Kinetic Profiling of Vitamin B2 Degradation in the Presence of Reducing Divalent Anions Under Light Exposure

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ABSTRACT

This study investigates the degradation of riboflavin under light exposure when mixed with sulfur-containing divalent anions. Light-induced degradation of riboflavin occurs through photoaddition and photoreduction pathways, leading to the formation of various photoproducts, including cyclodehydroriboflavin (CDRF) and lumichrome (LC). The fluorescence of riboflavin decreases as a result of its complex formation with the divalent anions. The highest rate of CDRF formation was observed at neutral pH, in the following order: thiosulfate < sulfite < metabisulfite, whereas the rate of LC formation followed the reverse trend.

Keywords: Divalent Anions, Kinetic Study, Pathways, Photoproducts, Riboflavin.

INTRODUCTION

Riboflavin (RF) or vitamin B2 has high solubility in water (Gul *et al*. 2014). RF was given its name because of its yellow color (*flavus* = yellow in Latin) (Monteiro and Daniel, 2012). The RF molecule contains an isoalloxazine ring with a ribose side chain. Food sources having RF includes milk, legumes, eggs, fish, and fruits (Merrill *et al*. 1981). RF is available both alone and in combination with other vitamins and minerals in different dosage forms.

RF is very sensitive to light and is affected by different degradation mechanisms like intramolecular photo-addition, photo-reduction, and chemical reduction into various major and minor photoproducts of which CDRF and LC are of importance (Pharmacopoeia *et al*. 1998).

OBJECTIVE

This study deals with the kinetic study of the degradation of RF when mixed with sulfate, thiosulfate and meta bisulfite ions within the pH range of 6.0-8.0. the RF-divalent anions complex was also studied in the absences of light. The kinetics of these reactions will help us understand the nature and range of interaction between RF and these divalent anions.

METHODOLOGY

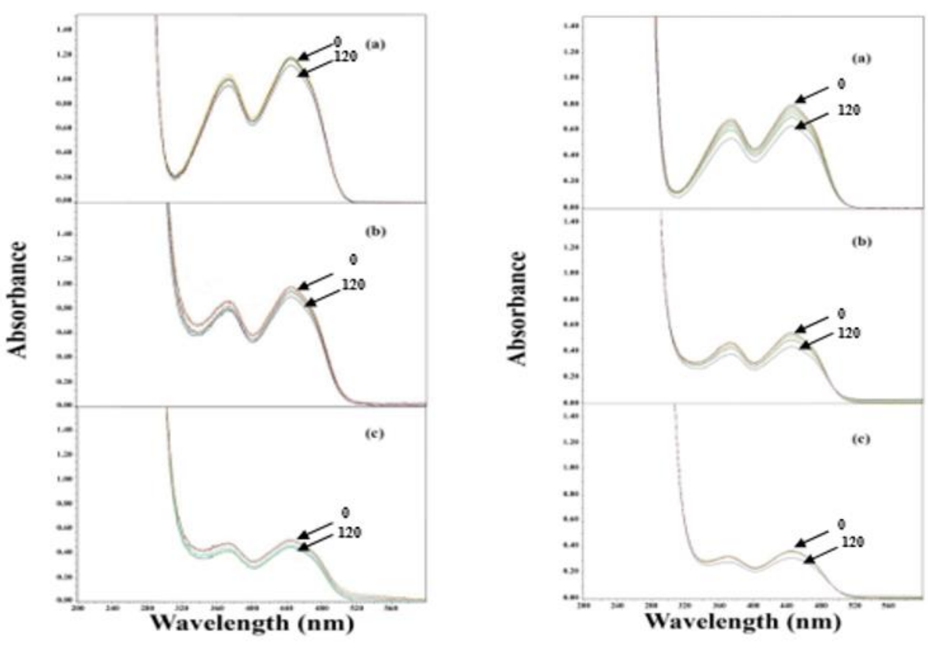
The solutions of riboflavin (RF) containing sulfur-containing reducing divalent anions were prepared within a concentration range of 0.2 to 1.0 M. The desired pH was adjusted using 1.0 M HCl solution. The study was carried out both in the presence and absence of light. All solutions were made using analytical grade reagents, and freshly distilled water was employed for their preparation.

RESULT

- Riboflavin (RF) forms a complex with the divalent anions, leading to the formation of various photoproducts, as listed in Table **1**.
- The UV-Visible spectra of the RF-divalent anion complex, both in the presence and absence of light, are shown in Figure **1**.
- The effect of the complex on fluorescence is illustrated in Figure **2**.
- A comparaison of the RF degradation rate constant and pH is provided in Figure **3**.

Table 1. RF Degradation Rate Constants (First-Order) (k_{obs}) and Formation of the Photoproducts CDRF (k_1) and LC (k_2), and DHRF (k_3) in the Presence of Sulfur-Containg Divalent Anions.

