Membrane bio-adhesion on double-end grafted DNAs

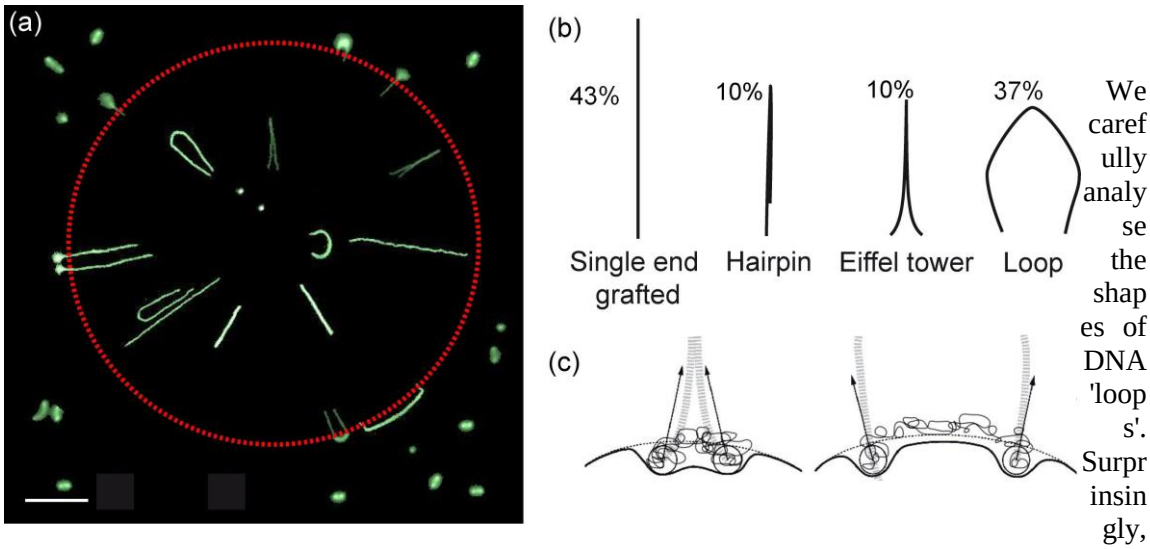
Yuting Sun, Carlos Marques, André Schroder[1]

Institut Charles Sadron, Université de Strasbourg, CNRS UPR22, 67034 Strasbourg, France
[1]andre.schroder@ics-cnrs.unistra.fr

Abstract

We have recently developed[1] a model system for understanding the different forces at play during the formation of a bio-adhesive contact that typically implies a lipid membrane with its adhesive binders, a complementary functional substrate and the different macromolecular species that decorate both the membrane and the substrate. Our experimental model consists in a bio-adhesive phospholipid vesicle that is brought into contact with a carpeted surface of end-grafted lambda-phage DNAs. During contact, the spreading front of the adhesive patch propagates outwards from a nucleation center, acting as a scraper that strongly stretches the end-grafted DNA chains.

The figure, taken at the end of the adhesion process, exemplifies the effect of scraping and stapling of fluorescent end-grafted DNAs by the bio-adhesive membrane. All DNAs in the adhesion gap (i.e. inside the dotted circle) appear as elongated objects, as expected from such a radial process. Single-end grafted DNAs appear as straight, radially oriented lines, while double-end grafted chains exhibit more complex shapes, i.e. hairpins, Eiffel towers, and loops (see figure (b)).



We carefully analyse the shapes of DNA 'loops'. Surprisingly, they exhibit two well defined regions, corresponding to two stages of the stretching and confinement scenario; first, each DNA strand is stretched and confined radially, as two independent DNAs, up to a transition point corresponding to the starting of the cap of the loop formation process. The quantitative analysis of the fluorescence intensity distribution of each loop shows that this transition occurs for an average stretching degree of 0.55±0.09 of the DNA part that is pushed away in front of the advancing membrane front. This result suggests that a non-trivial interaction between the membrane and the DNA occurs at the spreading front. An interesting possibility would be that the pressure applied by the DNA molecule on the membrane creates a concave zone that laterally confines the DNA[2]. This in turn could explain the generation of Eiffel towers, since when two of such concave depressions are very close, a net inward force could result that brings two strands together (see figure (c)). The analysis of the Eiffel towers shapes confirms such a hypothesis.

[1] : M-L Hisette, P Haddad, T Gisler, C-M Marques, and A Schroder, “Spreading of bio-adhesive vesicles on dna carpets, Soft Matter”, 4:828--832, 2008.

[2] : F Thalmann, V Billot, and C~M Marques, “Lipid bilayer adhesion on sparse dna carpets: Theoretical analysis

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membrane deformations induced by single-end-grafted polymers", Physical Review E, 83(6):061922, 2011.