DNA Aptamer Adsorption onto Cellulose

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Abstract

The adsorption of Cellulose binding DNA aptamer, CELAPT at different $CaCl_2$ concentrations have been examined with quartz crystal microbalance measurements, QCM-D, to compare cellulose binding tendencies of DNA aptamers with poly(diallyldimethyl ammonium chloride), PDADMAC, and an aptamer not optimized for cellulose binding, NCELAPT. The QCM-D analysis showed that both of CELAPT and NCELAPT in 5, 20, and 100mM $CaCl_2$ aqueous solution had as high binding affinity to cellulose in 5, 20, and 100mM $CaCl_2$ aqueous solution with binding constants similar to as antigen-antibody complexes. On the other hand, in higher ionic strength (100mM $CaCl_2$ the maximum) cellulose aptamer binding onto cellulose, ΔM_{max}, of increased whereas adsorption of the control aptamer (NCELAPT) decreased. CELAPT at 100mM was higher than that at 5, 20mM. ΔM of NCELAPT was decreased with increasing ionic strength. These effects suggest that the specific nucleic acid sequence is important. We conclude that it may be possible to design papermaking additives that employ short DNA sequences that bind to cellulose.

Introduction

The ever increasing use of recycled fiber coupled with lower water consumption has promoted the presence of charged contaminants in papermaking[1]. Most conventional papermaking chemicals exploit electrostatic attraction between oppositely charged molecules or surfaces. Charge contaminants can therefore interfere with the adsorption of polymeric additives on fiber surfaces. In this paper we report the results of a preliminary investigation of a completely new, non-electrostatic method of modifying polymers to adhere to fibers based upon short, synthetic DNA chains.
Recent publications suggest that short chain fragments of single strand DNA, called DNA aptamers, will spontaneously bind to cellulose[2]. In this paper we report measurements comparing the cellulose binding properties of cellulose DNA binding aptamer to PDADMAC, a common papermaking additive. In future work, the cellulose binding aptamers will be grafted to water soluble polymers.

Materials

A cellulose binding DNA aptamer[2] <CELAPT>
Mw:22,000 Base : 70
(5'TGGGCTCGCGTTGCAGAGGGGGTGGGATTGGGTCACCAC TGGCGCGGAAGCCAAGGGTGTGGTGTGCAG)

Non cellulose binding DNA aptamer, <NCELAPT>
Mw:22,000 Base : 71
(5'GATGTGTGCGTTGTCGAGACCTGCGACCGGAACACTACA CTGTGTG GGATGGATTTCTTTACAGTTGTGTG)

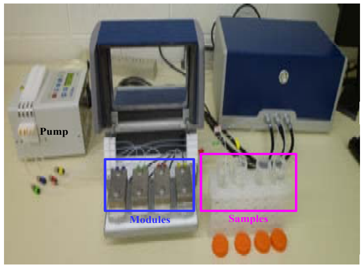
(from Integrated DNA Technologies, Inc.)

Poly (diallyldimethyl ammonium chloride) <PDADMAC>
Mw : 200,000

(Sigma-Aldrich, Inc., Prod.no.409014)

Experiment

Quartz Crystal Microbalance with Dissipation (QCM-D, E4 model from Q-Sense, Sweden)



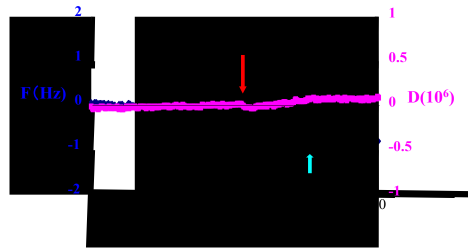
What is the QCM-D?
The QCM-D measures change in frequency (ΔF) and dissipation (ΔD) simultaneously of quartz crystal sensor. If the adsorbed mass is small compared to the mass of the crystal, ΔF is related to the adsorbed mass via the Sauerbrey equation[3, 4].

$$\Delta M = -\frac{C\Delta F}{n}$$

Where Δm is the adsorbed mass per unit surface (mg/m^2), n is the overtone number used in the measurement, and C is a sensitivity constant (0.177 mg/m^2).

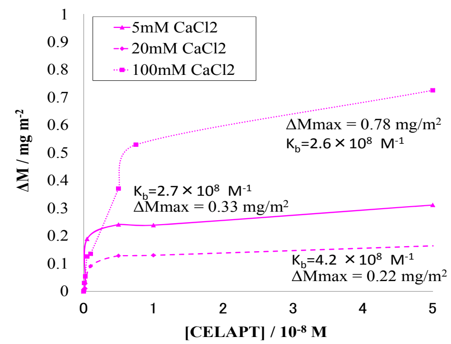
Experiment Method
1. Cellulose microfibrils coating sensors (QSX334 from Q-Sense) were soaked in water overnight
2. After stabilization of the baseline of the QCM-D in the $CaCl_2$ solution, the DNA aptamer solution was injected at a specific concentration at a constant rate of 150 µl/min to the QCM-D module at 23 degree Celsius.
3. ΔM was calculated from the ΔF of the 7th overtone after rinsing when the adsorption step was finished.

Example.)

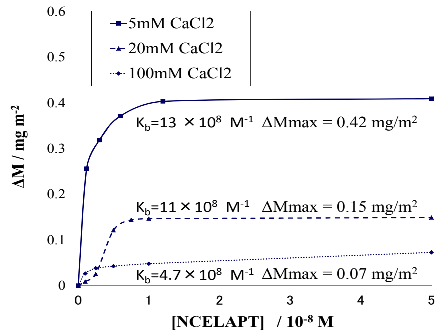


Primary Result (1) Adsorption Isotherms

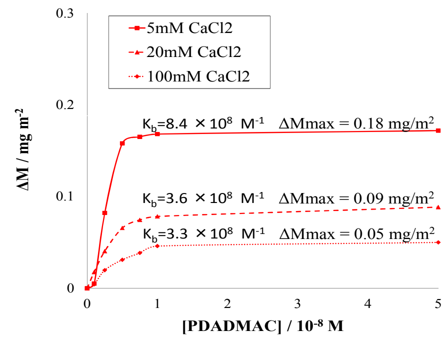
A) Cellulose binding DNA Aptamer



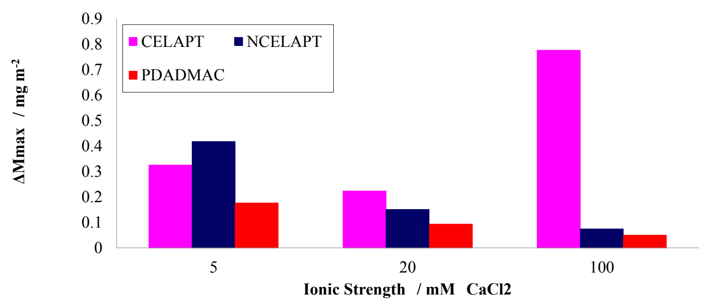
B) Non Cellulose binding DNA Aptamer



C) PDADMAC



Primary Result (2) Effect of Ionic Strength



Conclusion and Future work

A novel non-electrostatic interaction between DNA aptamer and cellulose microfibrils was demonstrated with QCM-D analysis. These results suggest that it may be possible to design papermaking additives that make use of short DNA sequences that bind to cellulose.

Acknowledgment

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Reference

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