Application Note

Chemical Sensors Enabled by Carbon Nanomembranes

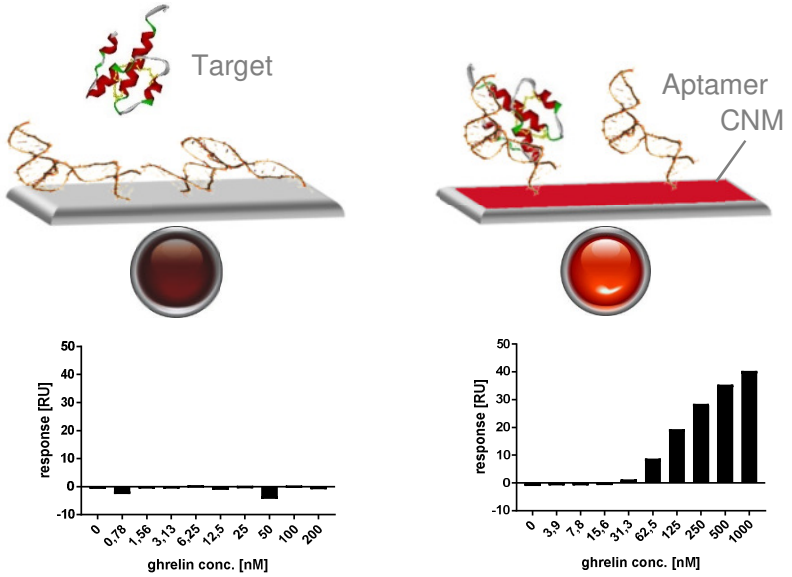

Figure 1: Top: Principle of a surface-sensitive sensor with immobilized aptamer "receptors". Bottom: Detection of various concentrations of the peptide ghrelin by surface plasmon resonance by an immobilized ghrelin-binding L-aptamer. Left: Target recognition is inhibited by interactions of the receptors with the surface. Right: Using a CNM nanointerposer, aptamers maintain their three-dimensional structure and thus their target binding properties.

Oligonucleotides can adopt complex three-dimensional structures comparable to proteins. If specifically selected against a target of interest, they can bind this with high affinity and specificity and can thus be used for diagnostic or therapeutic purposes. These molecules are referred to as "aptamers". Especially L-aptamers (built from mirrored nucleotides), which are not affected by blood plasma, compare favorably with conventional antibodies:

- easy and fast manufacturing
- versatile chemistry
- extreme biological stability
- high physicochemical stability
- high shelf-life
- affinity in nM- to pM-range
- high specificity and selectivity

However, upon immobilization on surfaces, aptamers often lose their three-dimensional structure due to interactions with the surface. This restriction has hampered a widespread implementation of aptamers in bio-sensors (Figure 1). As a solution to this problem, **we have developed a nanointerposer based on Carbon Nanomembranes (CNMs) to immobilize nucleic acids and especially aptamers to surfaces.** CNMs are polymer-like, two-dimensional materials with a thickness of one molecular layer (1 nm). They are thin enough to enable the detection of interactions on their surface by underlying sensors. The use of CNMs allows for maintaining the oligonucleotides' three-dimensional structure and thus their target binding properties. Using surface plasmon resonance, we have demonstrated high sensitivity (Figure 2) and high specificity for the detection of chemokines (small proteins) from biological samples.

Detection systems using this strategy can be label-free, e. g. based on refractory index (surface plasmon resonance, ring resonators, ellipsometry), charge (field effect transistors like the Graphene-FET developed by Friedrich-Schiller University Jena), mass change (quartz crystal microbalance, microelectromechanical systems), electrochemical impedance), surface stress (cantilever biosensors) or based on optical readout (fluorescence, absorption and luminescence) when used with labeled competitors.

CNM Technologies GmbH and Aptarion biotech AG hold all the rights to this development and can support interested partners in implementing this technology in their sensor concepts in widespread areas, such as healthcare, environmental and food analysis as well as civil security.

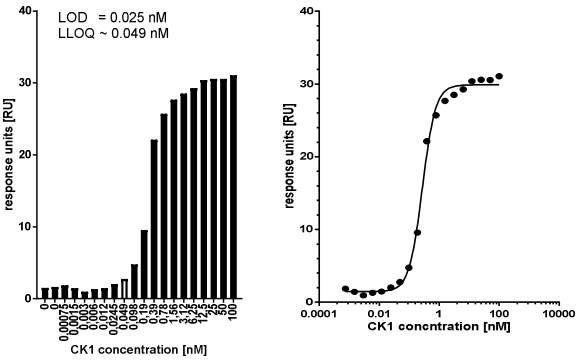

Figure 2: Detection of various concentrations of chemokine 1 (CK1) spiked into a nasal swab sample by an anti-CK1 L-aptamer immobilized via click-chemistry to a CNM on a surface plasmon resonance chip. The limit of detection (LOD) is 25 pM; the lower limit of quantification (LLOQ) is 49 pM.

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