Colloids and Surfaces A: Physicochem. Eng. Aspects 417 (2013) 250–255

Contents lists available at SciVerse ScienceDirect

Colloids and Surfaces A: Physicochemical and Engineering Aspects

journal homepage: www.elsevier.com/locate/colsurfa

# Study of the G-quadruplex–dipalmitoylphosphatidylcholine interactions at the air/water interface

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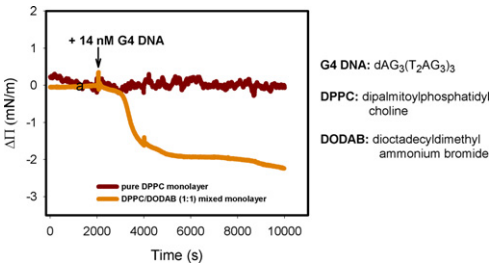
## HIGHLIGHTS

- G-quadruplex (G4 DNA) does not interact with zwitterionic lipid monolayer at the air–water interface.
- G4 DNA shifted $\pi$–$A$ isotherm of the mixed zwitterionic/cationic lipid film to lower molecular areas.
- Extent of shift in $\pi$–$A$ isotherm depended on the charge density of monolayer interface.
- Diffusion rate of DNA molecules to monolayer increased with its charge density.

## GRAPHICAL ABSTRACT




## ARTICLE INFO

*Article history:*
Received 5 September 2012
Received in revised form
14 November 2012
Accepted 15 November 2012
Available online 28 November 2012

*Keywords:*
Guanine quadruplex
Human telomere DNA
Langmuir monolayer
Mixed DODAB/DPPC monolayer

## ABSTRACT

The surface film balance studies of dipalmitoylphosphatidylcholine (DPPC) monolayer and mixed monolayers of DPPC and a cationic dioctadecyldimethylammonium bromide (DODAB) surfactant in the presence of 22-mer quadruplex-forming DNA oligonucleotide bearing human telomere sequence of $dAG_3(T_2AG_3)_3$ (G4 DNA) are reported. Insight into processes related to the G4 DNA–monolayer interactions was provided by differences in profiles of $\pi$–$A$ isotherms recorded in the presence and absence of G4 DNA on subphases with varied composition. The G4 DNA–monolayer interactions were also studied by recording time profiles of the surface pressure of monolayer at a constant mean molecular area, while perturbants (G4 DNA and/or KCl) were sequentially injected under the monolayer surface.

The surface pressure balance study indicated that interactions of G4 DNA with zwitterionic DPPC monolayer do not occur. The importance of monolayer charge on the ability of G4 DNA to adsorb on the monolayer interface was evidenced for mixed DPPC/DODAB monolayers and DPPC monolayers modified by incorporation of divalent metal ions. Shifts of isotherms towards lower molecular areas in the presence of G4 DNA were observed when compared with the reference isotherms recorded on subphases without G4 DNA.



## 1. Introduction

The applications of DNA for gene transfection and development of microarrays for genetic assays have prompted many studies on the interactions between DNA and lipids [1]. The air–water interface has been widely used for studying lipid membrane interactions with proteins [2–4] and recently, also to follow the interaction of DNA with Langmuir monolayers in order to characterize the molecular recognition processes at the surface of lipid monolayers [5–12]. Ramakrishnan et al. reported sequential hybridization of two complementary oligonucleotides or PNA and DNA molecules (PNA–DNA hybrid) with the cationic Langmuir monolayer at the air–water interface on pure water and at low salt concentrations [5,6], but both subphases poorly mimicked cellular conditions. Experiments at higher ionic strength conditions were reported by a joint research team who applied the surface film

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http://dx.doi.org/10.1016/j.colsurfa.2012.11.025