UDC 57.08+543.4 https://doi.org/10.15407/biotech17.02.036

# ABSORPTION AND LUMINESCENCE PROPERTIES OF ACID AND SALT FORMS OF MONONUCLEOTIDES, THEIR COMPONENTS AND COMPLEXES WITH D-MANNITOL AT ROOM TEMPERATURE

*M.A. DOTSENKO, R.O. NIKOLAIEV, Z.Yu. TKACHUK*

Institute of Molecular Biology and Genetics of the National Academy of Sciences of Ukraine, Kyiv

*E-mail: mychailodotsenko@gmail.com*

Received 2024/03/21
Revised 2024/04/10
Accepted 2024/04/30

Today, medicines are being actively developed whose principle of action is based on the interaction of mononucleotides with biomolecules. At the same time, nucleotides in acidic form can differ greatly in their properties from salts, which was used in the development of the mRNA coronavirus vaccine [1]. Thus, studies of both this interaction and the mononucleotides themselves are very relevant. Our previous studies have shown that the addition of mannitol contributes to the antiviral effect of RNA molecules, unlike other sugars, amino acids, alkaloids, etc. Therefore, an interaction between mannitol and RNA molecules would be expected.

One of the most common areas of research is the use of spectroscopic methods that are non-destructive, relatively inexpensive, and provide important information about samples, such as electronic transition energies [2]. Heterocyclic molecules can luminesce because the energy difference between the ground and excited states of the electrons corresponds to the energy of the optical radiation that can be detected by spectroscopic methods.

However, spectroscopic studies of the radiation of aqueous solutions of nucleotides are usually performed at the boiling point of nitrogen or helium, when the sensitivity of most instruments allows for clear spectra [3–7]. In addition, most of the spectroscopic studies of mononucleotides to date have focused on their salts, which are widely available [8, 9]. However, this approach does not enable studying nucleotides in the state in which they are found in cells. Therefore, there is a need for spectroscopic studies of aqueous nucleotide solutions at room temperature.

***Aim.*** The aim of this work was to analyze and compare spectral properties of aqueous nucleotide solutions and their mixes with D-mannitol in conditions close to biological systems.

***Methods.*** We studied the absorption and luminescence (Ex and Em fluorescence and Em phosphorescence) of monoribonucleotides, their disodium salts, bases and nucleosides, and mixes with D-mannitol dissolved in water at room temperature. For these samples, we measured absorbance spectra using a Specord 210plus (Germany) instrument and fluorescence excitation and emission and phosphorescence spectra using Horiba Fluoro Max 4+ (USA) instruments.

***Results and Discussion.*** We obtained absorption, excitation, and luminescence spectra of aqueous solutions 1 mg/ml of nucleotides, their components, and mixtures with mannitol (in ratio 1:4). We observed a change in the ratio between the peaks of the spectra of acidic and salt forms of nucleotides. The presence of mannitol practically did not affect the absorbance of most samples (except for cytosine). At the same time, the addition of D-mannitol could significantly change the appearance of the excitation, emission, and phosphorescence spectra of the samples. For example, the addition of D-mannitol changed the excitation spectrum of uridine monophosphate in its acidic form, as shown in the Figure.

It indicates the presence of low-affinity interactions between nucleotide molecules and mannitol and the possible formation of complexes. At the same time, the interaction with D-mannitol was different for nucleotides of acidic and salt forms.

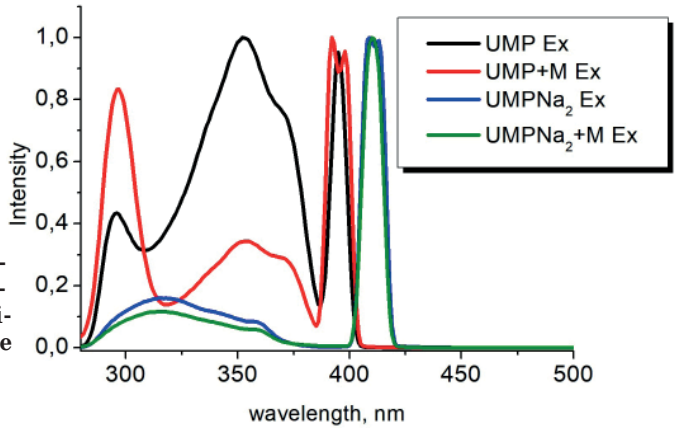


*Fig.* **Normalized excitation spectra of uridine monophosphate in acidic form (UMP), uridine monophosphate in acidic form with D-mannitol (UMP+M), uridine monophosphate in salt form (UMPNa2), uridine monophosphate in salt form with D-mannitol (UMPNa2+M)**

