INTRODUCTION

cis-Diaminedichloroplatinum (cis-DDP) is an anticancer drug which has found wide application in clinical medicine since its discovery about three decades ago. This drug is highly efficient in the treatment of a number of tumors, although it is of limited usefulness due to its toxicity and nonselectivity [1–4]. At present, the search for active and nontoxic analogs of cis-DDP among coordination compounds is a very pressing problem [5, 6]. It is known that DNA is the basic target for cis-DDP inside the cell [7]. In this connection, the comparative examination of the molecular mechanism governing the action of cis-DDP and its analogs with the use of dilute DNA solutions as model systems is of considerable interest for the initial selection of new drugs. The trans isomer of diaminedichloroplatinum (trans-DDP) which differs from cis-DDP only by the arrangement of ligands in the coordination sphere of the metal is therapeutically inactive. The interaction of DNA with cis- and trans-DDP are responsible for the antitumor activity of this preparation. Presently, it is obvious that the end result of the cis-DPP action inside the cell is the formation of a coordination bond between platinum and nitrogenous bases of DNA (most frequently, a bond between the platinum atom and the N7 atom of guanine is considered). According to [10 11], the binding of cis-DDP to DNA induces the turn of its helix. Widening the scope of techniques used to investigate DNA complexes with platinum coordination compounds can gain insight into the mechanism of their interaction.

In this work, the conformations of DNA molecules complexed with cis-DDP and its inactive trans analog were studied by the methods of fluorescence and atomic force microscopy (AFM), dynamic light scattering (DLS), low-gradient viscometry, spectrophotometry, and luminescence.

EXPERIMENTAL

Starting Compounds

Thymus DNA (9000 base pairs; molecular mass was calculated from intrinsic viscosity in 0.15 M NaCl) purchased from Serva and bacteriophage T4 DNA (166 kilopair bases) from Sigma were used. The concentration and nativity of DNA in solution were determined spectrophotometrically according to Spirin [12].
were synthesized and characterized at the St. Petersburg Chemical and Pharmaceutical Academy. Metal salts of reagent grade, ethidium bromide (Sigma), and an oxazole yellow (Yo-Yo1) dye (Molecular Probes, Inc.) were employed.

\[
\begin{align*}
\text{cis-DDP} & : \quad \text{NH}_3\text{Cl} & \text{NH}_3\text{Cl} \\
\text{trans-DDP} & : \quad \text{NH}_3\text{PtNH}_3 & \text{NH}_3\text{PtNH}_3
\end{align*}
\]

Dynamic Light Scattering

DLS studies were carried out with the thymus DNA (9000 base pairs). The concentration of platinum compounds in the examined solutions was 5 × 10⁻⁶ mol/l, and \( c_{\text{DNA}}\) was 0.008% in a 0.005 M NaCl. Solutions were dedusted by filtration through Durapore membranes with a pore diameter of 65 × 10⁻⁸ m (Millipore).

Measurements were performed at 25°C using a PhotoCor-SP instrument (PhotoCor, Russia) equipped with a 16-bit correlator and a Uniphase 1135P He–Ne laser with a radiation wavelength of 632 × 10⁻⁹ m and a power of 1 × 10⁻² W. Scattering angles ranged from 30° to 90°. The homodyne intensity correlation function \( G^{(2)}(t) \) was determined. For each angle measurements were conducted with three different delay times and the functions obtained were joined as described in [13, 14]. Considering the motions of particles as independent, accurate to the terms of the order of \( 1/N \) (\( N \) is the number of scatters), one can use the Siegert relation

\[ g^{(2)}(t) = 1 + \beta g^{(1)}(t)^2, \]

where \( g^{(2)}(t) = G^{(2)}(t)/G^{(2)}(\infty) \) is the normalized scattering correlation function, \( G^{(2)}(\infty) \) is the experimentally determined base line, \( \beta \) is the coherence factor, and \( g^{(1)}(t) \) is the normalized field autocorrelation function.

