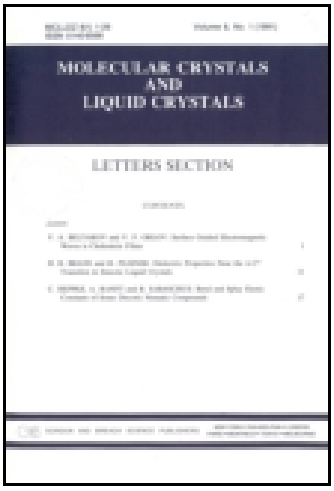

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Molecular Alignment Structure of DNA Doped Liquid Crystals

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Molecular Alignment Structure of DNA Doped Liquid Crystals

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We focus on liquid crystals (LCs) doped with deoxyribonucleic acid (DNA). We have researched the effect of the single strand DNA doping on the LC molecular alignment structure in terms of the kind of base (adenine, thymine, guanine, and cytosine), the concentration, and the molecular weight of DNA. As a result, it is found that the DNA doping can induce a twist deformation of LC alignment. Furthermore, the twisted structure strongly depends on the kind of DNA base.

Keywords liquid crystal; DNA; alignment structure; circular dichroism

1. Introduction

All matters are formed by atoms and molecules without any distinction of their kinds. However, biological organisms are entirely different from other matters in terms of the self-assembling nano-structure of living tissue and the high responsiveness. On the other hand, distinctive features of liquid crystal (LC) system [1–5] are also the easy self-assembly and the high responsiveness. Therefore, we can easily understand their close connection which inspires us with biological systems being not able to exist without liquid crystal systems [6]. It is a well known fact that the study of the liquid crystal started from its discovery during the research of the biological matter in 1888 [1, 2]. Focusing on this relationship, in a previous paper, we reported the characteristics of the LC doped with double helix deoxyribonucleic acid (DNA) molecules [7]. It was found that the DNA molecules can induce a twisted alignment structure of LC molecules. The four kinds of bases; adenine (A), thymine (T), guanine (G), and cytosine (C) constitute a DNA molecule. If the characteristics of LC doped with DNA depend on the kind of base, the nucleotide sequence analysis can be performed by utilizing LC. In this study, we investigated the influence of single-strand DNA (ss-DNA) doping upon the molecular alignment structure of liquid crystal.

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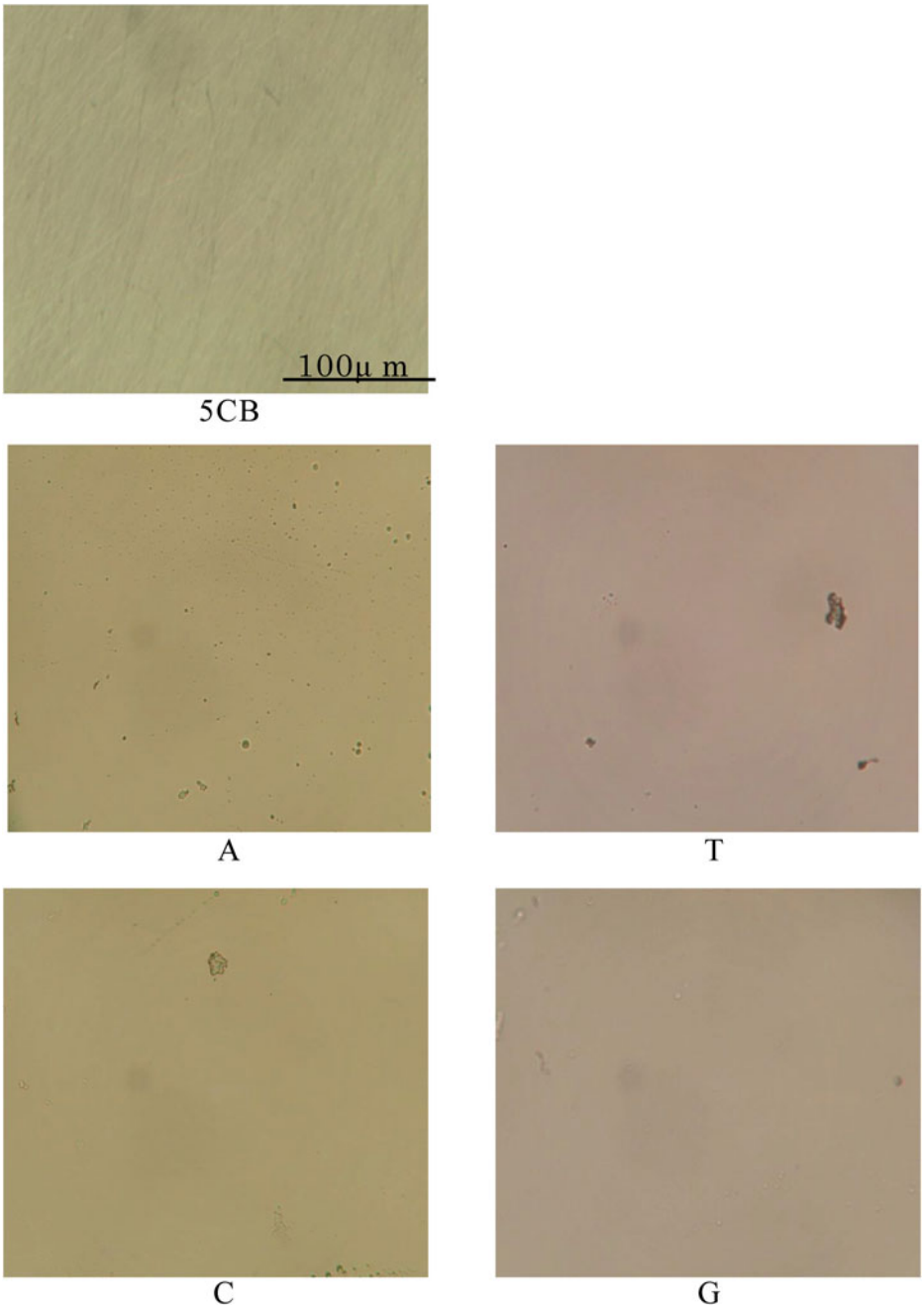

