Phthalocyanine compounds have several important chemical properties due to their chemical structures. Nowadays, phthalocyanine compounds have great attention from scientists around the world because of their explicit applications including photodynamic treatment [1], sensors [2], pigments [3], chemotherapy treatment and enzymatic inhibitors [4, 5]. Around the world, a great number of human beings suffer from deadly carcinoma, and many people die every day due to cancer [6]. It is reported in the literature that cancer is a very critical health problem worldwide, and it is expected that it will keep causing the deaths of numerous people in the near future [7]. Due to these reasons, chemotherapy treatment and studies on preventing cancer have gained great importance. Therefore, designing cancer drugs is a fundamental concern for overcoming this fatal disease. Recently, there has been significant progress in treatments against cancer cells. On the other hand, this progress has not yet reached the desired level. As stated in the recent literature, many researchers have particularly focused on the cell cycle and DNA molecule [7, 8]. The interaction between therapeutic drugs and DNA may change DNA’s structure and transcription of the DNA molecule [9, 10]. Binding is considered to be where the major binding mode of tiny healing biological molecules with the DNA takes place via the intercalation and non-intercalation binding modes [10, 11].

Recently, various studies have been carried out on the binding of phthalocyanines to DNA molecules. Various phthalocyanine-containing groups could bind to DNA molecules by either of intercalation and non-intercalation mechanisms [12]. The reactivity of phthalocyanines may be modified by changing their peripheral ligands [13]. For instance, it was reported that the phenoxy-acetamide-substituted metal phthalocyanine complex is a biologically active compound. The phthalocyanine metal complex with octakis phenoxy acetamide ligands could have potential applications in cancer treatment [14] and antibacterial healing [14, 15].

The binding of phthalocyanines to the DNA can inhibit the spread of cancer cells, and this health issue has gained great attention. Many interesting studies have been conducted in this field. Phthalocyanine compounds could be very useful therapeutic agents for inc-
The synthesis of PcF compound

In this study, PcF compound was prepared according to literature [16].

DNA binding experiments

In CT-DNA binding experiments, the changes in intensities of absorption spectrum are associated with the interaction between such compounds and DNA because of the packing of the aromatic part with DNA bases [17]. The DNA interaction of PcF at varied amounts were investigated based on absorption titration in the buffer solution at pH of 7.1 at controlled room temperature. PcF displayed absorbance peaks at around 675 nm, 640 nm and 340 nm. Adsorption spectroscopy was used the wavelength of 260 nm for calculating the molar extinction constant of the DNA molecule for preparing CT-DNA samples. The experiment showed that CT-DNA was protein-free [18]. UV/Vis titration spectra were analyzed from 300 to 800 nm. The findings from the experiment were compared to the control absorption titration spectra with Tris-HCl instead DNA for determining the dilution effects [18]. The binding constant of the PcF compound was computed with Wolfe-Shimmer formula [19].

Fluorescence spectra experiments

In this research, CT-DNA interactive properties of PcF using the fluorescence spectroscopy technique were studied in a Tris-HCl buffer at a fixed pH of 7.1. In this study, the calf thymus DNA (CT-DNA) sample was used to examine the interactive activities of PcF. The concentration of the compound (20 µM) was kept constant during titration with the increasing amounts of the DNA. The mixture consisted of PcF and the calf thymus DNA in a Tris-HCl and NaCl buffer at a pH 7.1. Firstly, the excitation of PcF compound was performed, and then, the emissions of the compound were recorded. The solution of CT-DNA and PcF was permitted to attain the equilibration for a certain time before the experiments were conducted [20, 21].

Thermal melting experiments

To verify CT-DNA interactive activities of PcF, thermal denaturation experiments were conducted by absorption spectroscopy of the DNA at varying concentrations in a Tris-HCl buffer at a constant pH 7.1. The melting temperature measurements were conducted at a constant wavelength [22-25] by using absorption spectroscopy. The sample of CT-DNA and PcF in the buffer solution at a pH of 7.1 containing sodium chloride were increased temperature from 25 to 95 °C every 5 mins. The values of ab-

Figure 1. Chemical structure of the PcF compound.
Absorption titrations were obtained after successive heating of the CT-DNA and PcF solution.

