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DNA Melting Induced by Alcohols: Role of the Solvent Properties.

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Summary. — The isothermal denaturation of calf thymus DNA, induced by the presence of some monohydric alcohols in the solution, was investigated. Measurements were performed at a temperature (67.2 °C) at which the denaturation, in the absence of alcohols, is about 20% and melting profiles at varying temperatures were also recorded. Results show that with increasing alcohol concentration and alkyl group size DNA denaturation first reaches a maximum and then falls back. This behaviour, ascribed to « unusual » water properties as inferred also from compressibility measurements, indicates that hydrophobic and electrostatic effects are connected in a complex way.

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1. – Introduction.

Among the forces that stabilize the helical conformation of DNA a relevant role is played by DNA-solvent interactions (1). In particular, it has been reported by several authors that the presence of alcohols in the solution medium lowers the temperature at which the helix-coil transition of DNA takes place (2-5). Since sugars in nucleic acids are exposed to the solvent both before and after denaturation, one might assume that the effects of the alcohols are not largely responsible for the variations of the free energy of interaction between the DNA sugars and the perturbed solvent. Rather one could, in principle, attribute such perturbing effects 1) to the varied electrostatic free energy of charged groups due to the lowering of the bulk dielectric constant of the solvent; 2) to the modified free energy necessary to transfer the DNA bases from the interior of the double helix to the solvent. It must, however, be considered that the transfer of a base from the interior of the double helix to the bulk solvent brings about two different contributions: *a*) the free energy associated with the hydrophobic moieties of the purine and pyrimidine bases; *b*) the free energy related to the polar moieties of the bases when they break hydrogen bonds with complementary bases and form new hydrogen bonds with the polar molecules of the solvent. Furthermore, the role of hydration on the stability of DNA should also be considered since it is known that the DNA conformation is strongly affected by water activity (6) which, in turn, is determined by the amounts of dissolved ions and alcohols. In the present paper we have studied the isothermal denaturation and the melting profiles of calf thymus DNA, induced by the presence of increasing concentrations of methanol, ethanol, isopropanol and *n*-propanol. We have also measured isothermal compressibilities of alcohol-water mixtures in order to obtain information about the properties of the solvent and gain some insight on their action on DNA stability.

2. – Materials and methods.

Calf thymus DNA (type I) and nuclease S_1 were from Sigma (St. Louis, Mo.), methanol, ethanol, isopropanol and *n*-propanol from Carlo Erba (Milano) or

(1) H. EDELOCH and J. C. OSBORNE jr.: *Adv. Protein Chem.*, **30**, 183 (1976).
(2) T. T. HERSKOVITZ, S. J. SINGER and E. P. GEIDUSCHEK: *Arch. Biochem. Biophys.*, **94**, 99 (1961).
(3) E. P. GEIDUSCHEK and T. T. HERSKOVITZ: *Arch. Biochem. Biophys.*, **95**, 114 (1961).
(4) T. T. HERSKOVITZ: *Arch. Biochem. Biophys.*, **97**, 474 (1962).
(5) L. LEVINE, J. A. GORDON and W. P. JANCKS: *Biochemistry*, **2**, 168 (1963).
(6) B. WOLF and S. HANLON: *Biochemistry*, **14**(8), 1661 (1975).

from ANALAR BDH (Poole, England). KB-3 medium was (Na-acetate 0.15 M, $ZnSO_4$ $3 \cdot 10^{-3}$ M, NaCl 0.5 M, CH_3COOH 0.26 N) (*p*H 4.5).

2·1. *Preparation of* DNA *stocks.* – DNA stocks used in isothermal denaturation experiments were prepared by dissolving DNA fibres at a final concentration of about 100 μg/ml into phosphate buffer 10^{-2} M (*p*H 7.4) and shaking for about 50 h at 30 °C. To 50 ml of this DNA solution were added 12.5 ml of KB-3 medium and 50 units of nuclease S_1. This solution was first shaken for 24 h at 30 °C and then exhaustively dialyzed against a solution of phosphate buffer $4 \cdot 10^{-2}$ M (*p*H 7.4) + EDTA 10^{-4} M. The treatment with single strand specific nuclease was necessary in order to obtain fully reversible denaturation processes in the presence of alcohols. DNA stocks used for melting profiles were dissolved into phosphate buffer $4 \cdot 10^{-2}$ M (*p*H 7.4) and immediately stored at 4 °C.

