

Towards a “Pre-RNA World”: Structure and hybridization capabilities of peptide nucleic acids (PNAs) adsorbed on surfaces

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Among nucleic acid analogs, peptide nucleic acids (PNAs) are characterized for their capability to strongly and specifically interact with DNA and RNA. The pseudopeptidic backbone of PNA is chemically stable, lacks sugar motifs, carries no charges and has no chiral centers. These properties have underlined PNA as a suitable candidate to have preceded RNA in a putative “Pre-RNA World”. In the context of the origin and early evolution of genetic information, it is also relevant the role that inorganic surfaces could have played, both in the catalysis of the polymerization of macromolecules and in the stabilization of the polymers.

We have investigated the interaction between single-stranded (ss) PNA oligomers and metallic surfaces, and its hybridization with ssDNA and ssRNA targets in solution, by means of atomic force microscopy, high resolution X-ray photoemission spectroscopy and X-Ray absorption. We have found that PNA chains of up to 7 nm long can spontaneously self-assemble on surfaces, rendering ordered layers of standing-up molecules with maximized capability to interact with complementary targets. Self-assembled monolayers of ssPNA on surfaces are stable in pure water, resist desiccation and re-hydration cycles, remain insensitive to biological or chemical degradation, and are highly resistant to high energy radiation. Interestingly, layers of PNA adsorbed on surfaces maintain their capability for recognizing complementary nucleic acids, with enough specificity to discriminate even a point mutation in target molecules. These structural and functional results favor the involvement of PNA-like molecules in the transition from informative molecules stable in prebiotic conditions to present-day nucleic acids.