**Viscosity measurement experiments**

In this study, the viscosity studies were conducted the with Ubbelohde viscometer. The viscometer was submerged into a water-filled bath at a fixed temperature approximately 30 °C. The concentrations of PcF and ethidium bromide were increased to identify the DNA binding properties of PcF. The flow time was obtained by measuring the sample three times. The viscosity of the solution was obtained from $\eta = (t_i - t_0)/t_0$ equation. $\eta$ represents the DNA viscosity and $t_i$ is the flow time of the Tris-HCl buffer at pH of 7.1. Recorded values are shown for $\eta/\eta_0 = (t_i - t_0)/t_0$ equation. $\eta_0$ represents the viscosity of DNA in the presence of EB and PcF, and $\eta$ shows CT-DNA viscosity [26].

**Agarose gel electrophoresis experiments**

The binding of PcF to the DNA was investigated by the electrophoresis in a TBE buffer solution. In these experiments, the concentration of the compound was kept fixed at 20 µM, but the amounts of the DNA were increased from 0 to 25 µM and the results are shown in Fig. 5. CT-DNA samples (0, 5, 15, 25 µM) and PcF (20 µM) were loaded with the dye. Agarose gel electrophoresis experiments were conducted at 80 volts during 3 hours in the buffer solution, and the CT-DNA bands were then monitored with a UV lamp. Agarose gel electrophoresis system from Thermo Scientific Owl company was used for this study [27-31]

**RESULTS AND DISCUSSION**

**Absorption spectra experiments**

Phthalocyanine compounds have two characteristic electronic spectra. One of these spectra appears approximately between 300 and 400 nm for the B-band and the other band is at about 600-780 nm for Q-band. For PcF, the typical Q-bands appeared at around 675-700 nm and B-band of PcF appeared approximately at 345 nm. The increase in the concentration of phthalocyanine compounds causes aggregation that is easy to observe in the absorption spectra of Q-band. In the present study, PcF exhibited aggregation in THF at varying amounts of PcF due to the large molecular structure of 2(3), 9(10), 16(17), 23(24) –tetrakis 4-(4-(2-phenylprop-2-yl) phenoxy) phthalocyanine [32].

The UV/Vis spectroscopy procedure is widely applied to investigate the binding of chemical complexes by the DNA. Generally, the interaction of tiny biomolecules to CT-DNA pertains to the change in hyperchromicity, hypochromicity, blue shift or redshift in wavelength of electronic titration spectra [33]. The binding mode of intercalation is generally associated with hypochromicity and redshift [32]. Absorption titration is a very much helpful method in investigating the binding activities of phthalocyanines on the DNA molecules. The interaction of tetracationic zinc and phthalocyanine were reported in the literature [34]. The results of previous studies indicated that the quaternary Zn(II) and metal-free phthalocyanine compound interact with the DNA molecule [34, 35]. Another study on the morpholine zinc (II) phthalocyanine complex demonstrated that phthalocyanine complex binds to DNA molecule with intercalative mechanisms [36]. The findings of other studies showed that positively charged phthalocyanines interact with DNA by non-intercalation mode [37]. A study on Cu(II), Mn(III) and Zn(II) phthalocyanine complexes demonstrated that phthalocyanine complexes bind to the DNA molecule by an intercalative mechanisms [38]. Cu(II) bearing hexamethyleneimino-ethoxy phthalocyanine complex was also studied, and the finding showed that it has a strong interaction by DNA [34]. Additionally, the interactions of a cationic cobalt and palladium phthalocyanine complexes with the DNA were also reported. The results of the investigation demonstrated that the phthalocyanine complex interacts with the DNA molecule [39]. The absorption titrations of the 2(3), 9(10), 16(17), 23(24) –tetrakis4-(4-(2-phenylprop-2-yl)phenoxy) phthalocyanine compound at various concentrations of CT-DNA are displayed at Fig. 2. In the absence of CT-DNA, the electronic titration spectra of PcF (20 µM) was performed from 300 to 800nm. PcF indicated two particular electronic spectra, which are at around 675 and 640 nm for Q-bands and approximately 340 nm for the B-band as shown in Fig. 2. The electronic titration experiment of the DNA binding activities with PcF compound was conducted in a Tris-HCl buffer at pH of 7.1 in the presence of the DNA. The absorption titration of PcF showed decreasing in absorbance intensities by increase in the concentrations of CT-DNA. The changing in the electronic titration spectra of PcF during titration by the DNA are indicated in Fig. 2. The results showed that PcF had hypochromicity with redshift as shown in Fig. 2. The hypochromicity that appeared proved that PcF binds to the DNA with intercalative mechanisms. It is accepted that redshift in absorption spectra is related to the decreasing of energy from HOMO to LUMO of the ring of phthalocyanine, but hypochromicity refers to the binding between chemical complexes and the bases of CT-DNA molecule [40-42]. The changing in hypochromicity indicates that PcF interacts by the DNA through the intercalation binding mechanisms. The results of this method proved that PcF compound binds to the DNA by intercalative binding. The additional, method described over, the Kb...
constant of PcF by the DNA was obtained by using the Wolfe-Shimer formula. The $K_b$ was calculated as $1.03 \times 10^6 \text{M}^{-1}$. The value demonstrated that PcF has a binding activity to the DNA by the intercalative binding[35].