2·2. *Preparation of* DNA *samples.* – Just before the preparation of DNA samples used in isothermal denaturation experiments, water and DNA aliquots were separately and quickly outgassed. This treatment was necessary in order to avoid the formation of bubbles during the measurements. DNA samples (25 μg/ml) were prepared at room temperature by first making suitable alcohol-water solutions and then adding with very gentle shaking aliquots of DNA stocks. Using the above DNA stocks, results were the same as if samples were prepared by adding alcohol dropwise to suitable DNA solutions; the final concentration of phosphate buffer was 10^{-2} M (*p*H 7.4 in H_2O). DNA samples used in the determination of melting temperatures were prepared by diluting aliquots of DNA stocks into double distilled water. Suitable quantities of alcohol were then added drop by drop; the ionic strength of the solution was adjusted with NaCl (BDH, Poole, England) to the desired value. The final DNA concentration was 20 μg/ml.

2·3. *Measurements.* – In order to measure isothermal denaturation, samples prepared at room temperature in teflon stoppered cuvettes were placed into the cell holder of a Cary 118 spectrophotometer thermostated at 67.2 °C. The variation of absorbance ($\lambda = 260$ nm) was then followed (fig. 1). The complete denaturation was measured by inserting the DNA samples into the cell holder thermostated at $T \geqslant 90$ °C. Buffer-alcohol solutions at the same alcohol concentration as that of the sample were used on the reference beam of the spectrophotometer. The temperature was measured by using a platinum thermometer calibrated against a similar one having a NBS certificate and inserted in a Leeds-Northrup precision bridge. The cell holder was thermostated within less than 0.1 C. The samples employed when measuring melting profiles were prepared at room temperature and placed into a rotating multiple-cell holder designed for absorbance measurements of 4 different samples without

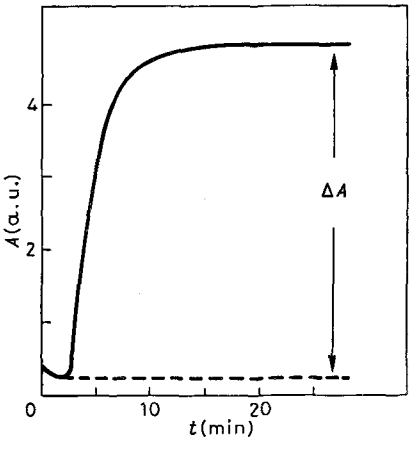

Fig. 1. – Typical absorbance at 260 nm of a DNA sample during heating from room-temperature to 67.2 °C.

removing the cells. The temperature was raised very slowly (1 °C every ten minutes) and the cell holder was thermostated to within $\pm$ 0.01 °C. The absorbance at 260 nm was measured at 1 °C intervals on a Perkin-Elmer 555 spectrophotometer.

2·4. *Analysis of the melting profiles.* – Several melting profiles, such as those reported in fig. 2, were determined in order to obtain both melting temperature (T_m) values and ΔH, ΔS. T_m was estimated from a graph of absorbance *vs.* temperature and by taking the midpoint of the transition with standard procedures (7) which take into account the extrapolation of the base lines at low and high temperatures. The equilibrium constant of the transition was defined as $K_{eq} = (1 - f)/f$, where f is the fraction of double stranded DNA as obtained from absorbance data. The enthalpy ΔH_m at the melting temperature was derived from the slope of the transition according to (7)

$$\Delta H_m = -4RT_m^2 \, \mathrm{d}f/\mathrm{d}T|_{T_m}$$

and ΔS_m from

$$\Delta S_m = \Delta H_m/T_m \quad \text{since} \quad \Delta G(T_m) = 0 .$$

2·5. *Measurement of adiabatic compressibilities.* – The sound velocity was measured using a variable-path interferometer working at 2 MHz. Measurements were performed at 20 °C; the temperature was controlled within $\pm$ 0.05 °C. The measurements of sound velocity were reproducible within $\pm$ 1 m/s. From

(7) C. R. CANTOR and P. R. SCHIMMEL: in *Biophysical Chemistry*, Vol. **3** (Freeman, San Francisco, Cal., 1980), p. 1199.

