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Genetic Effects of Potassium Dichromate and Chromium Trioxide in *Drosophila melanogaster*

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Salts of hexavalent chromium compounds have been reported to be carcinogenic (Stefee and Baetjer 1965, Blokhin and Trop 1974) and mutagenic in many organisms from bacteria (Nishioka 1975, Petrilli and De Flora 1978) to humans (Stella *et al.* 1982).

In this paper we report the effects of two hexavalent chromium compounds, potassium dichromate and chromium trioxide on sex-chromosome loss, non-disjunction and sex-linked recessive lethals in *Drosophila melanogaster*.

Materials and methods

The genetic scheme designed by Oster (1958) was used: Oster females have the X chromosomes with y sc^{s1} Inv 49 sc^{8}, and Oster males have a ring X chromosome with *y* and *B* and the *Y* chromosome with a translocation of X chromosome and sc^{8} as maker (X^{c2} *yB*/sc^{8} Y). For the detection of sex-chromosome loss and non-disjunction were counted F_1 flies with the phenotype ++ and *B*+ for females and *yB* and *y* for males. For the detection of sex-linked recessive lethals one looks for the presence or absence of *B*+ eyes males in F_2.

No mutagenic effects were observed when the substances were administrated by feeding, so injection was used. 24–48 old males were injected intraperitonealy with 100, 200, 300 and 400 ppm concentrations of potassium dichromate ($K_2Cr_2O_7$, obtained from Merck) and 100, 200 and 300 ppm chromium trioxide (CrO_3 also from Merck) employing 5% sucrose (Baker) as solvent. In each case, the highest concentration was the LD_{50}.

After treatment males and females were allowed to mate for three days, then discarded, and fifteen days later the emerged F_1 flies were counted to determine the induction of sex-chromosome loss and non-disjunction. F_1 fertilized females (by F_1 males) were put into fresh vials, one per vial and F_2 generation was scored for sex-linked recessive lethals. All experiments were carried out at 25°C ±1°C and parallel controls were run. Statistical significance test were based on χ^2 test (Spiegel 1970).

Results and discussion

Tables 1 and 2 summarize the results of these experiments. Potassium dichromate induces X-Y chromosome loss and non-disjunction only at the highest

concentration employed (400 ppm) while chromium trioxide did not induced sex-chromosome loss and non-disjunction (Table 1). Sex-linked recessive lethal mutations are induced by both compounds and show a linear response as the concentration increases (Table 2). Potassium dichromate is a strong oxidant when reduced from the hexavalent to the trivalent state. The induction of aberrations by chromium compounds in chromosomes may be due to enzymes liberated from the lysosomes and affecting the nucleic acids or nucleoproteins (Hermann and Speck 1954, Fuwa *et al.* 1960, Mertz 1969). Alterations on DNA extracted from treated mammalian cells (Whiting *et al.* 1979) and DNA treated *in vitro* (Tamino *et al.* 1981) have been reported.

Chromium salts also produced aberrations in root tip chromosomes of *Pisum sativum* (Von Rosen 1954) and *Vicia faba* (Gómez-Arroyo *et al.* 1983) and altered the spindle of *Allium cepa* root tip cells (Levan 1945). Chromate and dichromate compounds induced growth inhibition in mutant strains of *Bacillus subtilis* (Nishioka 1975) and tryptophan reversion in *Escherichia coli* (Venitt and Levy 1974). The mutagenic activity of potassium dichromate was demonstrated in *Schizosaccharomyces pombe* by Bonnati *et al.* (1976).

Table 1. Frequency of non-disjunction and sex chromosome loss induced by $K_2Cr_2O_7$ and CrO_3 in males of *Drosophila melanogaster*

Treatment conc/ppm	Females				Males			
	Normal	Exceptional		Frequency −control	Normal	Exceptional		Frequency −control
	yB	++ nd♀	*B*+ nd♂		++	*yB* Xl♀	y XYl♀,nd♂	
$K_2Cr_2O_7$								
control	668				746		3	
							0.40	
100	620				690		6	
							0.86	0.46
200	558	1			613		8	
		0.18					1.29	0.89
300	700				784		11	
							1.38	0.98
400	673		1		740		28	
			0.15				3.65*	3.25
CrO_3								
control	1089	1			1195	1	6	
		0.09				0.08	0.49	
100	1053		4		1273		17	
			0.38				1.32	0.83
200	1145		1		1344		12	
			0.09				0.88	0.39
300	988		4		1133		8	
			0.40				0.70	0.30

nd♀ =non-disjunction in females
nd♂ =non-disjunction in males
Xl♀ =Xloss in females
XYl♂ =X, Y loss in males
*$P<0.01$

Table 2. Frequency of sex-linked recessive lethals induced by $K_2Cr_2O_7$ and CrO_3 in males of *Drosophila melanogaster*

Treatment conc/ppm	Without lethal Males +, *B*+	With lethal Males +	Total	%	Frequency −control
$K_2Cr_2O_7$					
control	615	5	620	0.80	
100	430	5	435	1.15	0.35
200	421	12	433	2.77	1.97
300	582	27	609	4.43**	3.63
400	599	28	627	4.47**	3.67
CrO_3					
control	864	6	870	0.69	
100	862	24	886	2.71*	2.02
200	843	27	870	3.10**	2.41
300	745	38	783	4.85**	4.16

* $P<0.05$
** $P<0.01$

Hexavalent chromium compounds induced base pair substitutions in bacteria (Sirovet and Loeb 1976) and point mutations in *Salmonella typhimurium* (Petrilli and De Flora 1977) although the adition of microsomes from rat liver or human erythrocyte lysates produced total loss of mutagenic activity probably due to the reduction of chromium to the trivalent state (Petrilli and De Flora 1978).

Potassium dichromate and chromium trioxide induced chromosomal aberrations in cultured hamster cells (Tsuda and Kato 1977, Nakamuro *et al.* 1978, Majone and Levis 1979) and morphological transformations and aberrations in embryonic cells (Umeda and Nishimura 1979). Chromium compounds induced chromosomal aberrations in rat mammary gland cells (Nishimura and Umeda 1978). In rabbits trivalent and hexavalent chromium compounds showed a tendency to accumulate in organs and tissues irrespective of valence (Mathur *et al.* 1977).

Cytotoxic effects of potassium dichromate accompained by nucleoside uptake by mammalian cells *in vitro* are due to effects at the plasma membrane level and to the interaction of trivalent chromium with the nucleophilic sites on DNA molecules at the intracellular level (Levis *et al.* 1978) although some of the Cr (VI) is transported through the cell membrane and reduced in the cell nucleus (Levis and Majone 1981). The administration of chromium trioxide to pregnant hamsters was embryotoxic (Gale and Bunch 1979).

In humans chromium compounds produce several types of somatic effects as well as pulmonary cancer in industrial workers occupationally exposed (Machle and Gregorius 1948, Baetjer 1956, Royle 1975). These compounds also induce sister chromatid exchanges in leucocytes *in vivo* and *in vitro* (Gómez-Arroyo *et al.* 1981, Stella *et al.* 1982).

Summary

It was analyzed the genetic effects of potassium dichromate and chromium trioxide in *Drosophila melanogaster* males treated with different concentrations of

the salts. $K_2Cr_2O_7$ was less toxic than CrO_3.

Potassium dichromate induced sex-chromosome loss and non-disjunction at the highest concentration employed (400 ppm) while chromium trioxide did not showed these effects.

Both salts induced sex-linked recessive lethal mutations.

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