**Fluorescence spectra experiments**

Fluorescence spectroscopic titration procedure is often applied to search the DNA interaction activities with chemical compounds. The emission titration technique provides a significant amount of understanding on the interaction among chemical compounds and the DNA molecule. Recently, in the literature, there have been several fluorescence titration studies that aimed to investigate the interaction between DNA and small chemical compounds [43]. In the present study, the emission titration experiments were conducted to study the interaction of PcF with CT-DNA in the buffer at a pH of 7.1. PcF generated fluorescence spectra with forming a peak around 445 nm in a Tris-HCl solution at a pH of 7.1 in the absence of the DNA as indicated in Fig. 3. In the buffer solution at a pH of 7.1, the fluorescence emission spectra of PcF were studied in the presence of the DNA as shown in Fig. 3. The arrow indicates the change in the intensities upon increase in concentrations of CT-DNA. When the amounts of CT-DNA was increased, the intensities of peaks of fluorescence emission gradually increased. This finding indicated that PcF interacts with CT-DNA by intercalation mechanism as the molecular structure of DNA was shifted with a chemical compound [44]. The increasing concentrations of DNA caused the increasing in the intensity of the emission spectra of PcF. This result specified that PcF has binding activities to CT-DNA.

**Thermal denaturation profile experiments**

A melting temperature (Tm) experiment was performed on the DNA samples for analyzing the binding properties of PcF. Thermal denaturation experiments of DNA produce a substantial amount of information about the activities of DNA based on the changes in temperature at a 260 nm wavelength [45]. The intercalation binding mechanism of biochemical complexes by DNA molecule enhances the thermal melting because of the impact of the interaction mode, but thermal melting temperatures of the non-intercalative binding mechanism for some chemical compounds with DNA either decrease or do not change [43]. The thermal melting temperature of the DNA was conducted by electronic spectra titration in the presence of a buffer at a pH of 7.1. The findings of melting temperature experiments were shown in Table 1. The temperature of the thermal denaturation of the DNA was observed to be 73.57 °C. In the presence of PcF, thermal denaturation temperature was observed as 81.64 °C. These findings demonstrated that PcF interacts with the DNA by intercalation mechanism because of the enhancement of melting temperature.

**Table 1. Thermal denaturation temperatures (Tm) of CT-DNA in Tris-HCl at a pH of 7.1.**

| Sample        | Melting temperature (Tm) |
|---------------|--------------------------|
| CT-DNA        | 73.57 °C                 |
| CT-DNA+ PcF   | 81.64 °C                 |

**The study of agarose gel electrophoresis**

The Agarose gel electrophoresis method [46, 47] was utilized to investigate the interaction of phthalocyanine on CT-DNA in a Tris-HCl at a pH of 7.1 at 25 °C. The binding of PcF (20 µM) to CT-DNA (5, 15, 25 µM) was studied to verify the effect of CT-DNA on PcF (20 µM). Lane C represents the control DNA and lanes 1, 2 and 3 belong to the DNA and PcF mixtures. Lane M shows the DNA marker. Fig. 4 shows the DNA bands which were visualized under UV light. These findings clearly demonstrated that the band intensities of DNA significantly reduced when the concentrations of CT-DNA increased. There was a decline in the band intensities of CT-DNA after the interaction of PcF with CT-DNA because of the distortion of...
the DNA’s double helix [48, 49]. The results of this analysis verified that PcF interacted with the DNA molecule.

