

Protection of Gentian Violet on Gamma Irradiation in Presence of Certain Additives

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The present work has been carried out to investigate the effect of certain organic compounds on the radiolytic decomposition of gentian violet in aqueous medium. The γ -radiolytic decomposition of the dye solutions of various concentrations were studied at a dose range of 0.04–0.42 kGy in presence of oxygen and 0.06–0.59 kGy in an inert atmosphere. The amount of dye decomposed was estimated spectrophotometrically at λ_{max} of 583.0 nm. The protection of the dye was found to be better in absence of oxygen. In case of thiourea and glycerine as additives, the retention of the dye was 100% and as a result the G-value of dye decomposition was found to be zero. In case of glucose and EDTA, the protection of the dye was 90% whereas in case of urea only 70% retention was observed.

Key Words: Gamma radiolysis, Protection, Dye, Gentian violet.

INTRODUCTION

Methyl violet (C.I. 42535) and crystal violet (C.I. 42555) belong to a group of triaryl methane dyes¹. Gentian violet is a mixture of methyl violet and crystal violet (for convenience it is considered as 1 : 1 mixture). Gentian violet is used as ink for stamp pads and as an antiseptic on wounds and mucous membranes².

In the present paper, the effect of gamma γ -radiation on the dye has been studied. It is well known that gamma radiations bring about decomposition of the dye by the breakage of the double bonds. Perkowski and Mayer³ have reported decolorization of anthraquinone dye in aqueous solution by gamma radiation. They have also reported decolorization⁴ of the dyehouse wastewater by irradiation. Certain oxidizing agents speed up the decolorization process when added to the wastewater prior to irradiation. Gupta⁵ has reported decomposition of the xylenol orange dye. Certain compounds such as glucose, glycerine, etc. when added to the dye solution tend to protect the dye which is visible by the retention of colour even on exposure to that dose at which otherwise the dye by itself would decolorize almost completely.

EXPERIMENTAL

All chemicals used were of AR/GR grade and the solutions were prepared in doubly distilled water. The dye solutions were prepared fresh to avoid oxidation and used within 5 h. Gamma irradiation was carried out in stoppered corning glass tubes (14.0 cm height and 3.0 cm diameter) having B24 standard joints in cobalt-60 gamma chamber (GC 900) at a dose rate of 1.2 kGy h⁻¹ (7.488×10^{18} eV g⁻¹ h⁻¹).

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The dose rate was checked by Fricke dosimeter. Absorbed dose correction was carried out for calculation purpose taking into consideration Z/A value of the dye and Z/A value of the Fricke dosimetric solution. The amount of dye decomposed was estimated by recording the absorbance at λ_{max} 583.0 nm using Shimadzu UV-240 spectrophotometer. The additives used were glucose, glycerine, disodium salt of ethylene diamine tetra acetic acid (EDTA), urea and thiourea. No change was found in λ_{max} after the addition of these substances.

The dye solutions having concentrations 0.005, 0.01, 0.015 and 0.02 mM were irradiated at an absorbed dose of 0.04, 0.18, 0.30 and 0.42 kGy respectively where decolorization was found to occur. The solutions of the same concentrations were found to decolorize at an absorbed dose of 0.07, 0.30, 0.36 and 0.59 kGy in absence of oxygen. The dissolved oxygen was removed by purging nitrogen gas in the solution for 15–20 min prior to irradiation. The dye solutions with above concentrations were irradiated with varying concentrations of additives (0.01–0.1 M in case of glucose, glycerine and EDTA whereas 0.2–1.4 M for urea and 0.1–0.8 M for thiourea) at the above mentioned doses. The absorbances were measured immediately after carrying out γ -irradiation. The G values in the presence and absence of oxygen with various concentrations of additives are given in Tables 1 and 2.