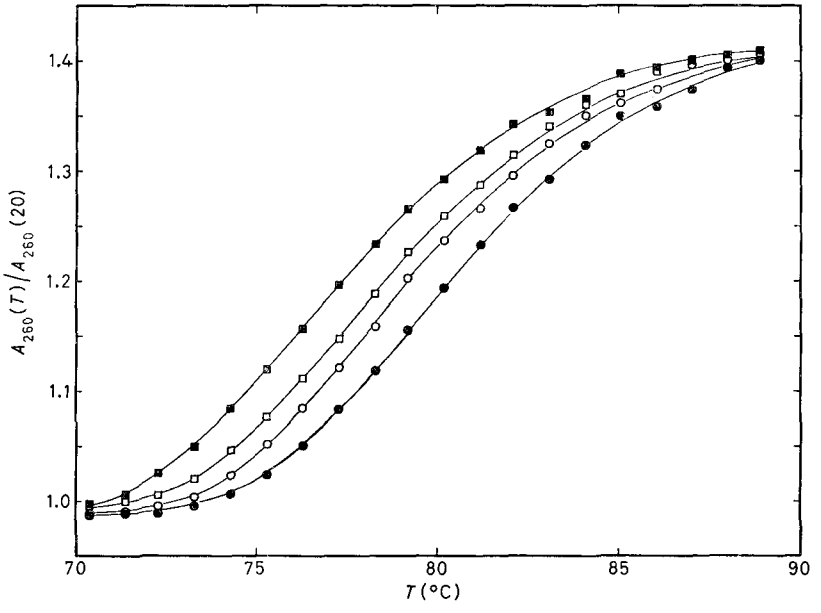

Fig. 2. – Typical melting profiles of calf thymus DNA (20 μg/ml) in the presence of different alcohols: • methanol, ○ ethanol, ■ *n*-propanol, □ isopropanol. The alcohol concentration is 5% volume fraction; $\mu = 0.1$ M NaCl.

the values of sound velocity v and density ϱ, the adiabatic compressibility has been calculated by means of the relation

$$\beta = 1/v^2\varrho \,.$$

The densities used to calculate β from velocity measurements have been taken from available literature data ([8]).

3. – Results and discussion.

3·1. *Results.* – The experiments on isothermal denaturation were carried out at 67.2 °C, a temperature corresponding, in our conditions, to 20% DNA denaturation in the absence of alcohols and at ionic strength $\mu = 0.010$. A typical curve is reported in fig. 1, where the optical density ($\lambda = 260$ nm) of the sample is plotted *vs.* time. We ascribe the initial decrease of the absorbance in fig. 1 to thermal expansion of the solution. In the present paper we shall call

([8]) *Handbook of Chemistry and Physics*, 65th edition (1984-1985).

1) $\Delta A(C_a)$ the difference between the asymptotic and the minimum absorbance value (see fig. 1) in the presence of alcohol at a concentration C_a.

2) $\Delta A_{max}(C_a)$ the analogous quantity measured at a temperature at which the DNA samples are completely denatured.

In fig. 3 are reported isothermal denaturation curves of calf thymus DNA, induced by the presence of different alcohols. In fig. 4 are shown the melting temperatures as obtained from data such as those of fig. 2. We should recall that DNA melting occurs stepwise because of the existence of domains each with a melting temperature occurring in a narrow range ([9,10]). Here, however, we observe average values of the thermodynamic quantities since we do not resolve the single domains.

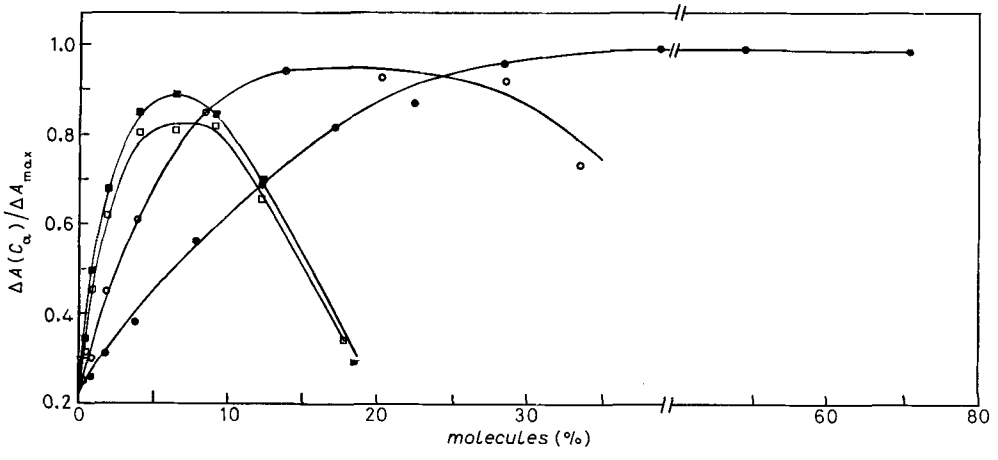

Fig. 3. – Denaturation of calf thymus DNA (25 μg/ml) at 67.2 °C *vs.* alcohol concentration. Phosphate buffer 10^{-2} M (*p*H 7.4); symbols are the same as in fig. 2.

