DSC STUDY OF NUCLEIC ACID DNA IN THE DRY AND HYDRATED STATES

By F. Jaroszyk and A. Pilawski

Biophysics Department, Medical Academy, Poznań*

(Received February 22, 1980)

Desoxyribonucleic acid DNA, dry as well as hydrated, was studied by DSC from room temperature to about +150°C. In dry DNA the reactions of decomposition occur in the +50°C to +100°C range, whereas in hydrated DNA in the range from +50°C to +130°C. Compared to dry DNA, hydrated DNA has a transition temperature higher by about 22°C. The present results convey information on the stabilizing action of water on the DNA conformation.

PACS numbers: 87.15.By, 82.60.Cx

1. Introduction

Certain results [1–3] led to attribute ferroelectric properties to the sodium salt of desoxyribonucleic acid DNA in solid state. Others [6, 7] suggested the presence of ferroelectric properties in the sodium salt of ribonucleic acid RNA as well. In this paper, we shall be dealing with the sodium salt of DNA only.

2. Experimental and discussion of the results

Refs [8, 9] permit the conclusion that nucleic acid is closely related with processes of memory in mammals and platyhelminths. Consequently, it is necessary to determine with accuracy in the first place those physical, chemical and physiological properties which are involved in the processes of information storage. It can be stated that the physical properties of solid DNA, though exhibiting some similarities with the phenomenon of ferroelectricity in dielectrics, are as yet insufficiently clarified and require further study [4,5]. It is worth noting that, in ferroelectrics, the state of polarization can be defined as memory of the electrical "history" of the material. The last remark is essential from the viewpoint of information storage mechanisms.

* Address: Zakład Biofizyki, Akademia Medyczna, Fredry 10, 61-701 Poznań, Poland.

Highly interesting are, as well, the interactions of water and DNA biopolymers. It is presumed that structural water, rigidifying the DNA conformation protects, as it were, the DNA molecules from the destructive action of the surrounding medium.

The evolutive cycle of the cell involves various degrees of its hydration. Changes in the hydration degree modify the forces of Coulomb bonding in the DNA, so that in the appropriate phase of uncoiling of the DNA spiral a change in hydration can facilitate the process of replication of the cell.

The present authors proceeded to a temperature-dependent study of the decomposition reaction of dry and hydrated DNA applying the method of DSC. Dry and hydrated DNA was enclosed hermetically in small aluminium crucibles. The investigation was

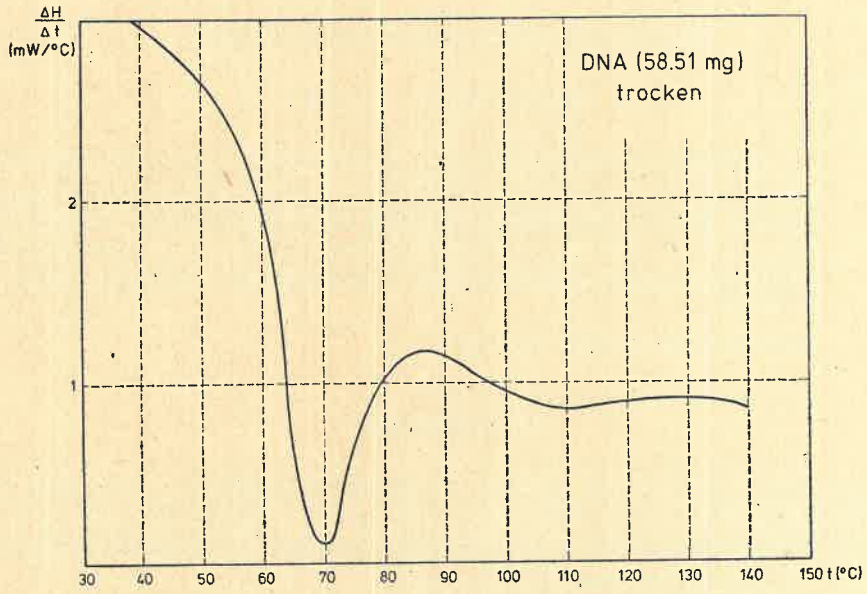

Fig. 1. DSC curve for dry DNA. $\Delta H/\Delta t$ — change in enthalpy per 1°C

performed with a device of the Mettler-TA 2000 A type. Fig. 1 shows, as an example, the DSC curve of dry DNA. Its analysis shows that, in dry DNA, the decomposition reaction takes place in the temperature range from +50°C to +100°C. In this range, the specific heat of DNA changes. The extremum of the specific heat variation is observed at +70°C. Fig. 2 shows the DSC curve for hydrated DNA (32.43 mg DNA + 10.62 mg water). In hydrated DNA, the decomposition reaction occurs in the range from +50°C to +130°C. The extremum of the specific heat variation lies at +92°C. The change in enthalpy ΔH per unit mass of hydrated DNA corresponding to the decomposition reaction amounts to 26.2 J/g.

Fig. 3 shows the DSC curve for hydrated DNA which, on cooling to room temperature, was heated again. Here, residual minima of the DCS curve are observed at +45°C and at +143°C.