TABLE-I
VARIATIONS IN G-VALUES WITH CONCENTRATION OF ADDITIVES IN PRESENCE AND ABSENCE OF OXYGEN (O₂ IN PRESENCE OF OXYGEN AND N₂ IN ABSENCE OF OXYGEN)

Concentration of dye (mM)	Concn. of additives (M)	G-values ($\times 10^4$)					
		Glucose		Glycerine		EDTA	
		O ₂	N ₂	O ₂	N ₂	O ₂	N ₂
0.005 (D = 0.04 kGy-O ₂ , 0.07 kGy-N ₂)	0.00	35.98	17.18	32.29	21.32	40.21	26.10
	0.01	15.01	2.95	—	—	4.01	2.05
	0.02	18.27	7.73	12.91	2.88	3.12	1.95
	0.04	16.61	7.73	9.69	0	5.93	3.90
	0.06	—	—	9.69	2.52	—	—
0.010 (D = 0.18 kGy-O ₂ , 0.30 kGy-N ₂)	0.00	11.71	7.36	11.52	6.75	12.78	7.76
	0.02	3.44	0.83	1.84	0.33	2.61	1.84
	0.03	—	—	1.93	0	—	—
	0.04	2.19	0.80	1.51	1.19	2.24	2.02
	0.06	3.20	0.54	2.78	1.19	2.55	1.79
0.015 (D = 0.42 kGy-O ₂ , 0.36 kGy-N ₂)	0.00	7.40	6.09	7.59	6.25	7.66	6.33
	0.02	2.34	0.70	1.48	0.64	1.92	5.20
	0.04	2.04	0.85	1.04	0.31	1.66	3.89
	0.07	—	—	—	—	1.81	2.67
	0.08	1.80	0.28	1.32	0.63	—	—
0.020 (D = 0.42 kGy-O ₂ , 0.59 kGy-N ₂)	0.00	5.94	4.07	5.05	4.12	5.62	4.12
	0.02	1.20	1.15	0.92	0.48	1.52	3.21
	0.04	1.45	1.14	0.64	0.41	1.40	3.05
	0.06	1.19	0.93	0.79	0.54	1.52	2.76
	0.07	0.54	0.39	—	—	1.48	2.76

TABLE-2
 VARIATIONS IN G-VALUES WITH CONCENTRATION OF ADDITIVES IN PRESENCE AND ABSENCE OF OXYGEN (O_2 IN PRESENCE OF OXYGEN AND N_2 IN ABSENCE OF OXYGEN)

Concentration of dye (mM)	Urea			Thiourea		
	Concn. (M)	G-values ($\times 10^4$)		Concn. (M)	G-values ($\times 10^4$)	
		O_2	N_2		O_2	N_2
0.005 (D = 0.04 kGy- O_2 , 0.07 kGy- N_2)	0.00	40.21	26.10	0.000	40.21	26.10
	0.10	29.30	12.49	0.025	12.46	0
	0.20	19.53	6.25	0.050	9.35	0
	0.40	17.18	6.77	0.075	9.35	0
	0.50	20.62	6.77	0.100	9.35	0
0.010 (D = 0.18 kGy- O_2 , 0.30 kGy- N_2)	0.00	12.79	7.76	0.00	12.79	7.76
	0.30	7.64	4.62	0.10	2.68	0.28
	0.40	6.70	4.04	0.20	2.30	0
	0.60	6.37	3.29	0.30	2.61	0
	0.80	5.69	3.35	0.40	2.61	0
0.015 (D = 0.30 kGy- O_2 , 0.36 kGy- N_2)	0.00	7.66	6.33	0.00	7.66	6.33
	1.00	3.23	2.46	0.10	1.07	0.17
	1.10	3.29	2.15	0.20	0.87	0.17
	1.20	3.10	2.11	0.40	0.86	0
	1.40	3.57	2.15	0.60	1.01	0.15
0.020 (D = 0.42 kGy- O_2 , 0.59 kGy- N_2)	0.00	5.62	4.12	0.00	5.62	4.12
	1.00	2.89	2.09	0.10	0.60	0.14
	1.20	2.68	2.02	0.20	0.68	0.07
	1.40	2.49	1.81	0.40	0.51	0.20
	1.60	2.68	1.78	0.60	0.58	0.19