The change in intensities in CT-DNA bands appeared in lanes 1, 2 and 3 in the comparison of the DNA bands to the C DNA as shown in Fig. 4. When the interaction ability of PcF with the DNA was aligned with control DNA, the findings showed that PcF had a strong interaction with CT-DNA. It was found that the control DNA showed no significant change. In a conclusion, the results of agarose gel electrophoresis study proved that PcF has a binding activity to CT-DNA.

**Viscosity measurement experiments**

The viscosity measurement procedure is widely applied to investigate the DNA binding characteristics of compounds based on increases and decreases in DNA viscosity based upon an increase in concentrations of chemical compounds. An increasing of viscosity indicates that chemical complexes bind to the DNA molecule with intercalative mechanisms that cause deformation and enlargement of the DNA. In contrast, a decrease in viscosity values demonstrates that the molecules interact by the DNA molecule through the non-intercalation mechanism.

The stacking of the ligands of compounds between DNA bases cause significant changes in the molecular structure of DNA [50, 51]. Viscosity measurements were performed to prove the binding activities of drug for treatment of DNA molecule for PcF compound at a constant pH of 7.1 as demonstrated in Fig. 5. Firstly, the relative viscosity measurements of ethidium bromide (EB) were carried out. Secondly, viscosity experiments of the DNA and PcF were performed in the presence of EB as given in Fig. 5. The increasing in the viscosity of CT-DNA was gradually enhanced when the concentration of PcF increased. The viscosity experiment demonstrated that PcF interacts with the DNA by partial intercalative binding.

**CONCLUSION**

In this study, the previously synthesised 2(3), 9(10), 16(17), 23(24)–tetrakis 4-(4-(2-phenylprop-2-yl) phenoxy) phthalocyanine compound was reported in the literature. The binding activities of the DNA for PcF compound were examined by electronic titration spectra, fluorescence spectra, thermal melting and the study of viscosity in the buffer at a pH of 7.1. The results of absorption spectra, fluorescence spectra, thermal melting and the study of viscosity methods verified that the compound binds to CT-DNA through an intercalative mechanism. In addition to above methods, the DNA interaction activities of PcF were also studied by the electrophoresis on calf thymus DNA. The result of the electrophoresis experiment showed that the compound binds to calf thymus DNA through an intercalative mechanism. These results suggested that PcF could be a potential therapeutic agent. Therefore, further studies are necessary to prove it as a therapeutic drug for the treatment of diseases such as cancer due to its DNA interaction characteristics.

**ACKNOWLEDGEMENT**

This scientific research was supported by Scientific Research Projects of Karabuk University and the Research Fund of Van Yüzüncü Yıl University (FYL-2016-5160). We special thank to Prof. Dr. Arif Baran and his research group members.

**References**

1. Mantareva V, Angelov I, Aliosman M, Stoineva I, Kussovski V. An overview on the impact of cationic phthalocyanine complexes for inactivation of drug-resistant microorganisms. Photodiagnosis Photodynamic Therapy 27 (2017) A43-A44.

2. Yazıcı A, Dalbul N, Altındal A, Salih B, Bekaroğlu O. Ethanol
sensing property of novel phthalocyanines substituted with 3,4-dihydroxy-3-cyclobuten-1,2-dione. Sensors Actuators B: Chemical 202 (2014) 14-22.

3. S. Evrim MA, İlgün C, Güll A. Preparation of heterogeneous phthalocyanine catalysts by cotton fabric dyeing. Dyes and Pigments 89 (2011) 162-168.

4. Kantar C, Mavi V, Baltaz N, İslamoğlu F, Şaymaz S. Novel zinc(II)phthalocyanines bearing azo-containing Schiff base: Determination of pKa values, absorption, emission, enzyme inhibition and photochemical properties. Journal of Molecular Structure 1122 (2016) 88-99.

5. Kantar GK, Kantar N, Baltaz N, Mentşeş E, Şaymaz S. Microwave-assisted synthesis and investigation of xanthine oxidase inhibition of new phthalonitrile and phthalocyanines containing morpholine substituted 1,2,4-triazole-3-one. Journal of Organometallic Chemistry 787 (2015) 8-13.