Figure 1. Microscopic textures of pure 5CB LC and DNA-doped LCs (10 base 100 μM).

2. Experimentals

The materials used in this research were as follows: the liquid crystal was 5CB (Kanto Chem.); the DNAs were ss-DNAs of 10-base and 80-base A, T, G and C (invitrogen); and

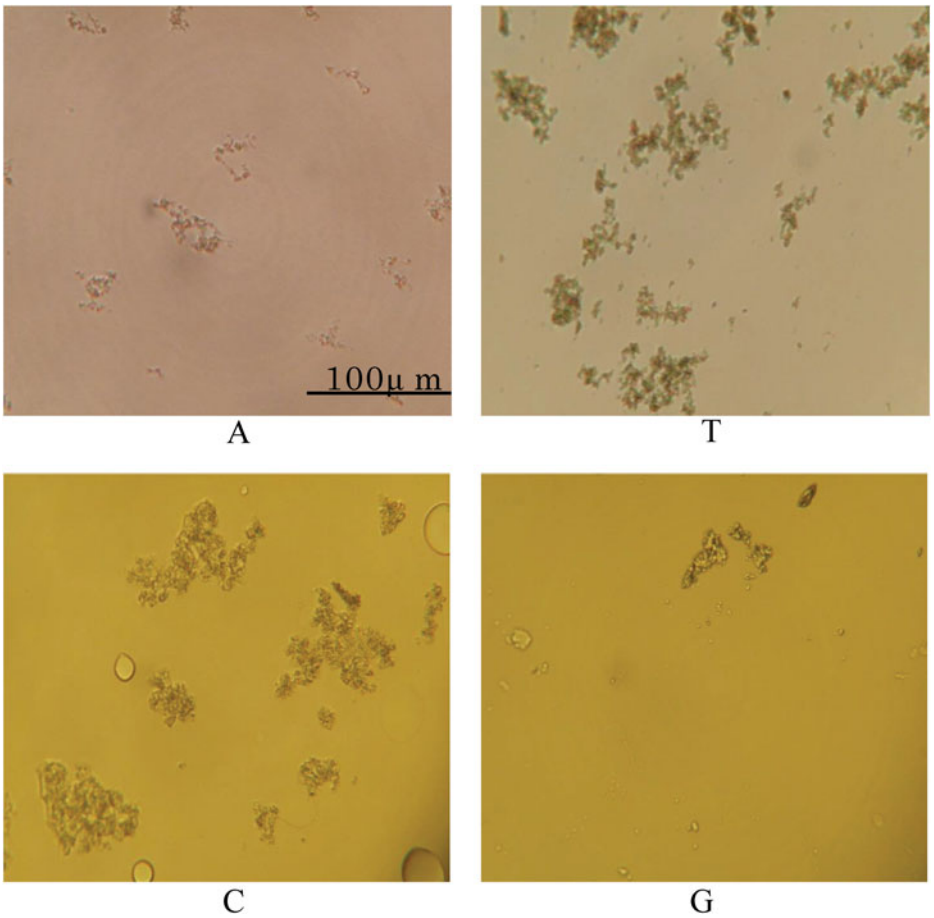

Figure 2. Microscopic textures of DNA-doped LCs (10 base 800 μM).

the LC alignment film was polyimide SE-150 (Nissan Chem. Ind.). The phase sequence of 5CB is: crystal (25°C) nematic liquid crystal (35°C) isotropic liquid.

LC preparation was as follows: A series of oligonucleotide DNAs were dissolved in deionized-distilled H_2O (dd H_2O) to a final concentration of 1 mM. An aliquot of the 1mM oligonucleotide DNA solution was brought to a final volume of 80 μl by addition more ddH_2O. Then the DNA solution was mixed with 30.4 