Executive Summary

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Project "Blood sugar measurement through the skin"

The aim of the project is to prevent impaired brain development in extreme preterm neonates in addition to reducing pain, infection risks, and costs for hospitals by continuous, non-invasive, transdermal, auto-calibrating glucose monitoring with passive diffusion.

The skin of preterm neonates is much simpler structured than the one of adults. It does not sweat and lacks a thick uppermost layer of the skin, its barrier to diffusion, the stratum corneum. Hence, small molecules such as glucose diffuse passively through the skin. It has been shown that this diffused glucose can be employed to monitor the blood glucose concentration of preterm neonates with high precision by microdialysis. But this method needs a calibration, because the skin permeability is unknown and depends on several parameters such as temperature, humidity, and pH. To overcome this problem, we developed a smart membrane whose permeability to glucose is controlled and switched by exposition to light.

In part of the project we successfully developed light-responsive smart membranes, which control the diffusion of body fluids and thus enable an accurate spectroscopic measurement of dissolved glucose. The light-responsive membranes reversibly change their resistance towards glucose upon light as external stimulus, i.e. in their low permeable state, when exposed to white light, their resistance is above the resistance of the skin of (pre)term neonates, whereas in the high permeable state, when exposed to UV light, it is significantly lower. Different approaches for the synthesis of light-responsive membranes were investigated such as grafting from processes and direct synthesis of membranes. We achieved membranes where the low permeability state can be adjusted as a function of the production process and membrane composition. All membranes showed a reversible and relevant increase in permeability under UV irradiation (up to >1000%). The most promising lightresponsive membrane involves a simple one-step production process and a high photostability (>75 switching cycles), but its mechanical stability needs improving.

Another part of the project was to develop a setup to measure glucose based on this novel principle. It includes a microdialysis chamber a light responsive membrane to collect glucose through the skin of preterms. We tested different designs of the microdialysis sensors such as a PMMA sensor made with standard fabrication techniques and a flexible microstructured polymer. This microdialysis head was attached to a microfluorimeter for measuring the glucose concentration in the dialysate. We tested the membrane in-vitro with synthetic and animal (pig fetus) skin. Thus, we were able to control dialysate extraction of glucose. Thus, in principle the system is functional. Further tests and a clinical trial are planned for the future.