6. Siegel RL, Miller KD, Jemal A. Cancer statistics. CA: A Cancer Journal For Clinicians 65 (2015) 5-29.

7. Bagda E, Yaba E, Bagda E. Analytical approaches for clarification of DNA double-decker phthalocyanine binding mechanism: As an alternative anticancer chemotherapeutic. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 172 (2017) 199-204.

8. Oliveira LT, Garcia GM, Kano EK, Tedesco AC, Mosquesra VCF. HPLC-FLD methods to quantify chlorouraininum phthalocyanine in nanoparticles, plasma and tissue: application in pharmacokinetic and biodistribution studies. Journal of Pharmaceutical Biomedical Analysis 56 (2011) 70-77.

9. Palchoudhuri R, Hergenrothe PJ. DNA as a target for anticancer compounds: methods to determine the mode of binding and the mechanism of action. Current Opinion in Biotechnology 18 (2007) 497-503.

10. Rescifina A, Zagni C, Varrica MG, Pistara V, Corsaro A. Recent advances in small organic molecules as DNA intercalating agents: Synthesis, activity, and modeling. European Journal of Medicinal Chemistry 74 (2014) 95-115.

11. Ozluer C, Satana Kara HE. In vitro DNA binding studies of anticancer drug iraducibin using spectroscopic techniques. Journal of Photochemistry and Photobiology B: Biology 138 (2014) 36-42.

12. Williams AK, Dasiyca SB, Bhatta A, Rawal B, Liu M, Korobkova EA. Determination of the drug-DNA binding modes using fluorescence-based assays. Analytical Biochemistry 411 (2012) 66-73.

13. Uslan C, Sesalan BS. The synthesis, photochemical and biological properties of new silicon phthalocyanines. Inorganica Chimica Acta 94 (2013) 353-362.

14. Aboraiia AS, Abdel-Rahman HM, Mahfouz NM, El-Gendy MA. Novel 5-(3,4-dioxynphenyl)-3-substituted-2,3-dihydro-1,3,4-oxadiazole-2-thione derivative Promising anticancer agents. Bioorganic and Medicinal Chemistry 14 (2006) 1236-1246.

15. Şahin G, Palaska E, Ekizoglu M, Ozalp M. Synthesis and antimicrobial activity of some 1,3,4-oxadiazole derivatives. II. Farmaco 57 (2002) 539-542.

16. Durmus C, Master Thesis, Synthesis and Investigation of Some Properties of 4-(2-(Phenylprop-2-yl)phenoxy) substituted phthalocyanines. Yüzüncü Yıl University (2017).

17. Demirbaş U, Barut B, Özel A, Çelik F, Kantekin H, Sancak K. Synthesis, characterization and DNA interaction properties of the novel peripherally tetra 4-(3-methyl-4-(3-morpholinopropyl)-5-oxo-4,5-dihydro-1H-1,2,4-triazole-1-yl) substituted water soluble Zn(II) and Cu(II) phthalocyanines. Journal of Molecular Structure 1177 (2002) 571-578.

18. Saha U, Mukherja K. DNA binding and nuclease activity of an oxovanadium valinato-Schiff base complex. International Journal of Biological Macromolecules 66 (2014) 166-171.

19. Fu XB, Wang GT, Liu DD, Lin XY. Synthesis, characterization, DNA binding and cleavage, HSA interaction and cytotoxicity of a new copper(II) complex derived from 2-(2'-pyridyl)benzothiazole and glycinecyline. Journal of Photochemistry and Photobiology A: Chemistry 276 (2014) 83-95.

20. Wólc A, Shimer GH, Mehran T. Polycyclic aromatic hydrocarbons physically intercalate into duplex regions of denatured DNA. Biochemistry 26 (1987) 6392-6396.

21. Barut B, Demirbaş U, Özel A, Kantekin H. Novel water soluble morpholine substituted Zn(II) phthalocyanine: Synthesis, characterization, DNA/BSA binding, DNA photocleavage and topoisomerase 1 inhibition. International Journal of Biological Macromolecules 105 (2017) 499-508.