rate of formation of photoproducts									
pH	**Dianion**	**Conc. (M)**	**1st Order Rate-Constants (a)**	**CDRF (b)**	**LC (c)**	**DHRF (d)**	**b/c**	**b/d**	**d/a**
			(min^{-1})±SD						
6.0	Thiosulfate	1.0	1.57±0.07	0.35±0.01	0.95±0.03	0.33±0.11	0.34	1.03	0.20
6.5		1.0	2.13±0.08	0.45±0.02	1.25±0.05	0.42±0.02	0.35	1.07	0.20
7.0		1.0	3.05±0.14	0.76±0.02	1.61±0.06	0.68±0.02	0.47	1.11	0.22
7.5		1.0	2.70±0.11	0.59±0.02	1.46±0.06	0.61±0.02	0.40	0.97	0.22
8.0		1.0	2.54±0.10	0.51±0.02	1.47±0.05	0.56±0.02	0.35	0.91	0.22
6..0	Sulfite	1.0	1.28±0.06	0.34±0.01	0.60±0.02	0.33±0.01	0.57	1.00	0.25
6.5		1.0	1.90±0.07	0.55±0.02	0.94±0.04	0.40±0.02	0.59	1.36	0.21
7.0		1.0	2.75±0.10	0.75±0.01	1.14±0.05	0.54±0.02	0.66	1.38	0.23
7.5		1.0	2.32±0.09	0.60±0.02	1.12±0.04	0.60±0.02	0.54	1.00	0.26
8.0		1.0	2.20±0.08	0.44±0.02	1.18±0.05	0.59±0.02	0.37	0.73	0.26
6.0	Metabisulfite	1.0	1.20±0.05	0.37±0.01	0.55±0.03	0.28±0.01	0.67	1.32	0.23
6.5		1.0	1.65±0.07	0.50±0.02	0.70±.04	0.35±0.01	0.71	1.42	0.21
7.0		1.0	2.30±0.09	0.82±0.03	0.90±0.05	0.48±0.01	1.02	1.89	0.21
7.5		1.0	2.02±0.08	0.66±0.04	0.90±0.03	0.46±0.02	0.73	1.43	0.23
8.0		1.0	1.90±0.07	0.44±0.02	1.02±0.05	0.44±0.02	0.43	1.00	0.23



(I) (II)

Figure 1. UV-Vis spectra of RF in the presence of sulfate, metabisulfite ad thiosulfate anions. (in the presence (I) and absence (II) of light).

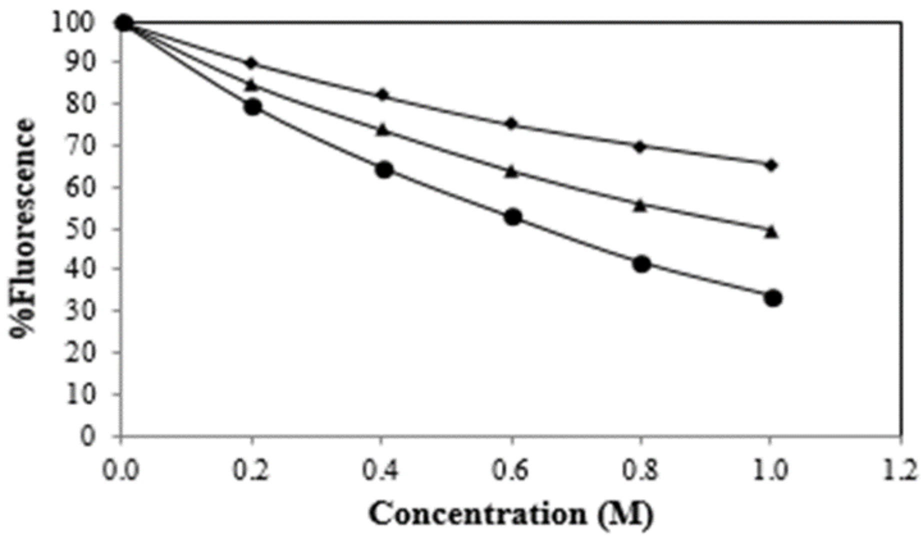


Figure 2. Fluorescence percentage of RF in the presence of thiosulfate (●), sulfate (■), metabisulfite (♦) anions.

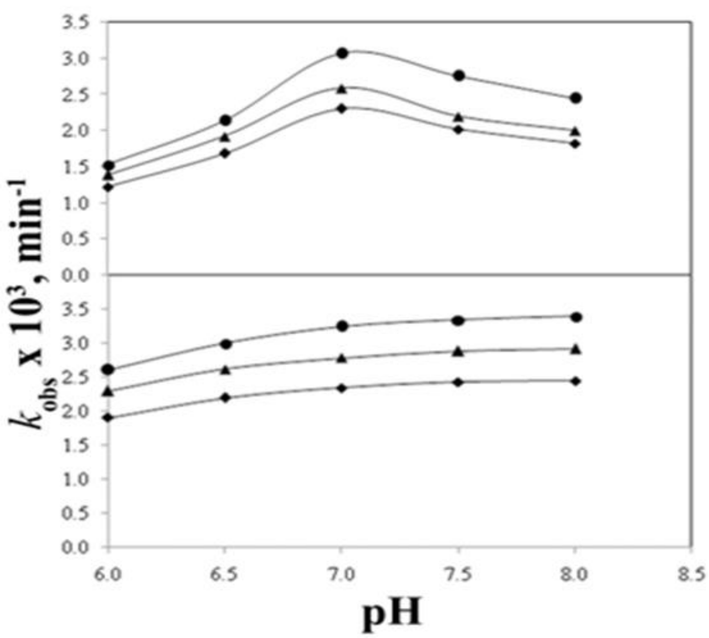


Figure 3. pH vs RF degradation rate constant in the presence of thiosulfate (●), sulfate (■), metabisulfite (♦) anions (in the presence (I) and absence (II) of light).

CONCLUSION

- Riboflavin (RF) undergoes photodegradation and photochemical interaction (in the absence of light) following first-order and second-order kinetics, respectively.
- The rate of these reactions follows the order: thiosulfate > sulfite > metabisulfite, with the highest activity observed at neutral pH.

- The complex formed between RF and sulfur-containing divalent anions results in fluorescence quenching.

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