μl of liquid crystal solution, which consisted of 5CB, 1-butanol and n-octane (ratio, 50:1:25). After sonication, the emulsion was snap-frozen in liquid nitrogen. The frozen sample was then lyophilized under 200–400 Pa for 24 h.

A solution of polyimide was spun on glass substrates coated with indium-tin oxide and then baked. After the thermal treatment, the substrates were rubbed. Then, the liquid crystal medium, which was doped with the DNA molecules, was injected in the isotropic phase via capillary action into an empty cell, in which the rubbing directions and the cell gap were set anti-parallel and 25 μm, respectively. Next, the cell was cooled gradually to the room temperature where the LC medium was in the nematic (N) phase.

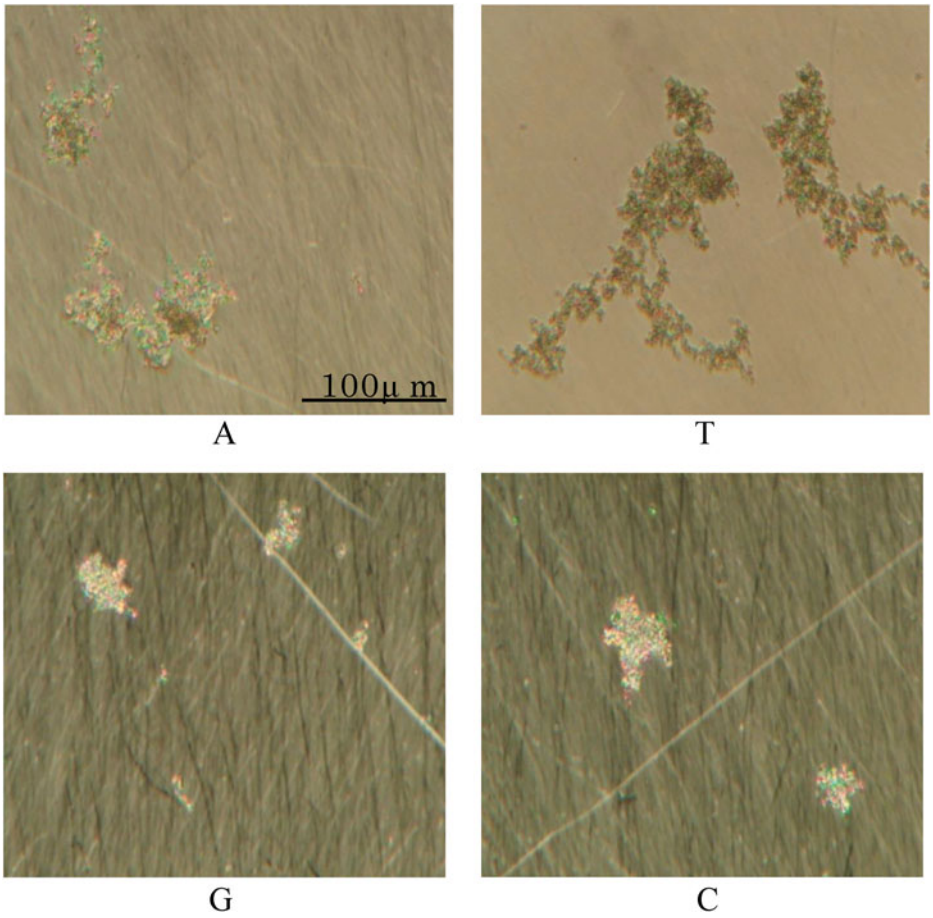

Figure 3. Microscopic textures of DNA-doped LCs (80 base 100 μM).