These data show that

1) At low alcohol concentration T_m lowers when alcohol concentration increases; consistently, the fraction of denatured DNA increases; the effect is more pronounced for the heavier alcohols, the branched alcohol isopropanol being slightly less effective denaturant than *n*-propanol.

2) In the case of methanol, when increasing alcohol concentration, T_m keeps decreasing, whereas, for the other alcohols, it reaches a maximum and then falls back.

([9]) W. S. YEN and R. D. BLAKE: *Biopolymers*, **19**, 681 (1980).
([10]) R. D. BLAKE, F. VOSMAN and C. E. TARR: in *Biomolecular Stereodynamics* I, edited by R.H. SHARMA (Plenum Press, New York, N. Y., 1981), p. 439.

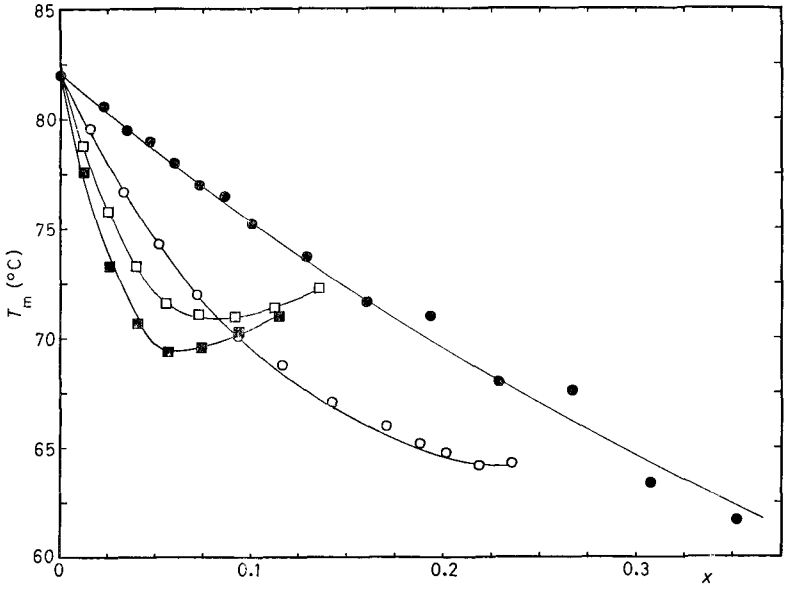

Fig. 4. – Melting temperatures of calf thymus DNA (20 μg/ml) *vs.* alcohol concentration; $\mu = 0.1$ M NaCl; symbols are the same as in fig. 2.

3·2. *Electrostatic interactions.* – The alcohol-induced DNA destabilization could be ascribed to the increased electrostatic repulsion among the phosphate groups of the helix, due to the lowering of the bulk dielectric constant which is caused by the presence of alcohols in the solution. Effects related to the decrease of the bulk dielectric constant upon addition of alcohols have been shown for the $T \rightarrow R$ transition of hemoglobin, where at low alcohol concentration the effects caused by the presence of alcohols seem to be related to the varied interaction energy among charges on the protein surface, due to the lowering of the dielectric constant ([11,12]). In order to ascertain whether the above effects are relevant also for the DNA denaturation induced by alcohols, we have drawn the plot in fig. 5, where the same data of fig. 3 are reported against the inverse bulk dielectric constant of the solvent. The values of the solution dielectric constant in fig. 5 have been obtained by using the following expression:

$$\varepsilon(C_a) = a(C_a) \exp [b(C_a) T] ,$$

([11]) L. CORDONE, A. CUPANE, P. L. SAN BIAGIO and E. VITRANO: *Biopolymers*, **18**, 1975 (1979).
([12]) E. VITRANO, A. CUPANE and L. CORDONE: *J. Mol. Biol.*, **180**, 1157 (1984).