In dilute solutions of monodisperse particles under the condition \( q(R^2)^{1/2} \ll 1 \) \( (q = (4\pi/\lambda)\sin(\theta)/2) \), \( \theta \) is the scattering angle, \( R^2 \) is the root-mean-square radius of gyration), the field autocorrelation function is related to the translation diffusion of a particle (macromolecule) as

\[ g^{(1)}(t) = \exp(-t/\tau) = \exp(-\Gamma t) = \exp(-Dq^2t), \]

\[ D = \lim_{q \to 0} (\Gamma/q^2). \]

Here, \( \tau \) is the relation time of the relaxation process under investigation and \( D \) is the translation diffusion coefficient; the rate of relaxation is \( \Gamma = 1/\tau \). If there is a set of independent relaxation processes in the system, the field autocorrelation function is the weighed sum of...
individual contributions. For the continuous distribution, we have
\[ g^{(1)}(t) = \int_0^\infty A(\tau) \exp(-t/\tau) d\tau, \]
where \( A(\tau) \) is the function of distribution (over \( \tau \)) of scattered light intensity.

For DNA solutions and its complexes with cis- and trans-DDP measured at an angle of 90°, relaxation time spectra composed of two separate bands were obtained by the Laplace inverse transform technique, imposing the solution nonnegativity condition. The treatment in terms of the two-mode model according to the formula
\[ G^{(2)}(t) = y_0 + (A_1 \exp(-t/\tau_1) + A_2 \exp(-t/\tau_2))^2 \]
yielded the consistent results; therefore, this model was used in all subsequent calculations. The diffusion coefficient estimated from the fast relaxation mode was extrapolated to a zero angle.

**Results and Discussion**

Figures 1 and 2 display the AFM images for the systems under examination. Specimens were prepared by drying the drop of the DNA solution (DNA with cis-DDP or DNA with trans-DDP) placed on the mica substrate. Solutions were preliminarily incubated for 1 day at 4°C to ensure the formation of coordination bonds between platinum compounds and DNA [17]. Before fixation, 0.001 mol/l MgCl₂ solution was added to solutions. As was shown in [18], Mg²⁺ links to DNA via phosphate groups. The introduction of magnesium ions upon the formation of coordination bonds between the platinum compounds and DNA cannot affect the structure of the complex [19] but assists the fixation of molecules on the substrate necessary for AFM measurements [20].

Figure 1 shows that the fixation of the DNA molecule by the procedure described above leads to its stretching, although DNA occurs in solution in the coiled conformation with the persistent length \( 50 \times 10^{-9} \) m. The measured length of the macromolecule turns out to be \( L = (4 \pm 1) \times 10^{-6} \) m (for a fully extended molecule). Note that the calculated value of \( L = (3.0 \pm 0.3) \times 10^{-6} \) m for formation with ethidium bromide, the excitation wavelength was \( \lambda_{exc} = 500 \times 10^{-9} \) m and the emission wavelength was \( \lambda_{em} = 610 \times 10^{-9} \) m. Concentration ratios of ethidium bromide and platinum compounds to DNA (expressed in base pair moles) were \( c_{EBB}/c_{DNA} = r_{rEBB} = (0.01–0.4) \) and \( c_{Pt}/c_{DNA} = r_{r(Pt)} = 0.2–0.8 \), respectively.

**Low-Gradient Viscometry**

Relative viscosities \( \eta_r \) of DNA solutions were measured at 21.0 ± 0.1°C with a Zimm–Crothers low-gradient rotational viscometer. The intrinsic viscosity of DNA calculated by extrapolating the concentration dependence of the reduced viscosity \( (\eta_r - 1)/c \) to the zero concentration of DNA is connected to the conformational parameters of a macromolecule through the Flory relation
\[
[\eta] = \Phi \left( \frac{h_0^2}{M} \right)^{3/2} - \alpha^3, 
\]
where \( M \) is the molecular mass of DNA, \( \Phi \) is the Flory parameter depending on the quality of the solvent and the rigidity of macromolecules [15, 16], and \( \alpha \) is the coefficient of the linear swelling of the macromolecule equal to the ratio of root-mean-square end-to-end distances of real and ideal molecules \( \alpha = \left( \frac{h^2}{h_0^2} \right)^{1/2} \). Rate gradients were varied in the range \( g = 0.5–2 \text{ s}^{-1} \).
the macromolecule with a given molecular mass containing 9000 base pairs indicates that AFM images (Fig. 1) most likely display single macromolecules. The analysis of images obtained for DNA complexes with cis- and trans-DDP revealed that the DNA molecule decreases in size. This agrees with the finding that the reduced volume of the macromolecule diminishes upon complexation with cis- and trans-DDP [21].