The microscopic texture observation was done using a conventional polarizing microscope. In order to research the twist deformation of molecular alignment, the circular dichroism (CD) measurement was carried out using a spectropolarimeter J-720WI (JASCO) with a wavelength range of 300–900 nm. We investigated the influence of single-strand DNA (ss-DNA) doping upon the molecular alignment structure of LC.

3. Results and Discussion

The microscopic textures are shown in Figs. 1–3. There is no significant change of texture in LC doped with DNA. Therefore, there is no change in the macroscopic molecular alignment structure of LC. By the way, in the texture of 5CB doped with 10 base 800 μM and 80 base 100 μM DNA, the aggregation of DNA molecules is partially observed, as shown in Fig. 2 and 3. This is because that the solubility of 5CB-LC and DNA is not well such as oil and water. Therefore, it is difficult to obtain the sample with a higher concentration than 800 μM of 10 base DNA and a longer base than 80 base of 100 μM DNA.

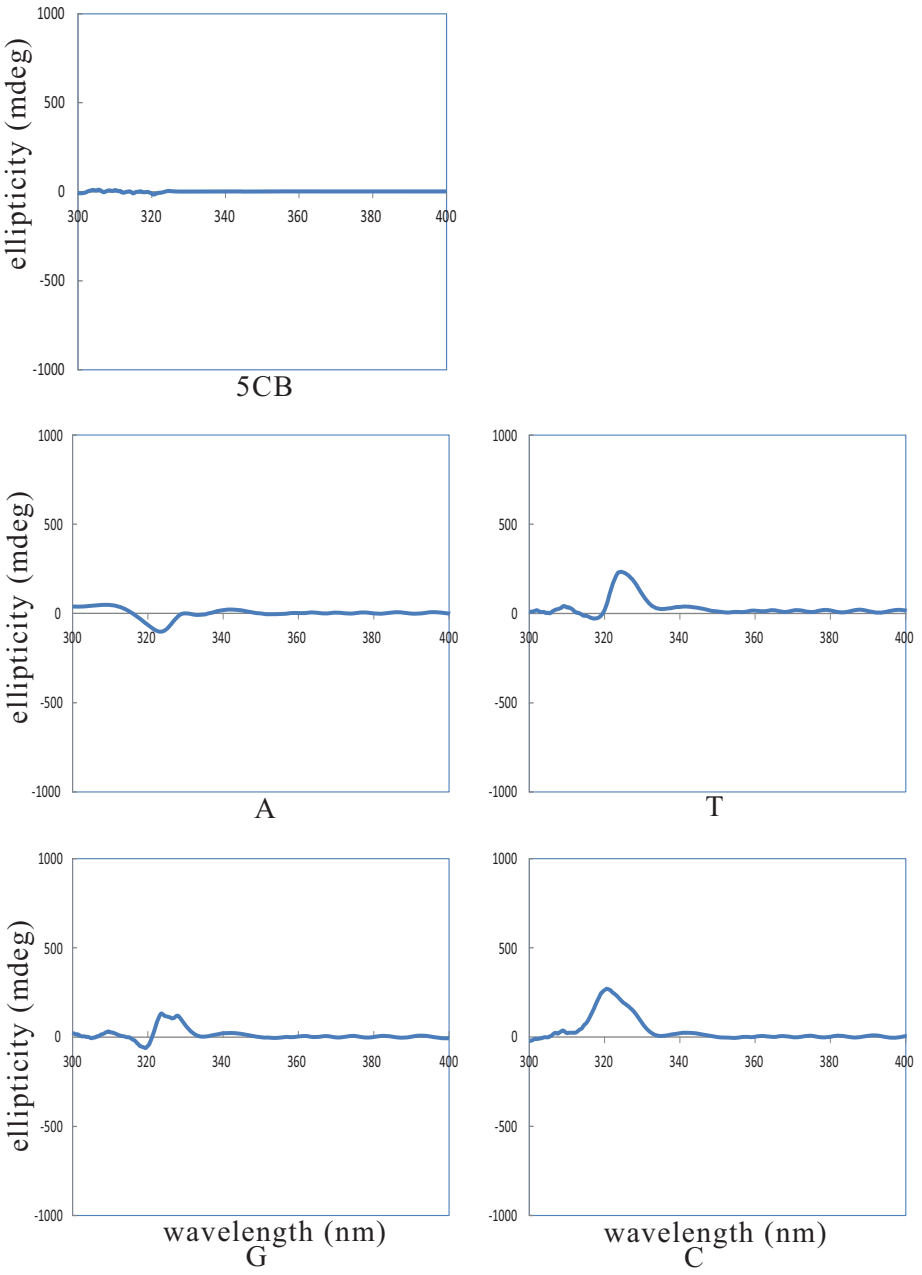

Figure 4. CD spectra in pure 5CB LC and DNA-doped LCs (10 base 100 μM).

The measurement results of CD spectra in a pure LC and 10base 100μM DNA doped LCs are shown in Fig. 4. It is confirmed that any CD peak cannot be observed in the pure LC, because of a perfect parallel orientation of LC molecules. On the other hand, a CD peak can be observed in the LC doped with ss-DNA. Therefore, although the ss-DNA molecules

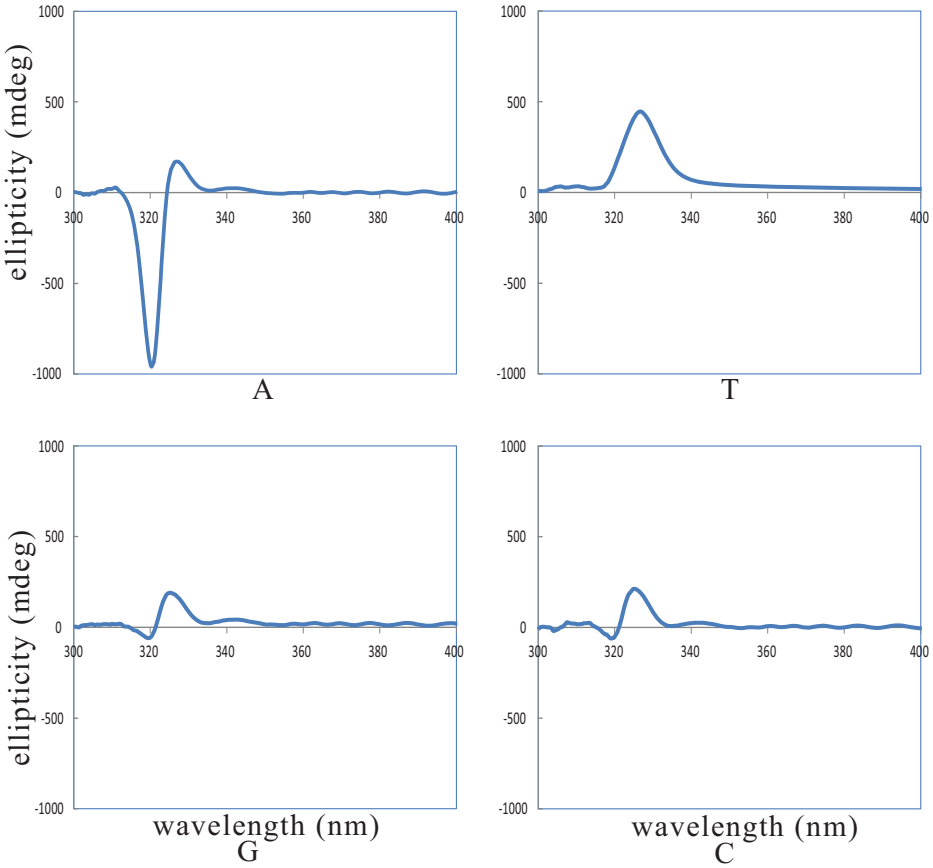

Figure 5. CD spectra in DNA-doped LCs (10 base 800 μM).