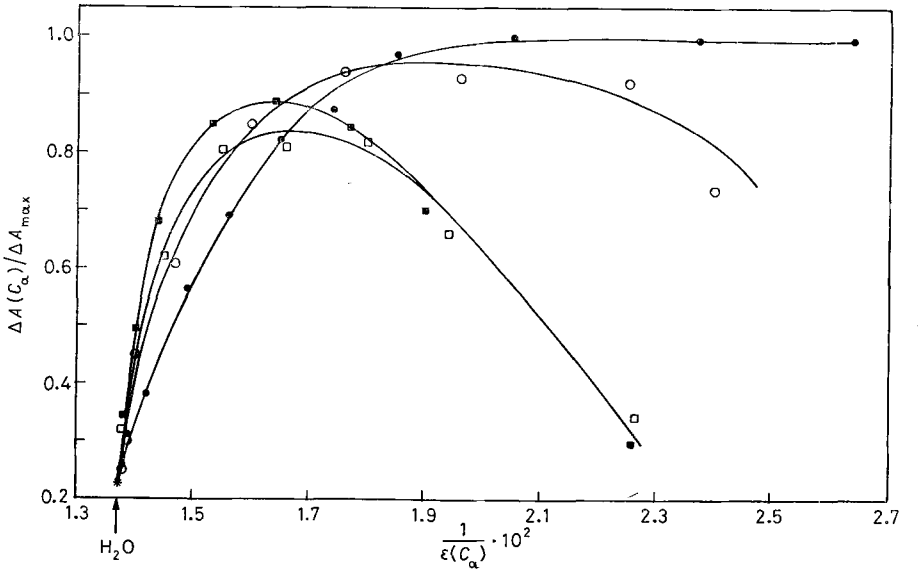

Fig. 5. – Denaturation of calf thymus DNA (25 μg/ml) *vs.* the inverse bulk dielectric constant of the solution; symbols are the same as in fig. 2.

the parameters $a(C_a)$ and $b(C_a)$ have been obtained by interpolation of the data reported in ref. ([13]).

If the most relevant contribution to the destabilization of the double helix is to be related to the lowering of the solvent bulk dielectric constant, curves corresponding to different alcohols should overlap in this plot. An inspection of the curves reported in fig. 5 indicates that this does not happen for the reported results and that, therefore, the effects we measured are not dominated by the variation of the bulk dielectric constant; furthermore, it must be noted that, instead, according to the theory of Manning and Record ([14,15]), an opposite behaviour, increased stability, should be expected. In fact, following the approach of Record *et al.* ([15]) for the dependence of the melting temperature on the ionic strength μ, we obtain for the reaction

$$\text{double helix} \longrightarrow \text{single strand}$$

$$1)\quad \partial \ln K/\partial\varepsilon = (kT/2e^2)[(b_s - b_d)(1 + \ln \mu) - 2(b_s \ln \chi b_s - b_d \ln \chi b_d)] \simeq -0.01$$

and

$$2)\quad \partial T_m/\partial\varepsilon = (RT_m^2/\Delta H^0)\, \partial \ln K/\partial\varepsilon\,,$$

([13]) G. AKERLOF: *J. Am. Chem. Soc.*, **54**, 4125 (1932).
([14]) G. S. MANNING: *Q. Rev. Biophys.*, **11**, 179 (1978).
([15]) M. T. RECORD jr., C. F. ANDERSON and T. M. LOHMAN: *Q. Rev. Biophys.*, **11**, 103 (1978).

where χ is the reciprocal of the Debye screening length and b_d, b_s refer to the charge spacing in the double helix and in the single strand, respectively. The two terms in the r.h.s. of eq. (1) are due to counterion condensation effects and to the screened repulsion among DNA charges, respectively. The leading term is the second one which is about three times larger than the first and negative. Since ΔH^0 must be positive, see *e.g.* ref. ([15]), one has that the expected $\partial T_m/\partial \varepsilon$ should be negative, whereas the above measures show the opposite behaviour.

