A DNA Aptamer for Trivalent Lanthanide Ions with Low Nanomolar Affinity

Lanthanides are a group of 15 metal elements that have unique optical and magnetic properties, granting them uses in modern technologies such as magnetic imaging contrast agents, permanent magnets and upconverting nanoparticles. Existing technologies for detecting lanthanides currently require expensive equipment that is unsuitable for on-site or real-time detection.
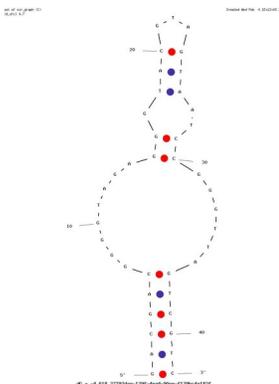

In 2025, Wang et al. discovered an aptamer, Tb-1, that broadly binds to lanthanide ions, with a slight preference for the heavier ones. Though Tb-1 was selected for binding against terbium ions (Tb3+) only, testing by Thioflavin T fluorescence-based binding assays showed it to be capable of binding to all trivalent lanthanides while not binding to non-rare-earth metal ions or the quadrivalent lanthanide ion Ce4+.

Figure 1. Predicted structure of aptamer Tb-1 Note that secondary structure may be inaccurate due to changes resulting from interactions with the target.

Wang's team then incorporated Tb-1 into a strand-displacement fluorescent sensor using a FAM label on the aptamer and a complementary quencher strand. This sensor was tested against each lanthanide and showed strong fluorescent response against all trivalent lanthanide ions except for Sc3+. The true Kd value of Tb-1 against Tb3+ was found to be 3.9 nM after accounting for the quencher-labeled strand as a competitor. Further testing showed that the sensor was also capable of detecting Tb3+ spiked into filtered and buffered lake water with a limit of detection of 0.5 nM, demonstrating its potential for the detection of lanthanide ions.

*Reference: Apta-Index™ ID# 9779   P.H.K.

TLR4-Binding DNA Aptamers Show a Protective Effect against Acute Stroke in Animal Models

Toll-like receptors (TLRs) are pattern-recognition receptors that regulate innate immunity and influence adaptive immune responses specifically in the inflammatory responses to ischemic injury. Using SELEX, ApTLR#4FT, was identified and shown to possess TLR4 antagonistic activity. Given known species-specific differences in TLR4 signaling, these aptamers were designed to selectively target human TLR4. Binding affinity and specificity were confirmed by incubating selected aptamers with either recombinant hTLR4 or hTLR4-expressing cells, followed by recovery and quantification of bound aptamers using qPCR. ApTLR#4FT demonstrated higher binding affinity and was selected for further investigation.
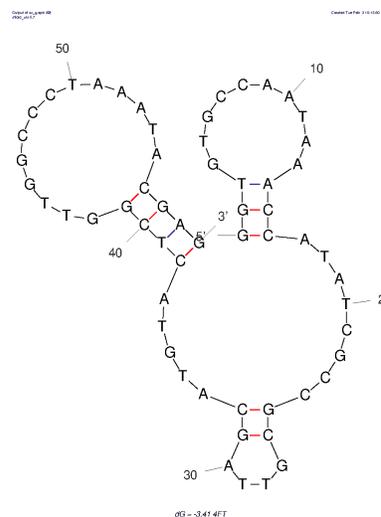

Figure 1. Predicted structure of aptamer TLR#4FT. Note that secondary structure may be inaccurate due to changes resulting from interactions with the target.

Mice received doses of aptamers 10 minutes after ischemic occlusion. Studies demonstrated that post-stroke administration of ApTLR#4F and ApTLR#4FT significantly reduced infarct volume in ischemic stroke models, an effect absent in TLR4-deficient mice, confirming TLR4-dependent activity. ApTLR#4FT provided sustained protection up to 21 days post-stroke and was associated with improved functional recovery.

ApTLR#4FT reduced circulating levels of pro-inflammatory cytokines and attenuated blood–brain barrier disruption after ischemic injury. These findings support continued development of ApTLR#4FT as a therapeutic candidate for stroke and other TLR4-mediated conditions.

*Reference: Apta-Index™ ID# 9775   -R.S.

