formulations having a variety of physical and chemical properties. Favored formulations to date are optimized to enable short term implanted glucose sensors, however, formulations may be easily adjusted to the needs of a variety of biosensors dependent on the required transport needs of various physiological analytes.

Sensors will enable many of the individualized medical break-throughs of the future, but they will require well-designed interface materials to enable accurate and long-lasting performance. By leveraging our knowledge of biomaterials, DSM Biomedical has been able to improve upon current solutions by creating unique polymer formulations that meet these challenging needs. If you would like more information about this topic, please reach out to Andre Martinez at the email address below.

**About the Author:**

Andre Martinez, Ph.D. is a Scientist at DSM Biomedical. He has 5 years of experience in design, development, and commercialization of medical devices and has a doctorate in Polymer Chemistry from the University of Connecticut. Andre has extensive experience in working with customized Thermoplastic Polyurethane materials. If you would like more information about this topic, Andre can be reached at Andre.Martinez@dsm.com.

**About DSM Biomedical:**

DSM Biomedical is the world's unrivaled biomaterials expert and committed partner driving sustainable innovation in healthcare. For 30+ years, their solutions have been recognized for their unmatched quality, consistency and performance, ultimately supporting their company-wide vision of solving the world's healthcare needs through sustainable science.

**References:**

[1] Sandip B. Bankar, Mahesh V. Bule, Rekha S. Singhal, Laxmi Ananthanarayan. Glucose oxidase — An overview. Biotechnol. Adv., 2009, 27, 489-501

[2] Leypoldt J., Gough D. Model of a Two-Substrate Enzyme Electrode for Glucose. Anal. Chem. 1984, 56, 2896-2904

[3] Tanaka, M. et al. (2001) 'In situ studies on protein adsorption onto a poly(2-methoxyethylacrylate) surface by a quartz crystal microbalance', Colloids and Surfaces A: Physicochemical and Engineering Aspects, 193(1), pp. 145–152. doi:10.1016/S0927-7757(01)00682-3.