3·3. *Hydrophobic effects.* – The fact that the more hydrophobic alcohols at low concentration are more efficient in decreasing the melting temperature suggests that hydrophobic effects may play an important role in determining the thermal stability of DNA ([16]). The relevance of hydrophobic interaction on biomolecule stability has already been reported for the $T \rightarrow R$ transition of hemoglobin, whereby it has been shown that the presence of alcohols decreases the free energy needed to expose apolar surfaces to the aqueous solvent ([11,12]). Accordingly, the destabilization brought about by alcohols in DNA might be ascribed to the lower free energy required to expose the hydrophobic moieties of the bases to the solvent. In order to test this hypothesis, we have determined the thermodynamic parameters ΔG, ΔH and ΔS associated with the melting. Indeed, if hydrophobic interactions would play a major role when alcohols affect the DNA stability, one should find a behaviour similar to that already reported for the $T \rightarrow R$ transition of hemoglobin ([17]). Such parameters are reported in table I. As can be seen, the values of the thermodynamic parameters seem to indicate that DNA-solvent hydrophobic interactions do not play a dominant role in the melting. Indeed

1) The exposure of the apolar moieties of the bases to the solvent is expected to require less entropy changes when alcohols are present in solution, since alcohols are known to be efficient in ordering water molecules. Consequently we expect that $\Delta S(X) - \Delta S(0) = \Delta\Delta S > 0$, since $\Delta S(X)$ and $\Delta S(0)$ are both negative, but $|\Delta S(X)| < |\Delta S(0)|$. Furthermore, $\Delta\Delta S$ should increase with the number of carbon atoms in the alcohol molecules, the heavier alcohols being more efficient as structure makers ([18]). The results presented above display, instead, $\Delta\Delta S \sim 0$ for methanol and ethanol and $\Delta\Delta S < 0$ for the propanols.

([16]) L. CORDONE, A. CUPANE, M. A. DOLCE, S. L. FORNILI, P. L. SAN BIAGIO, G. SGROI E. VITRANO: in *Developments in Biophysical Research*, edited by A. BORSELLINO, P. OMODEO, R. STROM, A. VECLI and E. WANKE (Plenum Press, New York, N. Y., 1980), p. 259.

([17]) L. CORDONE, A. CUPANE, P. L. SAN BIAGIO and E. VITRANO: *Biopolymers*, **20**. 53 (1981).

([18]) F. FRANKS and D. J. G. IVES: *Q. Rev. Biophys.*, **20**, 1 (1966).

TABLE I. – *Excess thermodynamic functions* $\Delta\Delta H$ *and* $\Delta\Delta S$ *associated with the melting referred to* 5% *alcohol molar fraction at* 0.01 *and* 0.10 *ionic strength.* $\Delta\Delta H$ and $\Delta\Delta S$ are defined as $\Delta\Delta H = \Delta H(C_a) - \Delta H(H_2O)$, $\Delta\Delta S = \Delta S(C_a) - \Delta S(H_2O)$. Enthalpies are expressed in kcal/mol, entropies are in cal/mol K.

	$\mu = 0.01$ M	$\mu = 0.1$ M
$\Delta H(H_2O)$	66 $\pm$ 1	85 $\pm$ 1
$\Delta\Delta H$(met)	3.5 $\pm$ 1	2 $\pm$ 1
$\Delta\Delta H$(et)	8 $\pm$ 1	2 $\pm$ 1
$\Delta\Delta H$(isopr)	2.5 $\pm$ 1	$-$ 5.5 $\pm$ 1
$\Delta\Delta H$(*n*-pr)	$-$ 2.5 $\pm$ 1	$-$ 11.5 $\pm$ 1
$\Delta S(H_2O)$	198 $\pm$ 4	242 $\pm$ 4
$\Delta\Delta S$(met)	10 $\pm$ 4	5 $\pm$ 4
$\Delta\Delta S$(et)	27 $\pm$ 4	$-$ 2.5 $\pm$ 4
$\Delta\Delta S$(isopr)	12.5 $\pm$ 4	$-$ 13 $\pm$ 4
$\Delta\Delta S$(*n*-pr)	$-$ 3.5 $\pm$ 4	$-$ 27 $\pm$ 4

2) From table I we see that $T_m|\Delta\Delta S| \sim |\Delta\Delta H|$ with $|\Delta\Delta H|$ slightly larger than $T_m|\Delta\Delta S|$, in agreement with the observed $\Delta T_m < 0$. This finding seems to rule out the typical hydrophobic effects since $\Delta\Delta S$ does not prevail ([19]).

Finally, the different behaviour of $\Delta\Delta H$ and $\Delta\Delta S$ at different ionic strengths seems to suggest that other mechanisms are effective in the melting process.

