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# RIBOFLAVIN INDUCED PHOTOCATALYSED SYNTHESIS OF XANTHENE DERIVATIVES**

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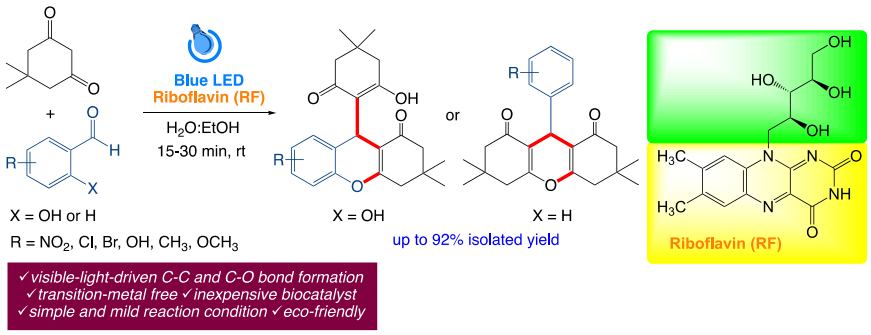
An efficient visible-light mediated riboflavin (RF) induced synthesis of xanthene molecules has been developed at room temperature, which providing a straightforward, green, and environmentally benign access to a wide variety of substituted xanthene derivatives under mild reaction conditions.




## INTRODUCTION

Synthesis of heterocyclic compounds has attracted immense interest among chemists because of their wide applicability in life and nature. Xanthenes are a special class of oxygen-containing tricyclic compounds characterized by a dibenzopyran nucleus. In the last few decades, xanthene derivatives[1] have attracted a considerable amount of interest in the fields of medicinal and material chemistry. Compounds like xanthene and benzoxanthene are such important class of compounds, they have received substantial significance because of their broad range of therapeutic and biological properties including antitumor,[2] anticoagulant,[3] antiviral,[4] antifungal,[5] anti-HIV,[6] anticancer[7] antitubercular,[8] antibacterial,[9] antioxidant,[10] xanthine oxidase inhibitors[11] and acetylcholinesterase inhibitors[12] **(**Fig. 1**)**. In addition to their medicinal applications xanthene derivatives have extensively been used as p*H* sensitive fluorescent material for the purpose of envisioning of biomolecules.[13,14] There are already a lot of techniques available due to their significant therapeutic benefits and other beneficial uses. The reported methods do have benefits but nevertheless have some disadvantages such as application of various homogeneous and heterogeneous catalysts

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which have low range of surface area and suffers from difficult separation, use of environmentally harmful solvents, expensive metal catalysts, non-recyclability of the catalyst, difficult work up, generation of by product, high temperature, low yield and prolonged reaction time.[15–27] Therefore, there is still need for the advancement of a greener, efficient and more convenient method for the synthesis of the xanthene molecule for industrial as well as for medicinal chemistry.

