

Effects of the Photooxidant on DNA-Mediated Charge Transport

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Abstract:

A direct comparison of DNA charge transport (CT) with different photooxidants has been made. Photooxidants tested include the two metallointercalators, $\text{Rh}(\text{phi})_2(\text{bpy}')^{3+}$ and $\text{Ru}(\text{phen})(\text{bpy}')(\text{dppz})^{2+}$, and three organic intercalators, ethidium (Et), thionine (Th), and anthraquinone (AQ). CT has been examined through a DNA duplex containing an A_6 -tract intervening between two 5'-CGGC-3' sites with each of the photooxidants covalently tethered to one end of the DNA duplex. CT is assayed both through determination of the yield of oxidative guanine damage and, in derivative DNA assemblies, by analysis of the yield of a faster oxidative trapping reaction, ring opening of N^2 -cyclopropylguanine (d^{CPG}) within the DNA duplex. We find clear differences in oxidative damage ratios at the distal versus proximal 5'-CGGC-3' sites depending upon the photooxidant employed. Importantly, nondenaturing gel electrophoresis data demonstrate the absence of any DNA aggregation by the DNA-bound intercalators. Hence, differences seen with assemblies containing various photooxidants cannot be attributed to differential aggregation. Comparisons in assemblies using different photooxidants thus reveal characteristics of the photooxidant as well as characteristics of the DNA assembly. In the series examined, the lowest distal/proximal DNA damage ratios are obtained with Ru and AQ, while, for both Rh and Et, high distal/proximal damage ratios are found. The oxidative damage yields vary in the order $\text{Ru} > \text{AQ} > \text{Rh} > \text{Et}$, and photooxidants that produce higher distal/proximal damage ratios have lower yields. While no oxidative DNA damage is detected using thionine as a photooxidant, oxidation is evident using the faster cyclopropylguanosine trap; here, a complex distance dependence is found. Differences observed among photooxidants as well as the complex distance dependence are attributed to differences in rates of back electron transfer (BET). Such differences are important to consider in developing mechanistic models for DNA CT.

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