22. Azza AS, Mohamed MS. DNA binding, spectrocopic and antimicrobial studies of palladium (II) complexes contain 2,20-bipyriden and 1-phenyipiperazine. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 96 (2012) 586-593.

23. Apilux A, Tabata O, Chatapakul M. Electrochemical behaviors of native and thermal denatured fish DNA in the presence of cytosine derivatives and porphyrin by cyclic voltammetry using boronedroed diamond electrode. Bioelectrochemistry 70 (2007) 435-439.

24. Arslantas A, Agirtas MS. A Comparative Study on DNA Binding Properties of 2,10,16,24-Tetrakis (4-(4-hydroxyphenyl)-1-phenylethyl) phenoxy)-Substituted Co(II) and Mg(II) Phthalocyanine Compounds. ChemistrySelect 2 (2017) 8661-8665.

25. Agirtas MS, Cabir B, Oezdemir S, Okumus V, Arslantas A, Syntesis, Aggregation, Antioxidant and DNA-Binding Properties of Metallophthalocyanines Bearing 5-Tert-butyl-2-hydroxyphenyl Iver Groups. ChemistrySelect 2 (2017) 11352-11357.

26. Demirezen N, Tarsc D, Polat D, Cesme M, Golcu A, Tumer M, Syntesis of trimethoprim metal complexes: Spectral, electrochemical, thermal, DNA-binding and surface morphology studies. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 94 (2012) 243-255.

27. Arslantas A, Agirtas MS. Investigation of DNA-Binding Activities of Zinc(II) and Cobalt(II) Phthalocyanine Compounds with 3,4,5-Trimethoxybenzyloxy Substituents. ChemistrySelect 2 (2017) 11659-11665.

28. Reddy PR, Shilpa A, Raju N, Raghavaiah P. Synthesis, structure, DNA binding and cleavage properties of ternaryamin acid Schiff base-pen/bipy C(II) complexes. Journal of Inorganic Biochemistry 105 (2011) 1603-1612.

29. Arslantas A, Agirtas MS. Studies on DNA Interaction with 2(13H,9(10),16(17), 23(24)-Tetrazik 2(4-Phenoyphenyl) Diazylbenzoic acid) phthalocyaninato Zinc (II) Compound. ChemistrySelect 3 (2018) 1755-1760.

30. Liu XW, Shiou YM, Li ZX, Zhong X, Chen YD, Zhang SB. Study on DNA binding behavior and light switch effect of new coumarin-derived Ru (II) complexes. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 49 (2015) 150-156.

31. Arslantas A, Agirtas MS. Investigation of DNA Binding Activities of Peripherally 2,10,16,24-Tetrazik Dimethyl 5-(Phenoxy)-Isophthalate-Substituted Ni(II) Phthalocyanine Complex. ChemistrySelect 3 (2018) 3155-3160.

32. Ozçesme N, Soro I, Hamurydan E. Synthesis, optical and structural studies of tetrakis[4(2',3',4',5',6'-pentfluorobenzoyl) benzoyl]-substituted mettallo-phthalocyanines. Synthetic Metals 162 (2012) 154-161.

33. Barut B, Demirbaş U, Şenocak A, Özel A, Fıntekin H. Water soluble axially morpholine disubstituted silicon phthalocyanines:
Synthesis, characterisation, DNA/BSA binding, DNA photocleavage properties. Synthetic Metals 229 (2017) 22-32.

34. Evren D, Kalkan A, Örçesmeci BI, Sesalan BS, Synthesis of novel tetracationic phthalocyanines and investigation of their DNA-binding properties. Dyes and Pigments 96 (2013) 475-482.

35. Çakir V, Çakir D, Göksel M, Durmuş M, Bıyıklıoğlu Z, Kanteke H. Synthesis, photochemical, bovine serum albumin and DNA binding properties of tetrasubstituted zinc phthalocyanines and their water soluble derivatives. Journal of Photochemistry and Photobiology A: Chemistry 299 (2013) 153-151.

36. Lopez Zevallos NC, Guaza GA, Garcia Vior MC, Awruch J, Dicelio LE. Interaction of cationic phthalocyanines with DNA and importance of the structure of the substituents. Journal of Photochemistry and Photobiology B: Biology 136 (2014) 29-33.