Use of Capillary Electrophoresis to Select a DNA Aptamer that Recognizes Swine Anaphylatoxin C5a

The complement system plays a central role in innate immunity, inflammation, and host defense. Among its effector molecules, anaphylatoxin C5a is one of the most potent inflammatory peptides, driving leukocyte recruitment, cytokine release, and vascular permeability. Dysregulated C5a signaling has been implicated in sepsis, inflammatory injury, and immune-mediated tissue damage. Reliable molecular tools capable of selectively recognizing C5a are therefore valuable for both mechanistic studies and translational applications.

C5aApt-1 is an aptamer identified by Li et al. in 2018 that binds swine anaphylatoxin C5a with measurable affinity and notable species specificity. Despite the high sequence and structural homology of C5a across mammalian species, this aptamer exhibits strong discriminatory power: SPR testing of C5aApt-1 yielded a K_D of 4.81 µM against swine C5a but showed no binding against human or mouse C5a. In vitro studies also confirmed that C5a-Apt-1 inhibits the activity of C5a. C5aApt-1 was identified by capillary electrophoresis-based SELEX (CE-SELEX), an increasingly powerful alternative to conventional magnetic-bead-based selection strategies.
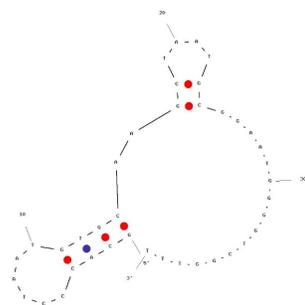

Figure 1. Predicted structure of aptamer C5aApt-1. Note that secondary structure may be inaccurate due to changes resulting from interactions with the target.

C5aApt-1 represents a promising molecular recognition element for species-specific detection of anaphylatoxin C5a. Future studies will aim to evaluate the potential of this aptamer and its inhibitory capabilities as a therapeutic agent against inflammatory diseases. With further optimization and validation, aptamers such as C5aApt-1 may support the development of diagnostic assays, inflammatory pathway studies, and targeted biosensing applications.

*Reference: Apta-Index™ ID# 9279   -P.J.K.

Pre-Defined Stem-Loop Structure Library for the Discovery of L-RNA Aptamers that Target RNA G-Quadruplexes

RNA G-quadruplexes (rG4s) have emerged as critical regulatory elements in gene expression, viral replication, and oncogenesis. These noncanonical nucleic acid structures, formed by guanine-rich sequences, play key roles in translational control and RNA stability. However, developing molecular ligands that selectively target rG4s remains challenging, owing to their structural polymorphism and the high failure rate of conventional aptamer selection strategies.

EBNA1 is an essential viral protein required for Epstein–Barr virus (EBV) genome maintenance and is constitutively expressed in EBV-associated malignancies, making it an attractive therapeutic target.
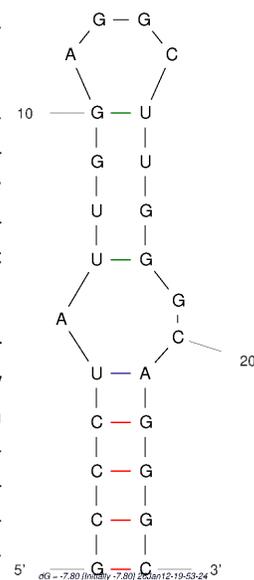

Figure 1. Predicted structure of aptamer L-Apt1-12. Note that secondary structure may be inaccurate due to other modifications and/or changes resulting from interactions with the target.

The L-RNA (mirror-image RNA) aptamer L-Apt1-12 was discovered using a newly developed G4-SLSELEX-Seq platform, a streamlined selection strategy specifically optimized for G-quadruplex targets. Unlike conventional SELEX approaches, this method introduces a pre-defined stem-loop architecture into the starting library, thereby biasing selection toward structural motifs favorable for G4 recognition. Remarkably, L-Apt1-12 was identified in only three selection rounds with 105 nM binding affinity. Treatment of human cancer cells with the aptamer downregulated EBNA1 protein expression, resulting in selective toxicity toward EBV-positive cancer cells. This represents a compelling example of next-generation aptamer engineering, combining L-RNA chemistry, structure-guided selection, and functional cellular validation.

*Reference: Apta-Index™ ID# 9737   -P.J.K.

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