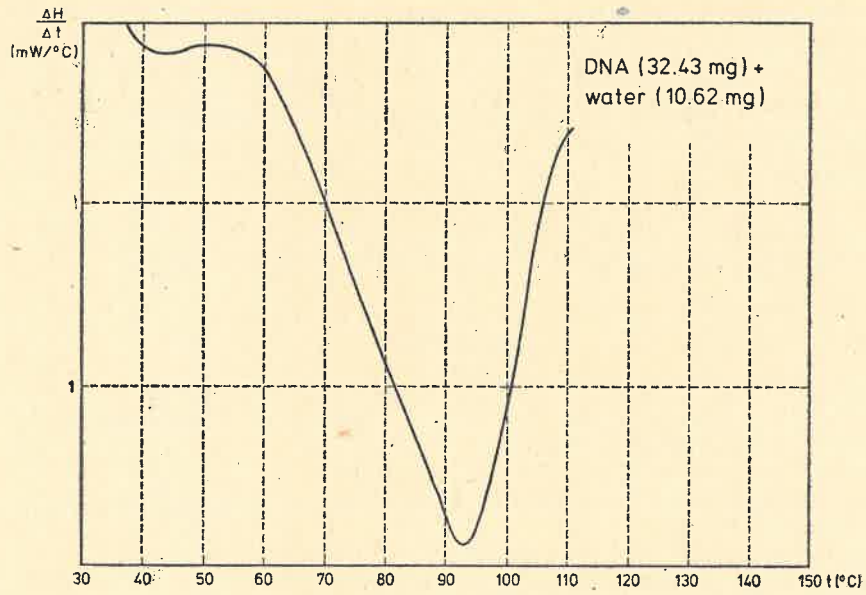

Fig. 2. DSC curve for hydrated DNA (32.43 mg DNA+10.62 mg water). $\Delta H/\Delta t$ — change in enthalpy per 1°C

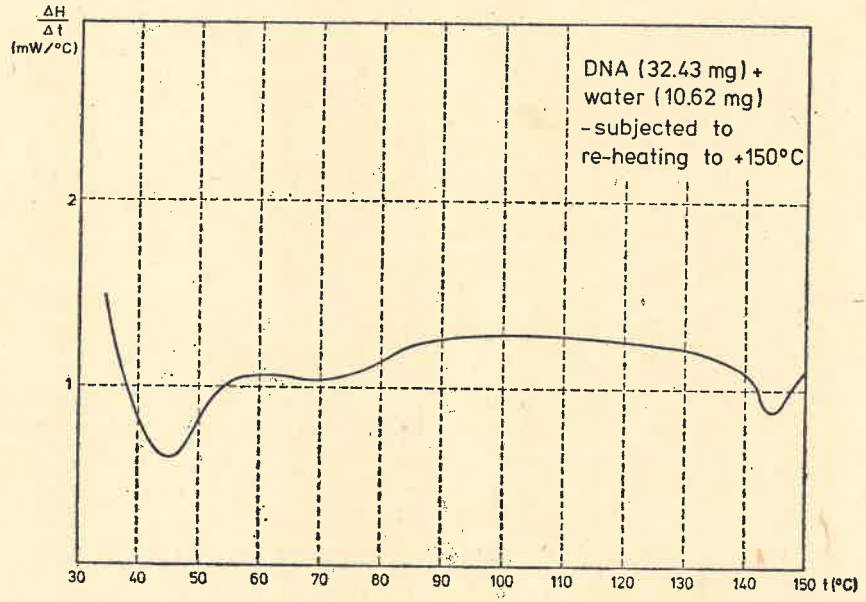

Fig. 3. DSC curve for hydrated DNA (32.43 mg DNA + 10.62 mg water), subjected to re-heating to +150°C. $\Delta H/\Delta t$ — change in enthalpy per 1°C

When analyzing the shape of the DSC curves (Fig. 1 and Fig. 2) of DNA in the range of the extremal variations of its specific heat one notes a strong similarity with the shape of the temperature-dependent changes in specific heat of ferroelectrics near their Curie point. The transition temperature of hydrated DNA is shifted upwards by about 22°C compared to that of dry DNA. This shows that the action of water is rigidifying and stabilizes the DNA conformation.

The authors wish to thank Mr. K. Vogel, of Mettler Instruments AG, Greifensee — Zürich, Switzerland, for kindly making available the TA-2000 A device.

REFERENCES

[1] J. Polonsky, P. Douzou, Ch. Sadron, *C. R. Acad. Sci.* **250**, 3414 (1960).
[2] P. Douzou, J. Franc, J. Polonsky, Ch. Sadron, *C. R. Acad. Sci.* **251**, 976 (1960).
[3] P. Douzou, Ch. Sadron, *Adv. Chem. Phys.* **7**, 339 (1964).
[4] A. Pilawski, *Acta Phys. Pol.* **A55**, 859 (1979).
[5] A. Pilawski, F. Jaroszyk, Proc. of the II Natl. Conf. of Biophysicists, University of Łódź, Uniejów 1976 (in Polish).
[6] J. W. Zemp, *Proc. Natl. Acad. Sci. USA* **55**, 1030 (1964).
[7] A. L. Stanford, L. A. Lorey, *Nature* **219**, 1250 (1968).
[8] W. C. Corning, E. R. John, *Science* **134**, 1363 (1961).
[9] H. Hyden, E. Egyhazi, *Proc. Natl. Acad. Sci. USA* **52**, 1090 (1964).