As follows from Fig. 2a, which demonstrates the images of DNA complexes with cis-DDP, DNA shows a tendency toward the appearance of kinks during complex formation. Let us note that windings of the double helix of DNA in the major groove direction appeared as a result of its binding with cis-DDP [22–25]. These changes in DNA conformations that accompany its complexation with cis-DDP are in good agreement with the results obtained by other methods [26–30]. The AFM pictures of DNA complexes with trans-DDP, indicating the occurrence of intra- or intermolecular aggregation of DNA with the formation of extended structures, are shown in Fig. 2b. Actually, DNA threads in Fig. 2b are much shorter than those in Fig. 1. Moreover, intermolecular crosslinks are seen which are apparently formed by trans-DDP with different DNA molecules. As is evident from the structure of this compound, leaving chlorine atoms that are responsible for the formation of coordination bonds with the DNA molecule are arranged in such a way that, in contrast to cis-DDP, it is more advantageous for trans-DDP to search for the second incoming group of the macromolecule on sufficiently remote DNA portions rather than on neighboring bases. It is pertinent to note that the formation of the bidentate complex between trans-DDP and neighboring nitrogenous bases of DNA leads to the destabilization of the double helix due to steric inconsistencies in the arrangement of incoming groups of adjacent base pairs and substituting ligands in the coordination sphere of platinum. Such a binding is usually observed at high concentrations of platinum [31]. In dilute solutions, the formation of intermolecular crosslinks is improbable; however, the conditions of fixation of macromolecules can differ appreciably from those in dilute solutions. Certainly, the fixation of the complex from solution on the surface can be accompanied by significant changes in the morphology of the DNA molecule. Therefore, it was of interest to compare the above data with the results from fluorescence microscopy measurements of analogous systems. The latter technique allows one to observe single DNA molecules in the drop of solution.

Figure 3 shows the typical image for the phage T4 DNA solution. The DNA molecule was approximated by the ellipsoid of revolution, and its maximum size was fixed. Almost 100 images were used to construct the size distribution of DNA molecules. Figure 4 represents the processed image of phage T4 DNA in 0.05 M NaCl. It was found that complex formation brings about the reduction in the size of the macromolecule for all the tested concentrations. The fluorescence micros-
copy data are summarized in Table 1. This table shows the mean maximum sizes of coils $Z_0$, root-mean-square end-to-end distances of a macromolecule $\langle h^2 \rangle^{1/2}$, which are derived from the ratio $Z_0 = 1.4 \langle h^2 \rangle^{1/2}$ valid for the Gaussian coil [32]. In this case, the root-mean-square radius of gyration $\langle R^2 \rangle^{1/2}$ is connected to $\langle h^2 \rangle$ through the ratio $\langle R^2 \rangle = 1/6 \langle h^2 \rangle$. In the latter column, relative changes in the sizes of DNA molecules are shown. As can be seen from the table, the binding of platinum compounds to DNA decreases its size, which is consistent with the viscometry data.

Table 2 shows the hydrodynamic parameters of complexes studied using the low-gradient rotational viscometer. Complexes were prepared by pouring solutions of DNA and the appropriate platinum compound with the desired concentration. The concentration of the platinum compound in solution was $5 \times 10^{-5}$ mol/l. The concentration dependences of the reduced viscosity of the free DNA and its complexes with cis- and trans-DDP in 0.005 M NaCl were examined after the starting solution were incubated for 1 day. The dilution procedure was described in [31].

The drop in the intrinsic viscosity of DNA (9000 base pairs) upon the formation of complexes with cis-DDP achieved almost 37%. The corresponding calculations for DNA complexes with trans-DDP yield a 33% reduction in $[\eta]$. In the latter case, one cannot state that the rigidity of DNA alters in the course of interaction, because complex formation is accompanied by a rise in the optical anisotropy of the macromolecule [21].

Since the intrinsic viscosity is proportional to the reduced volume of the macromolecule, the reduction in the sizes of coils upon complex formation as observed
study of DNA complexation with platinum coordination compounds

by fluorescence microscopy is in good agreement with viscometric data.