3·4. *Role of alcohols on the activity of water.* – In this context it appears instructing to examine the thermodynamic properties of alcohol-water mixtures ([18,20]); both the mixing enthalpy and excess entropy are negative with minima occurring in the water-rich region at values of the alcohol molar fraction surprisingly close to those at which the melting temperatures change their trends. Although it has recently been shown ([21]) that alcohol molecules are not found in the close proximity of the DNA phosphates, it is not unreasonable to expect a strong modification of the water structure around DNA induced by alcohols. It has, in fact, been suggested by several authors that the stability of DNA is controlled by the degree of its hydration; this, in turn, is controlled by the activity of water which depends upon the presence of ions and cosolvents such as alcohols. Furthermore, the water activity might play an important role on the binding of counterions to the phosphates by controlling the degree of ionic hydration as well as the ion activity in the bulk solution.

For what concerns the behaviour of the melting (see fig. 3 and fig. 4) we

([19]) C. TANFORD: *The Hydrophobic Effect* (Wiley, New York, N. Y., 1973).
([20]) F. FRANKS: in *Water: a Comprehensive Treatise*, Vol. **4**, edited by F. FRANKS (Plenum Press, New York, N. Y., 1975).
([21]) D. B. LERNER, W. J. BECKTEL, R. EVERETT, M. GOODMAN and D. R. KEARNS: *Biopolymers*, **23**, 2157 (1984).

note that T_m inversion occurs at values of X at which also the thermodynamic parameters of alcohol-water mixtures exhibit changes in their trend. Such phenomena have been attributed to « micellization » of the alcohols in water ([22,23]); this effect could be seen as responsible of water release when « micellization » occurs, leading to an inversion of the trend of water activity and, consequently, to a restabilization of the duplex due to this rehydration. Work in progress on the $B \rightarrow C$ transition under the influence of ions and alcohols supports these views since, when the critical values X are reached, the transition displays an inverted trend that can be attributed to rehydration of the helix ([6]).

In order to test this hypothesis we have performed detailed measurements of the adiabatic compressibility of alcohol-water mixtures in the concentration range $0 < X < 0.2$. The adiabatic compressibility in a liquid binary mixture is a function of composition and strongly depends on the nature and intensity of molecular interactions ([24]). Compressibility measurements become then apt to yield information, at least in a qualitative way, on the nature of the inter-

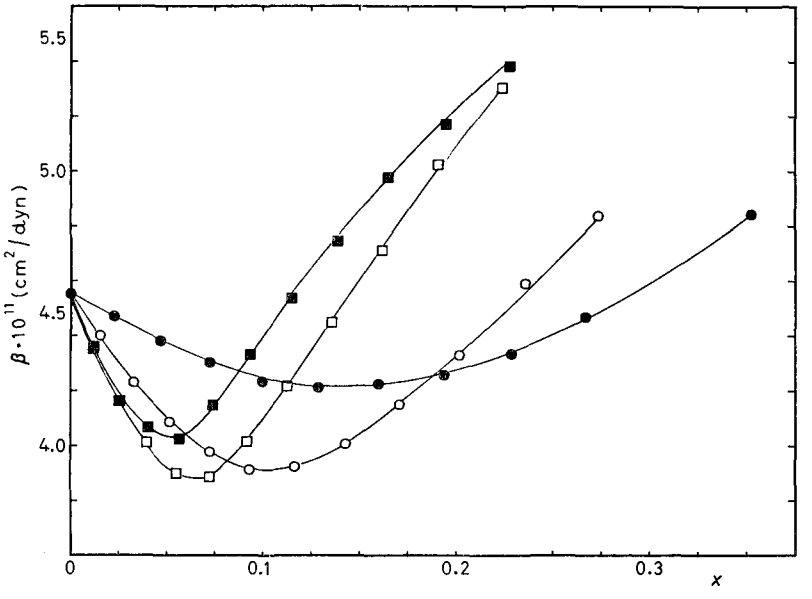

Fig. 6. – Compressibility of alcohol-water mixtures as a function of the alcohol concentration; symbols are the same as in fig. 2.

