Liquid Crystallization and Phase Separation in Solutions of Ultrashort DNA and RNA Oligomers

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Ultrashort complementary DNA and RNA oligomers, down to 6 base pairs in length, are found to exhibit nematic and columnar liquid crystal phases, even though such fragments of double helices lack the shape anisotropy required for liquid crystal orientational ordering. These phases are produced by the end-to-end adhesion and consequent living polymerization of the duplex oligomers into polydisperse anisotropic rod-shaped aggregates, which can order.

Mixtures of single- and double-stranded oligomers phase separate. Liquid crystal droplets rich in duplexes nucleate and coexist with an isotropic solution rich in unpaired single strands. This phase separation, that we find also in mixtures of DNA duplexes and PEG, can be understood as resulting from the combination of duplex adhesion and depletion-type forces favoring the segregation of rigid duplexes from flexible chains.

Quite surprisingly, this new form of spontaneous partitioning of complementary DNA can be extended to solutions of oligonucleotides with various degrees of randomness in their sequences, resulting in an intriguing randomness-length phase diagram.

The condensation of liquid crystallites of complementary sequences from random environment appears a new route to purification of short duplex oligomers. In the presence of ligation, this self-association of DNA and RNA oligos could promote the preferential synthesis of longer complementary sequences, a mechanism of possible relevance in prebiotic environments.

References

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