It should be emphasized that the formation of coordination bonds between platinum compounds and DNA can hamper further interaction of the macromolecule with dyes, which are used to visualize DNA in the above-described experiment. We examined the interaction of DNA with ethidium bromide after formation of coordination bonds with cis- and trans-DDP. Figure 5 presents the results from spectrophotometric titration experiments. These data were taken at an absorption band corresponding to ethidium bromide (with a maximum near 470 × 10⁻⁹ m) at its constant concentration 3 × 10⁻⁵ mol/l with cDNA being varied from 0.001 to 0.03%. Titration was carried out by adding equal amounts of the corresponding ethidium bromide solution to the calculated amounts of DNA prepared from the starting solution. The pattern of the spectra (the existence of the isosbestic point) gives us grounds to infer that there are two spectral forms corresponding to the free and bound ethidium bromide. As is known, the binding of ethidium bromide to DNA leads to intercalation of this probe between base pairs of DNA. As is seen from Fig. 5, the use of complexes with cis- and trans-DDP does not change the pattern of the spectra, although the constant of ethidium bromide binding to DNA is altered (Table 3).

The binding constant was determined using the Scatchard method by extrapolating the r_b/c_free versus r_b plot, where r_b is the number of bound dye molecules per the base pair of DNA, to the zero value of r_b. The effect of trans-DDP on ethidium bromide binding to DNA appears to be smaller than that in the case of cis-DDP. Possibly, this is explained by the fact that trans-DDP preferably forms a monodentate complex (one coordination bond with the nitrogenous base of a macromolecule), in contrast to cis-DDP, which typically gives rise

Table 1. Fluorescence microscopy study of DNA complexes with cis- and trans-DDP in the drop of 0.005 M NaCl solution at various concentration ratios r_{t(Pt)} = c_{Pt}/c_{DNA} (in all the systems, c_{DNA} = 2.3 × 10⁻⁷ mol/l; the concentration is expressed in base pairs of DNA)

<table>
<thead>
<tr>
<th>DNA, complex</th>
<th>Maximum spot size (the large ellipsoid axis Z × 10⁶, m)</th>
<th>Mean-square-root contour length ⟨h²⟩¹/₂ × 10⁶, m</th>
<th>⟨R²⟩¹/₂ × 10⁶, m</th>
<th>Relative change in average coil sizes Z/Z_{DNA}</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA</td>
<td>2.6 ± 0.4</td>
<td>1.86</td>
<td>0.74</td>
<td>1</td>
</tr>
<tr>
<td>DNA + cis-DDP, r_{t(Pt)} = 0.5</td>
<td>2.4 ± 0.4</td>
<td>1.71</td>
<td>0.68</td>
<td>0.92</td>
</tr>
<tr>
<td>DNA + cis-DDP, r_{t(Pt)} = 1</td>
<td>2.1 ± 0.3</td>
<td>1.50</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>DNA + cis-DDP, r_{t(Pt)} = 2.5</td>
<td>2.1 ± 0.3</td>
<td>1.50</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>DNA + trans-DDP, r_{t(Pt)} = 0.1</td>
<td>2.5 ± 0.4</td>
<td>1.79</td>
<td>0.72</td>
<td>0.96</td>
</tr>
<tr>
<td>DNA + trans-DDP, r_{t(Pt)} = 0.5</td>
<td>2.4 ± 0.4</td>
<td>1.71</td>
<td>0.68</td>
<td>0.92</td>
</tr>
<tr>
<td>DNA + trans-DDP, r_{t(Pt)} = 1</td>
<td>2.2 ± 0.3</td>
<td>1.57</td>
<td>0.63</td>
<td>0.85</td>
</tr>
<tr>
<td>DNA + trans-DDP, r_{t(Pt)} = 2.5</td>
<td>2.2 ± 0.5</td>
<td>1.57</td>
<td>0.63</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Table 2. Viscometric data for DNA and its complexes with platinum compounds (c_{Pt} = 5 × 10⁻⁵ mol/l)

<table>
<thead>
<tr>
<th>DNA, complex</th>
<th>Intrinsic viscosity [η], m³/kg</th>
<th>Relative change in intrinsic viscosity [η]/[η]₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA</td>
<td>6.3 ± 0.3</td>
<td>1</td>
</tr>
<tr>
<td>DNA + cis-DDP</td>
<td>3.9 ± 0.2</td>
<td>0.63</td>
</tr>
<tr>
<td>DNA + trans-DDP</td>
<td>4.2 ± 0.2</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Table 3. Spectrophotometric titration of DNA solutions by ethidium bromide in the presence of trans- and cis-DDP

