

587b Synchrotron X-Ray Characterization of Pna-Amphiphile Micelles

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Peptide nucleic acid (PNA) is a synthetic, uncharged analog of DNA that binds DNA and RNA with great specificity. Attachment of alkane chains to PNA peptides yields a “PNA amphiphile” useful for the hydrophobic tagging of particular DNA sequences for their pre-detection purification and concentration. Aided by their uncharged backbones, PNA amphiphiles (PNAA) readily self-assemble into micellar structures. This self-assembling property enables the use of PNAA in microscale, lab-on-a-chip separations based on electrokinetic flows. Capillary electropherograms on PNAA show a wide disparity between PNAA with various alkane chain lengths; additionally, multiple peaks are obtained in the presence of complementary DNA oligomers. The latter indicates that PNAA micelles disassemble on specific DNA binding, likely due to electrostatic repulsion engendered by the bound DNA. Cryo-TEM images of a 12 carbon tailed, 10mer PNAA show two distinct populations of micellar aggregates. The majority of the micellar phase consists of small, roughly elliptical aggregates less than 100 angstroms in length. The minority population is comprised of cylindrically shaped aggregates with a length scale of several hundred angstroms.

To better understand the morphology of PNAA micelles formed in solution under various conditions, we have screened many PNAA structures and sequences using synchrotron x-ray radiation. Although the majority of I vs. q data are fit well by a core-shell prolate ellipsoid model, the low q region shows significant deviation consistent with the existence of a small fraction of cylindrical micelles. Scattering curves for PNAA with longer tails lack the low q deviations, indicating the absence of the cylindrical population in favor of the ellipsoidal population. The co-existence of both populations is discussed in terms of a two-state assembly process where individual ellipsoids merge to form extended structures. Scattering curves resulting from the addition of DNA to PNAA display a broadened minimum immediately preceding the first oscillation of the elliptical form factor. Although this is typically indicative of polydispersity in the sample, in this case it is accounted for by the superposition of the pure PNAA scattering curve with a much weaker scattering curve from the PNAA/DNA duplexes extracted from PNAA micelles on DNA binding. The competition of hydrophobic, electrostatic, and hydrogen bonding interactions on the self-assembly of these materials is discussed, along with implications for the design of other surfactant-based biomaterials.