Formaldehyde as a radioprotector agent *

Formaldehido como agente radioprotector

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Many substances have been described as being radioprotector agents; none of them, including chemicals and biomolecules, contain the aldehyde function in their structure (Chemical Abstracts, 1955-1967 (1) and Radiation Research, 1954-1967) (2).

In this communication the radioprotective action of formaldehyde on aqueous DNA solution is described.

Samples containing DNA were prepared by dissolving 6 mg of highly polymerized salmon sperm DNA (Calbiochem) in 100 ml of bidistilled water.

In the testing samples, formaldehyde (Merck) was added to a final concentration of 2% (w/v). The solutions were irradiated with gamma rays, from a ^{137}Cs source (200 rad/min). Different doses were applied, the maximum being 48 x 10^4 rad.

RESULTS

As can be seen from Fig. 1, DNA irradiated in the presence of formaldehyde solutions is strongly protected against gamma radiation damage. This is the case even for solutions which had been submitted to heating and rapid cooling before the irradiation (denaturated).

In table I and II, the percentage of hydrolysis and destruction of native and denaturated irradiated DNA solutions are shown. These data indicate that the % of destruction for DNA solutions irradiated in the presence of formaldehyde is considerably smaller than that which occurs in solutions without formaldehyde. As an example, irradiation of native DNA with a total dose of 24 x 10^4 shows a value of O.D. at 260 μ of 0,081 for non protected DNA, and 1,522 for protected DNA. The last value is practically similar to the starting value before irradiation. In the experiments with denaturated DNA plus formaldehyde, we can see (table II) also a certain degree of hydrolysis of DNA, which is probably due to the reaction with formaldehyde, since the fraction hydrolyzed remains constant and is independent of the irradiation dose.

It is important to note that the absorbancy ratios (250/260, 270/260, 280/260 and 290/260), remain without change during irradiation.

We conclude from these data, that the formaldehyde protects both native and denaturated DNA from the damage induced by gamma radiation. This suggests that the protective action of formaldehyde is probably not related with a chemical reaction with the NH_2 groups of the bases and furthermore is independent of the secondary structure of DNA. The mechanism of radio protection could be assigned to a scavenger action of formaldehyde, on the free radicals induced by

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TABLE I

Radioprotection of native DNA by Formaldehyde

Dose (rads)	DNA			DNA + HCHO		
	Destroyed % *	Hydrolyzed** % *	Non destroyed % *	Destroyed % *	Hydrolyzed** % *	Non destroyed % *
0	0	0	100	0	0	100
$4 \cdot 10^4$	14	6.9	79	1.5	0	98
$8 \cdot 10^4$	30.4	8.9	61	1.5	0	98
$24 \cdot 10^4$	94.4	1.5	5	6.2	3.5	91
$48 \cdot 10^4$	94	1.5	4.2	8.2	6.7	86

* % were calculated from optical density values measured at 260 mμ.

** Hydrolyzed fraction was obtained from a column of DEAE cel. eluted with LiCl 0.025 M plus lithium acetate 0.0025 M.

TABLE II

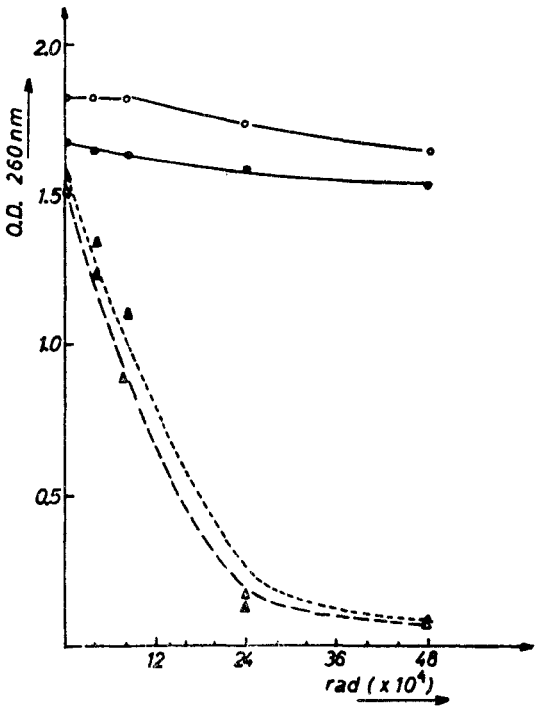
Radioprotection of denaturated DNA by Formaldehyde

Dose (rads)	DNA Destroyed % *	DNA Hydrolyzed** % *	DNA Non destroyed % *	DNA + HCHO Destroyed % *	DNA + HCHO Hydrolyzed** % *	DNA + HCHO Non destroyed % *
0	0	0	100	0	28	72
$4 \cdot 10^4$	19.5	4.1	76.5	0	27,5	72.4
$8 \cdot 10^4$	42.2	3.96	53.8	0	25.5	74.4
$24 \cdot 10^4$	88.4	0	11.3	5.8	32.7	61.6
$48 \cdot 10^4$	94.7	0.9	4.7	9	25.3	64.7

* and ** See Table I.

radiolysis of water. In this way formaldehyde could act as a trapper of oxygen, OH or peroxide radical, directly or indirectly through the formation of a radical of the type HC(O)OCH, able to release H, (Marx R. and Chatay). This idea could be supported by the finding that the pH decreases during irradiation from 6,7 to 4,4 in the denatured DNA solution, and from 4,1 to 3,1 in solutions of denaturated DNA plus formaldehyde indicating that there is a greater increase in H concentration in the latter conditions, due probably to trapping or recombination of OH.

Work is in progress in our laboratory to evaluate the importance of the aldehyde function as a radioprotector, its mechanisms and the possibility that other non toxic aldehydes, such as carbohydrates, could present the same properties.



Absorbancy of irradiated DNA solution, at 260 mμ. Black triangles, native DNA. White triangles, renatured DNA. Black circles, native DNA plus formalhehyde 2%. White circles, denatured DNA plus formaldehyde 2%.

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RESUMEN

Se describe la acción radioprotectora de la molécula de formaldehido para soluciones acuosas de DNA, irradiadas con rayos gamma de una fuente de ^{137}Cs.

Se sugiere que la radioprotección sería de tipo indirecto, ya que este efecto se evidencia tanto en el DNA nativo como en el denaturado. Por otra parte, el hecho que paralelamente a la radioprotección se produzca un mayor descenso del pH en las soluciones irradiadas en presencia de formaldehido, podría interpretarse como debido a una menor recombinación de H, con los OH, atrapados en este caso por el formaldehido activado.

Las razones de absorbancia 250/260, 270/260, 280/260 y 290/260, permanecen constantes durante la irradiación del DNA en presencia de formaldehido, lo que indicaría que la molécula de DNA mantendría su estructura.

REFERENCES

1.—CHEMICAL ABSTRACTS. — Vol. **49** (1955) to Vol. **66**, Nº 9, (1967).
2.—RADIATION RESEARCH. Vol. **1** (1954) to Vol. **30**, Nº 1, (1967).
3.—MARX, R. and CHATAY, Cl. — J. Chim. Phys. **58**, 527 (1961).