<table>
<thead>
<tr>
<th>DNA, complex</th>
<th>c_{Pt} × 10⁵, mol/l</th>
<th>Constant of ethidium bromide binding to DNA K × 10⁻³</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA</td>
<td>0</td>
<td>20 ± 1</td>
</tr>
<tr>
<td>DNA + cis-DDP</td>
<td>1.37</td>
<td>12 ± 1</td>
</tr>
<tr>
<td>DNA + cis-DDP</td>
<td>5</td>
<td>2 ± 1</td>
</tr>
<tr>
<td>DNA + trans-DDP</td>
<td>5</td>
<td>15 ± 1</td>
</tr>
</tbody>
</table>
to a bidentate complex (two coordination bonds with neighboring bases [21]). Note that the bidentate complex of trans-DPP with DNA groups (or groups of another molecule) distributed along the chain (one cannot exclude formation of this complex) shows almost the same effect on the character of DNA binding to ethidium bromide as the monodentate complex.

The effect of DNA binding to platinum compounds on its subsequent interaction with ethidium bromide can be associated with either a change in the geometry of the double helix (e.g., some authors observed that the width and depth of the small groove change) or steric hindrances for ethidium bromide related to platinum binding to nitrogenous bases of DNA. In any case, a change in the dye binding to DNA cannot significantly distort the results of fluorescence microscopy studies because the decrease in the binding constant is insignificant and its value remains sufficiently high.

This statement is proved by the examination of ethidium bromide luminescence in analogous systems. Our experiments showed that the intensity of ethidium bromide luminescence altered only in the case of DNA complexes with cis-DPP (Table 4). The luminescence intensity monotonically declined with an increase in the $c_{Pt}$-to-$c_{DNA}$ ratio. This phenomenon was observed within a wide range of $c_{EtBr}$ : $c_{DNA}$ ratios. It cannot be associated with a reduction in the fraction of the bound dye in DNA complexes with cis-DDP, as is evident from the values of binding constants (Table 3). The reason behind these changes may be the existence of photoprocesses involving ethidium bromide in the excited state which are related to the transfer of electron. However, further studies are necessary to verify this assumption.

Let us consider the results of dynamic scattering measurements. A high-molecular-mass DNA is a very complex object for DLS studies due to its polyelectrolyte nature and high rigidity. Relaxation spectra reported in [13, 33, 34] exhibited two or even three maxima that can be interpreted in different ways. We made an attempt to correlate the relaxation times derived from autocorrelation functions with the translational diffusion of DNA molecules and to analyze the effect of platinum compounds on the data obtained.

Figure 6 plots the apparent diffusion coefficient as a function of $q^2$. Table 5 demonstrates the results from extrapolation of these plots to $q = 0$. Notice that measurements were performed at the single concentration of DNA. Thus, it is reasonable to discuss the interdiffusion coefficient rather than the self-diffusion coefficient, which is determined by extrapolating the concen-

![Fig. 5. Spectrophotometric titration of DNA complexed with (a) cis-DDP and (b) trans-DDP ($c_{Pt} = 5 \times 10^{-5}$ mol/l, $c_{EtBr} = 3 \times 10^{-5}$ mol/l).](image1)

![Fig. 6. The apparent diffusion coefficient vs. the light wave vector for (1) DNA solution and its complexes with (2) cis-DDP and (3) trans-DDP in 0.005 M NaCl.](image2)
tration dependence of the diffusion coefficient to the zero concentration. Given the intrinsic viscosities of DNA and its complexes with cis- and trans-DDP, one can estimate the expected translation diffusion coefficient using the hydrodynamic invariant $A_0$

$$A_0 = D_\tau \eta_0 ([\eta]M)^{1/3}/T = 3.4 \times 10^{-17} J/(\text{grad } M^{1/3}) [35].$$

As follows from calculations, $D_\tau = (1.4 \pm 0.1) \times 10^{-12} \text{ m}^2/\text{s}$ for the free DNA, $(1.6 \pm 0.1) \times 10^{-12} \text{ m}^2/\text{s}$ for the DNA complex with cis-DDP, and $(1.5 \pm 0.1) \times 10^{-12} \text{ m}^2/\text{s}$ for the DNA complex with trans-DDP. It is seen that there is a quite satisfactory agreement between the results of two methods.