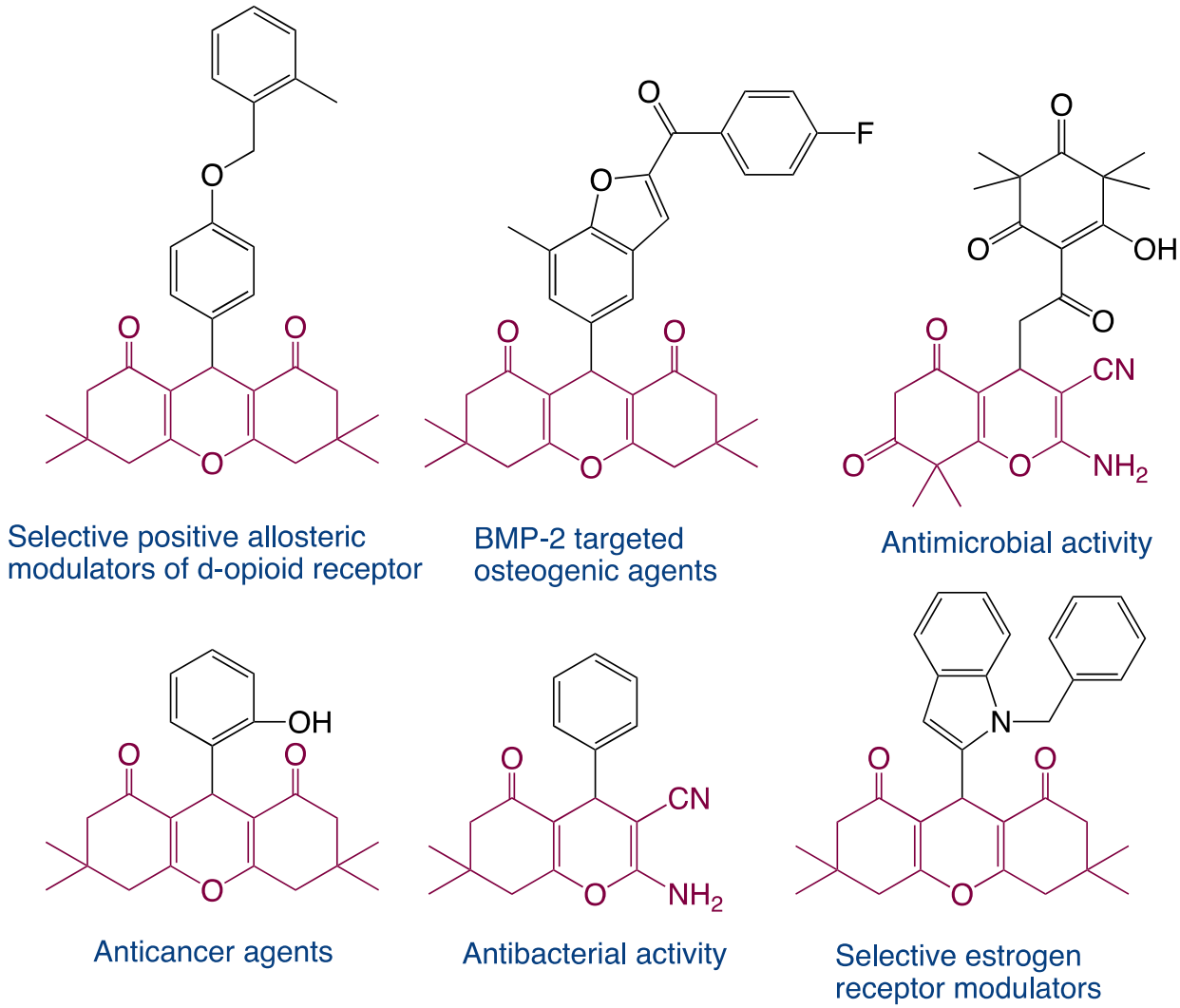


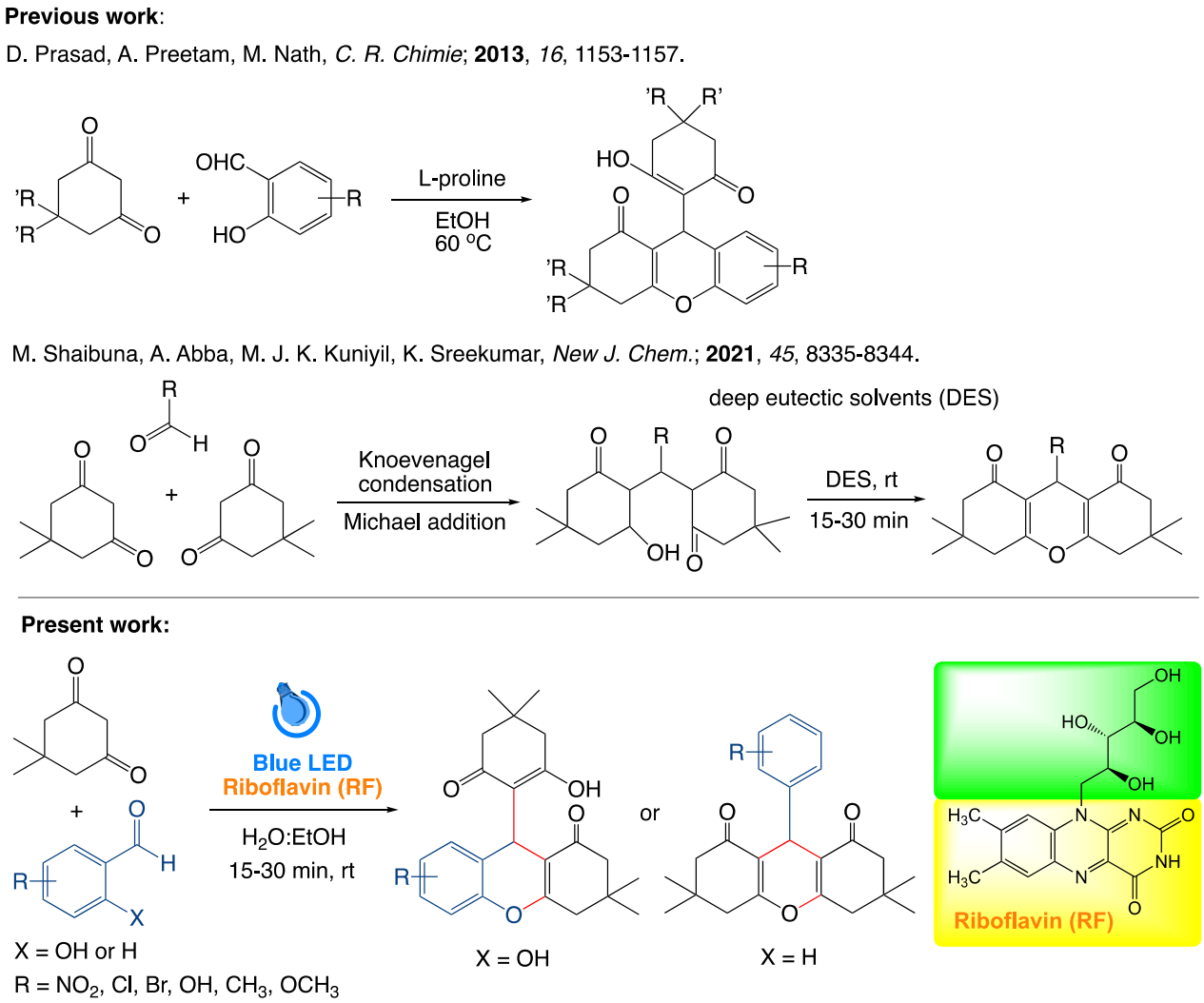

Fig. 1 – Xanthene-incorporated bioactive molecules.

Due to increased attention on applying green principles while synthesizing organic molecules in last few years, chemists have modified the methodology of synthesis by incorporating visible light. Since visible light-mediated catalysis is more cost-effective, sustainable, prevalent, environmentally friendly, safe, and scalable than other reactions. It's application and advancement in organic chemistry have become extremely vital that requires a light source which is readily available for the synthesis of xanthene derivatives under the mild conditions typically using the photocatalytic approach. This synthetic protocol represents an added value, in view of the crucial role of these derivatives in the preparation of more complex target compounds.[25-28] Recently, with the objective of developing new method for environmentally benign reaction conditions to organic reactions with excellent efficiency and selectivity,[29] visible light induced photocatalysed organic reactions has gained much more attention from a number of research groups.[30] This is because visible light is clean, easily available and easy to handle and an unlimited energy source for the development of eco-friendly and sustainable protocols for the synthetic organic chemistry which full fills basic principle of green chemistry.[31]

One of the most popular example of dye-based photoredox catalysts is vitamin $B_2$, riboflavin (RF),[32]

and its derivatives, which have gained plenty interest for their special redox organocatalyst properties that support a variety of catalytic oxidations.[33–36] These readily available photocatalysts provide an adaptable and environmentally friendly solution to various organic chemical reactions.[37–39] riboflavin (vitamin $B_2$) is an extremely versatile organocatalyst for many different kinds of transformations[40] due to its inherent energy transfer (ET) and single electron transfer (SET) modes which can be activated upon irradiation.[41–43] Despite of other advantages, riboflavin and it's derivatives have maximum absorption in blue region of the visible light spectrum with high molar absorption coefficients. The development of novel organic photocatalysts with extensive redox capabilities is therefore extremely desirable. Flavins therefore exceed other photocatalysts in modern organic synthesis due to their improved photostability, which will ultimately lead to the future development pattern of organic photocatalysts.

In continuation of our recent studies and previous work[44–69] on visible light induced photoredox catalysed synthesis using green synthetic routes for synthesizing important heterocyclic systems, herein, we have proposed visible light promoted, simple, clean and facile riboflavin induced one pot synthesis of xanthene molecules at room temperature (Scheme 1).




Scheme 1 – Visible-light photocatalysed synthesis of xanthene derivatives at room temperature.