***Conclusions.*** Thus, our observations confirm that nucleotides, nucleosides, and nucleic acid bases exhibit luminescence at room temperature, which may be useful information for further research in this area. A comparative analysis of the spectra showed possible interactions between nucleotide molecules and mannitol as well.

***Key words:*** nucleic acids, luminescence, mannitol.

*Authors' contribution.* Conceptualization, Z.T.; methodology, R.N.; software, R.N.; validation, R.N.; formal analysis, R.N..; investigation, M.D. and R.N.; resources, Z.T.; data curation, R.N.; writing—original draft preparation, M.D. and R.N.; writing—review and editing, M.D., R.N. and Z.T.; visualization, M.D.; supervision, Z.T; project administration, Z.T.

*Funding source.* The work was carried out within the framework of the State budget theme of the Institute of Molecular Biology and Genetics National Academy of Sciences of Ukraine № 2.2.4.15 — "Study of the expression of innate immunity genes and their regulation in particularly dangerous viral diseases" (0121U112029).

## REFERENCES

1. *Nauta M., Peeters D. J., Van Doorslaer T. F. S., Badkar A. V., Darvari R., Warne N. W., Jean J., Hendrikse D. P. G., Sahin U., Güler A., Kuhn A., Muik A., Vogel A., Walzer K., Witzel S., Hein S., Türeci Ö.* Coronavirus vaccine. US *Patent* PCT/EP2021/060004. April 16, 2021.
2. *Snitserova O. M. Terent'yeva Y.G., Pogrebna A.V., Koval Ju. V., Yashchuk V. M.* The perspectives of using the luminescent methods in studying biological tissues for medical application. *Bulletin of Taras Shevchenko National University of Kyiv Series Physics & Mathematics* 2013, 4: 275-280
3. *Terent'yeva Y.G., Snitserova O.M.* Room temperature fluorescence of adenosin. *Bulletin of Taras Shevchenko National University of Kyiv.* 2018, 1: 118–119
4. *Gryn D.V., Yashchuk V.M., Tkachuk Z.Yu.* Some peculiarities of spectral properties of various compounds of adenine nucleotide and polynucleotide. *Molecular Crystals and Liquid Crystals.* 2021, 717(1): 54–59. https://doi.org/10.1080/15421406.2020.1860528
5. *Yashchuk V.M., Kudrya V.Yu.* The spectral properties of DNA and RNA macromolecules at low temperatures: fundamental and applied aspects. *Methods Appl. Fluoresc.* 2017, 5: 014001. https://doi.org/10.1088/2050-6120/aa50c9
6. *Yashchuk V. M., Losytskyy M.Yu, Lebedyeva I. V., Ohulchanskyy T. Y., Piryatynskyy Yu P., Navozenko O. M. & Vretik L.O.* Some peculiarities of electronic and vibronic excitations transfer in organic media and hybrid nanosystems. *Molecular Crystals and Liquid Crystals.* 2020, 696(1): 3–14. https://doi.org/10.1080/15421406.2020.1731075
7. *Borresen H.C.* On the luminescence properties of some purines and pyrimidines. *Acta ChemicaScandinavica.* 1963, 17(4): 921–929
8. *Tkachuk Z. Yu.* Multiantivirus compound, composition and method for treatment of virus diseases. US *Patent* 8,420,617,B2. April 16, 2013.
9. *Yashchuk V.M., Kudrya V.Yu., Levchenko S.M., Tkachuk Z.Yu., Hovorun D.M., Mel'nik V.I., Vorobyov V.P., Klishevich G.V.* Optical Response of the Polynucleotides-Proteins Interaction. *Molecular Crystals and Liquid Crystals.* 2011, 535 (1): 93–110. https://doi.org/10.1080/1542140.2011.537953