([22]) G. ROUX, D. ROBERTS, G. PERRON and J. E. DESNOYERS: *J. Solution Chem.*, **9**(9), 629 (1980).
([23]) J. LARA and J. E. DESNOYERS: *J. Solution Chem.*, **10**(7), 465 (1981).
([24]) D. SETTE: in *Handbuch der Physik*, Vol. **11**(1), edited by S. FLUGGE (Springer-Verlag, Berlin, 1961), p. 275.

actions that the molecules of the system exchange ([22,25]). The compressibility β of alcohol-water mixtures is also found « anomalous » (see fig. 6). The $\beta(X)$ curves indicate that, although the alcohols are more compressible than water, small additions of alcohol cause a decrease in the compressibility; the compressibility goes through a minimum at an intermediate composition X^* and then increases with increasing X. The position of the minimum X^* is different for different alcohols, being smaller for the heavier alcohols. It is reasonable to assume that the observed behaviour is due to an initial reinforcement of water-water interactions at low X due to the addition of cosolvents, followed at $X > X^*$ by a structure-breaking action due to (dynamic) « micellization » of alcohols in water ([22,23]). The effect increases with increasing alkyl group size of the organic cosolvent; as an example, the slope $\mathrm{d}\beta(X)/\mathrm{d}X$ becomes more negative and the minimum in $\beta(X)$ occurs at lower molar fraction X^* of cosolvent, according to the sequence *n*-propanol, isopropanol, ethanol, methanol. The values of X^* are close to the ones at which the melting temperatures of DNA change their trend, indicating that DNA conformational stability is closely linked with the properties of the solvent.

4. – Conclusions.

The above discussion leads to the following remarks: electrostatic and hydrophobic effects, perhaps occurring simultaneously, are probably of the same order of magnitude and, therefore, hard to separate in the case of DNA denaturation. The complexity of the melting curves at high alcohol concentrations is certainly to be ascribed to the unusual properties of the solvent as suggested from data such as the compressibility of alcohol-water mixtures and salt-water mixtures ([22]). We note, however, that DNA in alcohol-water solutions displays a behaviour which parallels the hydration of small cations in the same solutions, as inferred from mobility data ([26]). This result is not unexpected since DNA is a polyelectrolyte with a strong electric interaction $e^2/\varepsilon b$ which is greater than the thermal energy kT. This effect leads to the « condensation » of hydrated counterions ([27]). The hydration of DNA seems then to be dominated by the electrostrictive interaction between DNA and water (whose activity is controlled by the alcohol concentration); therefore, the melting might reflect these interactions.

When considering lower alcohol concentration, which one expects to be associated with a simpler water structure, still there occur difficulties for a

([25]) O. CONDE, J. TEIXEIRA and P. PAPON: *J. Chem. Phys.*, **76**(7), 3747 (1982).
([26]) R. L. KAY: in *Water: a Comprehensive Treatise*, Vol. **4**, edited by F. FRANKS (Plenum Press, New York, N. Y., 1975).
([27]) F. OOZAWA: in *Polyelectrolytes* (Dekker, New York, N. Y., 1971).

clear-cut interpretation of the data. We feel, however, that most of these difficulties could be dealt with by means of a procedure leading to isolation of two effects: 1) the electrostatic contribution which apparently describes the melting at changing ionic strength and 2) the hydrophobic hydration of DNA bases expected to be relevant in water alcohol mixtures (at low alcohol concentration). The strong thermal dependence of the intermolecular structure of water appears to be an obstacle toward a separation of hydrophobic and electrostatic effects in DNA melting process. Work is in progress in order to establish the role of temperature on the thermodynamics of DNA-solvent interaction.

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● RIASSUNTO

Si è studiata la denaturazione isoterma del DNA da timo di vitello indotta dalla presenza di quattro alcoli semplici in soluzione. Sono state eseguite sia misure a 67.2 °C, temperatura alla quale la frazione denaturata senza alcoli vale circa 20%, che profili di « fusione » a temperature variabili. I risultati mostrano che al crescere della concentrazione e del gruppo alchilico degli alcoli la denaturazione dapprima raggiunge un valore massimo e poi torna indietro. Questo comportamento, attribuito alle proprietà « insolite » dell'acqua come risulta anche da misure di compressibilità, indica che gli effetti idrofobici ed elettrostatici intervengono in modo complicato.

Плавление DNA, индуцированное спиртами. Роль свойств растворителей.

Резюме (*). — Исследуется изотермическая денатурация DNA тимуса, индуцированная наличием моногидридных спиртов в растворе. Измерения проводятся при температуре 67.2 °C, при которой денатурация в присутствии спиртов составляет около 20%. Также регистрируются профили плавления при различных температурах. Полученные результаты показывают, что при увеличении концентрации спирта и размера алкильной группы денатурация DNA сначала достигает максимума, а затем убывает. Это поведение, приписываемое свойствам « необыкновенной » воды, что получено также из измерений сжимаемости, указывает, что гидрофобные и электростатические эффекты связаны сложным образом.

(*) *Переведено редакцией.*