The interaction of peptide nucleic acids (PNAs) with mineral surfaces: self-assembly processes in the abiotic-biotic transition?

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Peptide nucleic acids (PNAs) are artificial nucleic acid analogs that strongly and specifically interact with DNA and RNA. The pseudopeptidic backbone of PNA lacks sugar motifs, carries no charges and has no chiral centers. These properties, together with its outstanding chemical and biological stability, make PNA a suitable candidate to have preceded RNA in a putative "Pre-RNA World". In the field of the origin and early evolution of genetic information, inorganic surfaces have been claimed to be involved in the stabilization of the polymers and even in the catalysis of the polymerization of macromolecules from their building blocks.

In this context, we are investigating the interaction between single-strained (ss) PNA oligomers and metallic surfaces, as well as the hybridization between the attached PNA and DNA or RNA targets in solution. In a bionanotechnology-inspired, interdisciplinary approach, powerful surface characterization techniques have been used such as atomic force microscopy, high resolution X-ray photoemission spectroscopy, X-Ray absorption and Infrared Spectroscopy.

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 (SAMs) of ssPNA on surfaces are stable in a large variety of pHs and buffer compositions, remain unaltered after desiccation and re-hydration cycles, and are highly resistant to high energy radiation. Interestingly, SAMs of PNA adsorbed on surfaces maintain their capability for recognizing complementary nucleic acids, with enough specificity to discriminate even a point mutation or SNP in the target molecules. These structural and functional results favor the involvement of self-assembly processes in the abiotic-biotic boundary. They also suggest that a key role could have been played by mineral surfaces and PNA-like molecules in the transition from informative molecules stable in prebiotic conditions to present-day nucleic acids.