RESULTS AND DISCUSSION

It was noticed that higher concentrations of the dye required high dose for decolorization. Also, in the absence of oxygen the dose required for decolorization increases and also retention of colour is more for same concentration of the additive. This phenomenon is due to the fact that removal of oxygen reduces the concentration of the oxidizing species⁴ which would be formed on irradiation if dissolved oxygen were present in the system, thereby protecting the dye. On increasing the concentration of the additive the decomposition of the dye is reduced up to a certain limit beyond which the concentration of the additive has no effect on the retention of the dye.

In an inert atmosphere, the molecules of the additives may react with OH radicals formed as a result of radiolysis of water. As the decolorization is mainly due to OH radicals that are scavenged because of the additives, the dye gets protected. 100% retention of the dye was shown by only thiourea and glycerine in absence of oxygen at lower concentrations whereas none of the additives showed 100% retention in presence of oxygen indicating less consumption of OH

radicals by other additives. At higher concentrations only thiourea showed 100% retention in absence of oxygen. The graphs depicting the variations in G-values and per cent dye converted for 0.01 mM concentration of gentian violet in presence and absence of oxygen with varying concentrations of the additives are given in Fig. 1.

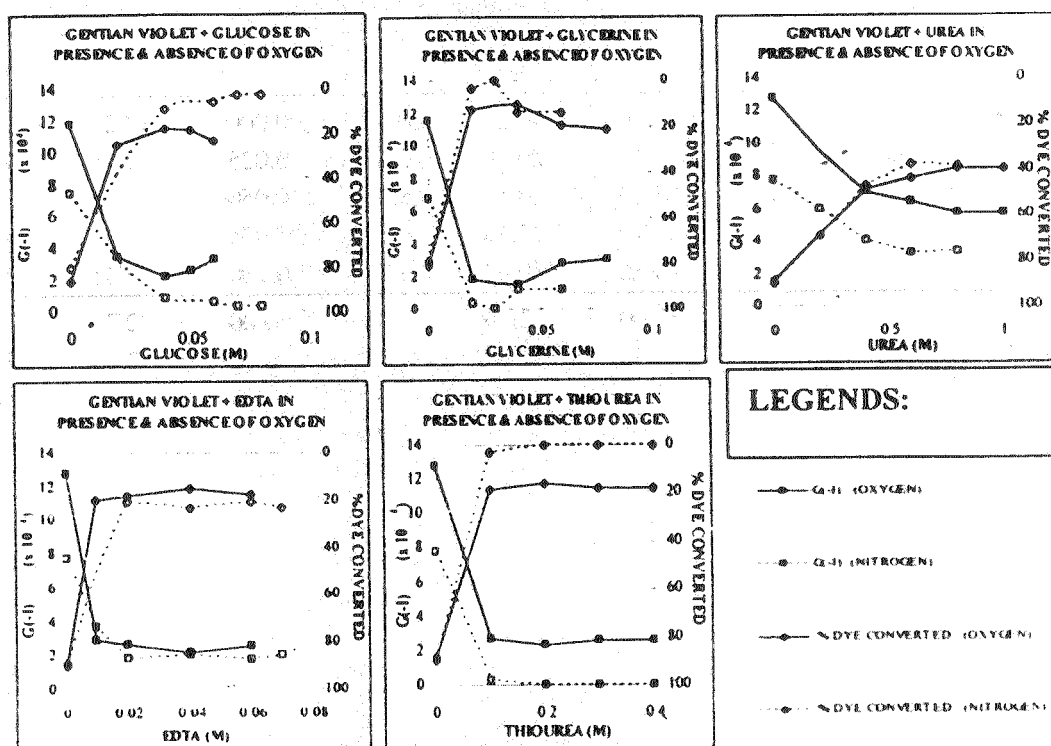


Fig. 1. Variations in G-values and % dye converted in presence and absence of oxygen with varying concentrations of the additives

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