37. Barut B, Sofuoğlu A, Bıyıklıoğlu Z, Özel A. The water soluble peripherally tetra-substituted zinc(II), manganese(III) and copper(II) phthalocyanines as new potential anticancer agents. Dalton Transactions 45 (2016) 14301-14310.

38. Uslan C, Sesalan BS. Synthesis of novel DNA-interacting phthalocyanines. Dyes and Pigments 94 (2012) 127-135.

39. Turanlı-Yıldız B, Sezgin T, Petek Çakar Z, Uslan C, Sesalan BS, Güll A. The use of novel photoetchable phthalocyanines to image DNA. Synthetic Metals 161 (2011) 1720-1724.

40. Bıyıklıoğlu Z, Barut B, Özel A, Synthesis, DNA/BSA binding and DNA photocleavage properties of water soluble BODIPY dyes. Dyes and Pigments 148 (2018) 417-428.

41. Smolkova R, Zelenak V, Grypes R, Sabolova D, Imrichova N, Hudecova D, Smolková R, Zelenak V, Grypes R, Sabolova D, Imrichova N, Hudecova D, Synthesis, characterization, DNA binding, topoisomerase I inhibition and antimicrobial activity of four novel zinc(II) fenamates. Polyhedron 141 (2018) 230-238.

42. Baş H, Barut B, Bıyıklıoğlu Z, Özel A, Synthesis, DNA interaction, topoisomerase I, II inhibitor and cytoxic effects of water soluble silicon (IV) phthalocyanine and phthalocyanine bearing 1-acetylpyperazine units. Dyes and Pigments 160 (2019) 136-144.

43. Zhang SS, Niu SY, Qu B, Jie GB, Xu H, Ding CF. Studies on the interaction mechanism between hexakis(imidazole) manganese (II) terephthalate and DNA and preparation of DNA electrochemical sensor. Journal of Inorgoanic Biochemistry 99 (2005) 2340-2347.

44. Özen F, Günel A, Baran A. DNA-binding, enzyme inhibition, and photochemical properties of chalcone-containing metallophthalocyanine compounds. Bioorganic Chemistry 81 (2018) 71-78.

45. Kesimal T, Barut B, Bıyıklıoğlu Z, Özel A. A comparative study on DNA/BSA binding. DNA pA comparative study on DNA/BSA binding, DNA photocleavage and antioxidant activities of water soluble peripherally and non-peripherally tetra-3-pyridin-3-ylpropoxy-substituted Mn(II), Cu (II). Dyes and Pigments 139 (2017) 575-586.

46. Song Y, Yang P, Yang M, Kang J, Qin S, Lü B, Wang L. Spectroscopic and voltammetric studies of the cobalt (II) complex of Morin bound to calf thymus DNA. Transition Metal Chemistry 28 (2003) 712-721.

47. Pravin P, Uthra PP, Kumaravel G, Raman N. Effective DNA binding and cleavage tendencies of malonic acid coupled transition metal complexes. Journal of Molecular Structure 1123 (2016) 162-170.

48. Hassani L, Hakimian F, Safaei E, Fazeli Z. Antibacterial effect of cationic porphyrines and anionic phthalocyanine and their interaction with plasmid DNA. Journal of Molecular Structure 1052 (2013) 221-227.

49. Örçesmeci M, Ecevit OB, Sürgün S, Hamuryudan E. Tetracationic fluorinated inc(ii)phthalocyanine: Synthesis, characterization and DNA binding properties. Dyes and Pigments 96 (2013) 52-58.

50. Al-Mogren MM, Alagha MA, Ebrahim EA. Synthesis, spectroscopic, molecular orbital calculation, cytotoxic, molecular docking of DNA binding and DNA cleavage studies of of transition metal complexes with N-benzylidene-N´-salicylidene-1,1-diaminopropane. Journal of Photochemistry and Photobiology A: Chemistry 114 (2013) 695-707.

51. Shankaraiah N, Jadala C, Nekkati S, Senwar KR, Nagesh N, Shrivastava S, Naidu VG, Sathish M, Kamal A. Design and synthesis of C3-tethered 1,2,3-triazolo-β-carboline derivatives: Anticancer activity, DNA-binding ability, viscosity and molecular modeling studies. Bioorganic Chemistry 64 (2016) 42-50.