do not form a double helix structure which is formed in the double strand DNA molecules, the ss-DNA can induce a twist deformation of LC molecular alignment. It is guessed that the ss-DNA may behave as chiral dopants. However, since there is no significant change of the texture, the twisted alignment may exist microscopically. The CD peaks observed are liquid-crystal-induced circular dichroism (LCICD) [8–12]. It is a great interest that the sign of the peak in the A-doped LC is different from that in the other DNA-doped LCs. Figures 5 and 6 show the CD spectra in 10 base 800 μM and 80 base 100 μM DNA doped LCs, respectively. It is found that the CD peaks in the A and T-doped LC increase as the concentration or the molecular weight (base number) of DNA increases. On the other hand, the CD peaks in the G and C-doped LC do not almost vary even in the increase of the DNA concentration or molecular weight. Furthermore, it is found that the effect of 80 base 100 μM DNA (A and T) doping is stronger than that of 10 base 800 μM DNA (A and T) doping. Therefore, it is concluded that the twist alignment structure of DNA doped LC strongly depends on the kind of base, the concentration, and the molecular weight of DNA. These results would originates in the difference between the kinds of DNA bases for the interaction of DNA with LC molecules.

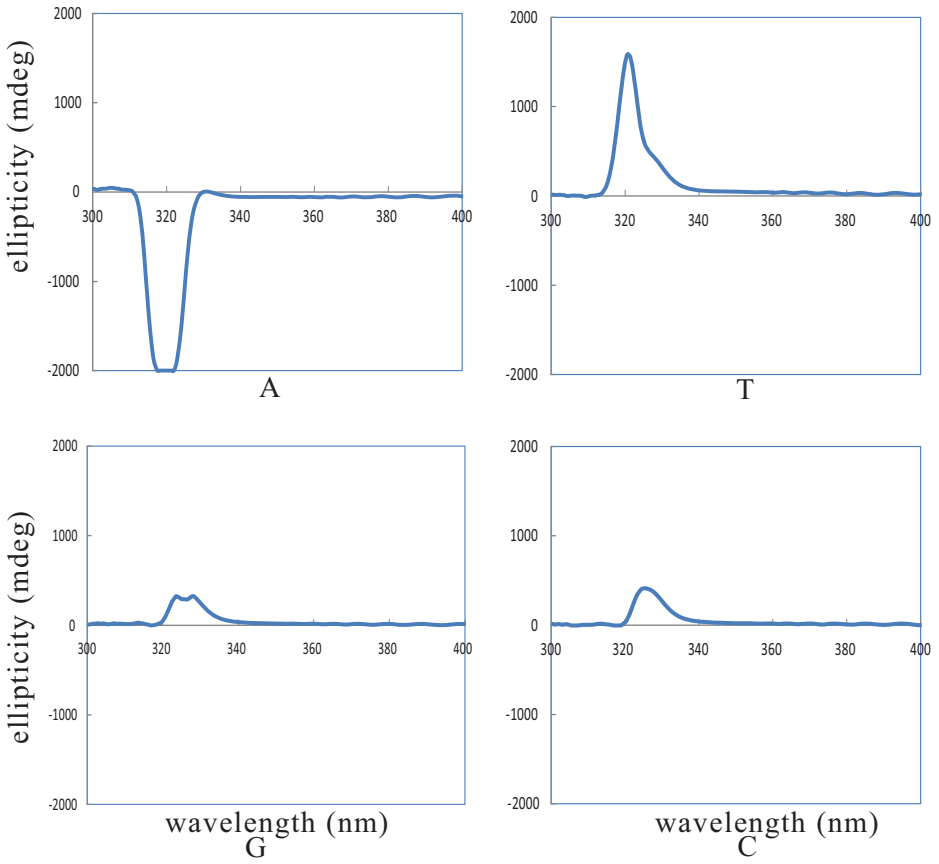

Figure 6. CD spectra in DNA-doped LCs (80 base 100 μM).

4. Conclusions

In this study, we investigate the molecular alignment structure of DNA doped LCs in terms of texture observation and CD measurement. There is no significant change of the texture in LC doped with DNA. On the other hand, in the CD spectra, the LCICD peaks can be observed in DNA doped LCs. Therefore, it is suggested that a twisted alignment of LC molecules exists microscopically even by the addition of ss-DNA. Furthermore, it is found that the sign and strength of the CD peak strongly depends on the kind of base, the concentration, and the molecular weight of DNA.

Acknowledgment

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