Solute-Solvent Interactions from Impedance Measurements: Concentration Dependence of DNA
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The unique nature of impedance data exhibited by palladium lipoic acid (1:1) complex, a chemotherapy agent developed in our laboratory, prompted us to investigate in detail the impedance of alkali chlorides as well as the most important biological molecule DNA. The alkali chloride data revealed frequency and potential dependent orientation effects of the water molecule. DNA impedance data was subtly dependent on the nature of the alkali metal ion. This prompted us to study further the concentration dependence of DNA impedance without any added electrolyte. The electrochemical literature data of nucleic acids are at very low concentrations of DNA and at negative potentials of the mercury electrode. The present investigation was intended to gain information on the influence of orientation of solvent molecules, packing, and dopant ions on the impedance. Therefore concentrations of 0.1, 1.0, 5.0, and 10.0 mg/mL Calf-Thymus double stranded DNA (Type I, sodium salt, pH 7.5) were used at potentials positive enough to produce dopant ions of mercury.

Typical admittance plots (Figures 1 and 2) indicate that solvent orientation and DNA conformation effects are more dominant (with four peaks) at higher concentrations of DNA than at lower concentrations (two peaks). The effects are also enhanced at lower frequencies. Mott-Schottky plots indicate dominant p-type behavior. Double layer capacitance plots exhibit two peaks at positive potentials. At potentials between 0.2 and 0.3 V, the impedance plot (Figure 3) and especially the phase angle plot (Figure 4) indicate that the double layer is altered. Unlike alkali halides, the double layer changeover potentials seem independent of DNA concentration. Low frequency effects are dominant during this changeover of double layer structure.

For all concentrations of DNA, the impedance data at -1.5, -1.0, -0.6, -0.3, 0.0, 0.1, 0.2, and 0.3 V could be fitted with the equivalent electronic circuit of R(RC)(RC)(RC)(RC). This circuit suggests a transmission line model for DNA conductance.

References
1. C.V. Krishnan, and M. Garnett, 1st Spring Meeting of ISE, Abs. P06, Spain 2003
3. C.V. Krishnan, and M. Garnett, 204th Meeting of ECS, Abs. 1378, Orlando 2003