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Analysis of DNA modified by cerium (III), lanthanum (III) and gadolinium (III) ions by using of raman spectroscopy

Veronika Kohoutkova, Petr Babula, Radka Opatrilova, Oldrich Vrana, Vojtech Adam, Rene Kizek*

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Abstract

Lanthanides are at the present group of heavy metals, which are at the centre of interest, especially because of their ability to interact with DNA and similarity with calcium(III) ions, which play crucial role in many cell processes. On basis of DNA interactions, anti–cancerogenic potential is established. In our work, we were focused on interactions of chosen lanthanides – lanthanum, cerium and gadolinium – with DNA. Results of our experiments demonstrate ability of lanthanides to form DNA adducts.

Keywords: DNA, raman spectroscopy, coumarin complexes

Introduction

The biological properties of the lanthanides have stimulated research into their therapeutic application. Up–to–date, we have been successfully using lanthanides(III) compounds for their anti–cancer potential. Cerium(III), lanthanum(III) and neodymium(III) coumarin complexes were synthesized with ligands, such as hymecromone, umbellipherone, mendiaxon, warfarin, coumachlor and niffcoumar. Preclinical studies with these compounds have demonstrated cytotoxicity against the HL–60 myeloid cell line. Clinical reports suggested that above mentioned compounds demonstrated cytotoxic effect; however the biochemical mechanism of their action is still unclear. Therefore, we aim our attention on studying of interactions DNA with inorganic salts of cerium(III), lanthanum(III) and gadolinium(III) (Duguid et al. 1995; Fricker 2006; Schmitt & Popp 2007; Vrana et al. 2007).

Veronika Kohoutkova, Petr Babula

Department of Natural Drugs, Faculty of Pharmacy, University of Veterinary and Pharmaceutical Sciences, Palackeho 1–3, CZ–612 42 Brno, Czech Republic

Radka Opatrilova

Department of Chemical Drugs, Faculty of Pharmacy, University of Veterinary and Pharmaceutical Sciences, Palackeho 1–3, CZ–612 42 Brno, Czech Republic

Oldrich Vrana

Institute of Biophysics, Academy of Sciences of the Czech Republic, Kralovopolska 135, CZ–612 65 Brno, Czech Republic

Vojtech Adam, Rene Kizek*

Department of Chemistry and Biochemistry,Faculty of Agronomy, Mendel University of Agriculture and Forestry, Zemedelska 1, CZ–611 37 Brno, Czech Republic

*Tel: +420 545 133 350, Fax: +420 545 212 044
E-mail: kizek@sci.muni.cz

Materials and methods

Spectra of samples – DNA after interaction with individual lanthanide – were measured on the Raman spectrometer Jobin–Yvon T64000 (Horiba Scientific, Japan). Concentrated solutions of samples were sealed in the glass capillaries Kimax 34507 (Kimble products, USA) and placed into focused laser beam. Excitation wavelength radiation was 488 nm (argon laser Innova 90C Fred, Coherent). The intensity of radiation reaching the sample was 100 mW and was monitored by using of Broadband Power Meter (Melles Griot, USA). Data processing was done by software LabSpec. From all processed spectra, were deducted contributions of solvent (0.1 M NaCl). In the case of differential spectra, they were deducted from the modified spectrum of DNA. The final appearance of the spectrum was treated in the Origin 8.

Results and Discussion

A. Lanthanum. Raman spectrum shows that the ratio of 683/670 cm^{-1} belts is less than 1, which marks the transition from B–conformation in the A–DNA. The increasing intensity of the peak 750 cm^{-1} is connected with the vibration of lanthanum. The rise of the belt in the area of 804 cm^{-1} indicates the local structural changes in DNA modified by lanthanum. A significant decrease in the intensity of the band 1490 cm^{-1} corresponds to change in the position N7 of guanine in all cases of the measured samples. The rise of intensity for the belt 1578 cm^{-1} corresponds to the changes in the G–C and T–A pairs of the bases.

B. Cerium. Similarly to DNA modification by lanthanum(III) ions, there were noticeable changes in the areas of 670 cm^{-1} and 683 cm^{-1}. The rate of intensities of belts 683/670 cm^{-1} is 0.7, which means the most transition from B–DNA into A–DNA of the modified DNA by the studied ions. The belts in the area of 735 cm^{-1}, 920 cm^{-1}, 973 cm^{-1}, 1018 cm^{-1}, 1073 cm^{-1}, 1137 cm^{-1}, 1211 cm^{-1}, 1337 cm^{-1}, and 1448 cm^{-1} are connected with contribution cerium vibrations.

C. Gadolinium. The ratio of 683/670 cm–1 is less than 1. DNA modified by gadolinium(III) ions changed its modification from B–DNA into A DNA. The increase in the field of 807 cm^{-1} is the highest from all DNAs modified by the measured lanthanides(III) ions. The belts in the area of 1078 cm^{-1}, 1218 cm^{-1}, 1361 cm^{-1}, 1448 cm^{-1} are linked to the contribution of the vibration of gadolinium.

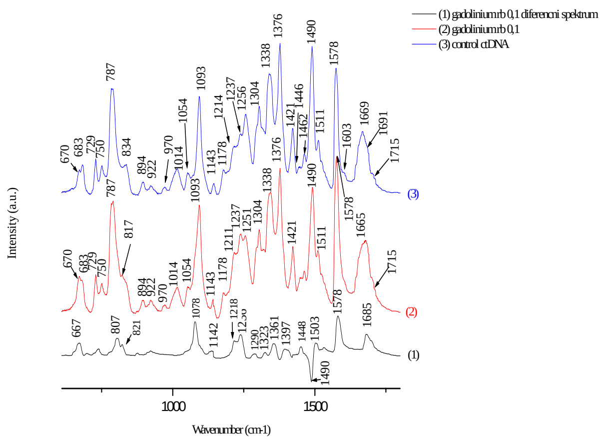

Figure 1: Changes of DNA spectra after interaction with gadolinium(III) ions. Typical belts are indicated by arrows. Changes in spectra are connected with formation of DNA adducts as well as with vibrations of gadolinium(III) ions themselves.

Conclusion

The differential Raman spectrum of DNA modified by all complexes is falling linearly in dependence on rb. For all measured modified DNAs, there are obvious changes in both parts of the spectra: vibration of the sugarphosphate skeletons as well as in the areas of vibration bases not least in the areas of the vibration of the individual ions (La, Gd, and Ce). For DNA modified by all ions there is a noticeable shift from B–DNA into A–DNA. The Raman spectroscopy represents a suitable tool for characterization of structural changes of DNA modified by the chosen lanthanides ions.

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