The root-mean-square contour length was assessed according to the known expression for the translation friction of a macromolecule

$$f = P_0 \eta_0 (h^2)^{1/2},$$

where $f = kT/D_\tau$, $P_0 = 5.11$, and $\eta_0$ is the solvent viscosity. The calculation data are listed in Table 5.

As for the relatively slow relaxation process (under the two-mode approximation for the autocorrelation function) detected by dynamic light scattering in all the systems under examination, the following suggestions can be put forward. The existence of the correlation function for the slow mode cannot be attributed to intermolecular interactions, because at the used concentration of DNA the volume fraction of swollen coils does not exceed 0.5. It is possible that the slow mode appears as a result of the polyelectrolyte nature of the polymer under investigation and the low ionic strength of solutions. Given this, the measured autocorrelation function is influenced by electrostatic interactions [14]. The finding that the contribution of the slow relaxation process becomes less distinct as the ionic strength of solution increases does not contradict the above assumption. For example, it was found that the width of the relaxation time spectrum markedly narrows as the ionic strength of solution increases to 0.5 M NaCl.

Thus, the application of various methods, specifically those allowing direct observation of macromolecular conformations, made it possible to obtain mutually consistent results. This provides an opportunity to expand the approach developed in this work to more complicated systems, including DNA complexes with new polynuclear platinum compounds.

### Table 4. Reduction in the intensity of ethidium bromide (EtBr) luminescence complexed with DNA upon binding with cis-DDP ($I_{DNA+Pt}/I_{DNA}$) (the measurement error is 1.5%)

<table>
<thead>
<tr>
<th>$c_{Pt}/c_{DNA}$</th>
<th>$c_{EtBr}/c_{DNA}$</th>
<th>$c_{Pt}/c_{DNA}$</th>
<th>$c_{EtBr}/c_{DNA}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>1</td>
<td>0.1</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Addition of ethidium bromide to DNA + cis-DDP complexes

| 0    | 1 | 1 | 1 |
| 0.2  | 0.98 | 0.94 | 0.97 |
| 0.4  | 0.97 | 0.94 | 0.97 |
| 0.8  | 0.88 | 0.89 | 0.88 |

Simultaneous addition of ethidium bromide and cis-DDP to the DNA solution. Solutions were incubated for a day before measurements

| 0.2 | – | 0.94 | 0.94 |
| 0.4 | – | 0.95 | 0.98 |
| 0.8 | – | 0.88 | 0.89 |

### Table 5. Dynamic light scattering data for the systems of interest

<table>
<thead>
<tr>
<th>DNA, complex</th>
<th>$D(0) \times 10^{12}$, m$^2$/s</th>
<th>$D_\tau \times 10^{12}$, m$^2$/s</th>
<th>$\tau_f(90)$, s</th>
<th>$\tau_s(90)$, s</th>
<th>$\langle h^2 \rangle^{1/2} \times 10^9$, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA</td>
<td>1.2 ± 0.2</td>
<td>1.4 ± 0.1</td>
<td>0.00053*</td>
<td>0.01*</td>
<td>688</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.00058**</td>
<td>0.009**</td>
<td></td>
</tr>
<tr>
<td>DNA + cis-DDP</td>
<td>1.6 ± 0.2</td>
<td>1.6 ± 0.1</td>
<td>0.00074*</td>
<td>0.01*</td>
<td>482</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.00081**</td>
<td>0.009**</td>
<td></td>
</tr>
<tr>
<td>DNA + trans-DDP</td>
<td>1.5 ± 0.2</td>
<td>1.6 ± 0.1</td>
<td>0.00075*</td>
<td>0.011*</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0008**</td>
<td>0.009**</td>
<td></td>
</tr>
</tbody>
</table>

Note: $D(0)$ is the interdiffusion coefficient derived from the DLS data by extrapolating $1/q^2 \tau_f$ to $q = 0$; $D_\tau$ is the translational diffusion coefficient calculated from the values of $[\eta]$; $\tau_f(90)$ is the relaxation time (the fast mode) determined at an angle of 90°; $\tau_s(90)$ is the relaxation time (the slow mode) determined at an angle of 90°.

* Calculated in terms of the two-mode model.

** Determined by the inverse Laplace transform method.
REFERENCES