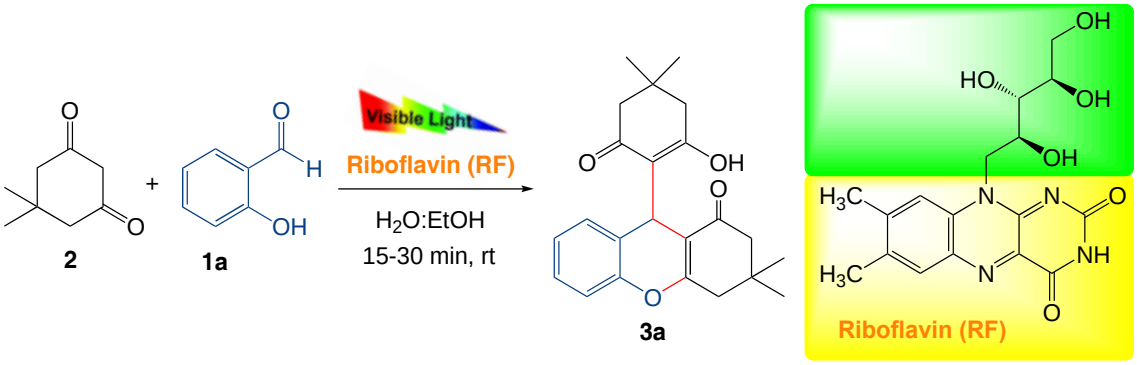
## RESULTS AND DISCUSSION

We began with optimization using salicylaldehyde 1a, and dimedone 2 in water without catalyst at room temperature. In order to achieve maximum yield, variation was done in intensity of visible light (green LED, blue LED, red LED, yellow LED,) and it was found that precisely blue LED is most relevant for present protocol. (Table 1). We were delighted to obtain

the desired xanthene product 3a in 68% yield for 30 minutes under blue LED by applying water as a solvent (Table 1, entry 8). With the choice of ethanol as the reaction medium at room temperature, the product was obtained with a 62% yield (Table 1, entry 7). To further increase the product yield, then, the control experiments were carried out and the reaction was conducted in the water-ethanol medium (1:1v/v), and the desired product was obtained with best yield 75% for 15 minutes (Table 1, entry 1). The good to moderate yield 55–70% was obtained in the water-ethanol medium (1:1v/v) (Table 1, entry 3,4,2). Further, using MeCN as a solvent the yield of desired product was very low with 15% (Table 1, entry 6) and there is no product formation in dark condition. (Table 1, entry 5). The scope of the water-ethanol (1:1 v/v) medium was further extended to benzaldehyde-fused heterocycle derivatives synthesis with the same result.

*Table 1*

Optimization of the Reaction Conditions[a]



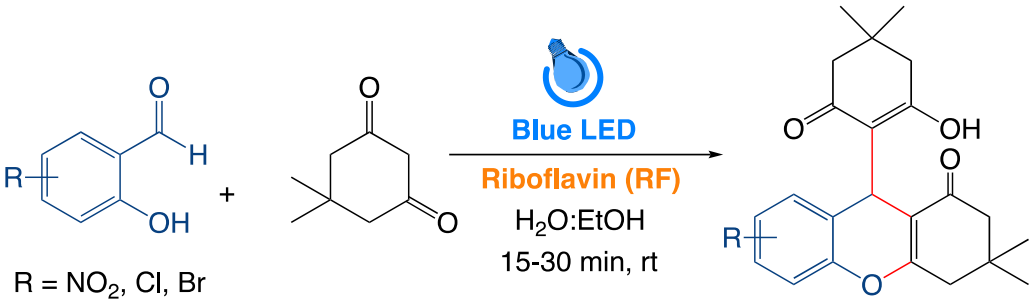

| Entry | Riboflavin (mol%) | Visible light | Solvent | Time (min) | [b]Yield % |
|---|---|---|---|---|---|
| 1 | 2 | blue LED | $H_2O$:EtOH | 15 | 75 |
| 2 | 2 | green LED | $H_2O$:EtOH | 30 | 70 |
| 3 | 2 | yellow LED | $H_2O$:EtOH | 30 | 55 |
| 4 | 2 | red LED | $H_2O$:EtOH | 30 | 65 |
| 5 | 2 | Dark | $H_2O$:EtOH | 30 | - |
| 6 | 2 | blue LED | MeCN | 30 | 15 |
| 7 | 2 | blue LED | EtOH | 30 | 62 |
| 8 | 2 | blue LED | $H_2O$ | 30 | 68 |
| 9 | – | blue LED | $H_2O$ | 30 | Nd[c] |

[a]Reaction condition: 1a (1mmol), 2 (2 mmol) in $H_2O$: EtOH (1:1 v/v), riboflavin (2 mol%) using high power blue LED [18 W, λmax 467 nm] at room temperature (rt) for 15-30 min. [b]Isolated yield 3a. [c]Reaction was carried out in absence of catalyst.

We then turned our focus to investigating the adaptability of various substrates or anticipated reaction conditions as we continued to search for the best reaction conditions for our model reaction (Table 2: four derivatives from salicylaldehyde and Table 3: eight derivatives from benzaldehyde). However, it was observed that aromatic aldehyde and dimedone with electron-withdrawing groups like bromo, nitro and chloro at various positions exhibited improved reactivity and produced the corresponding products in good to excellent yields (3b, 3c, 3d – Table 2 and 5e, 5f – Table 3). On the other hand, substrate containing electron-donating groups, such as methoxy and methyl provided the corresponding products in moderate yields (5c, 5g, 5h – Table 3).

*Table 2*

Substrate Scope for Salicylaldehyde




**1a-d** **2** **3a-d**

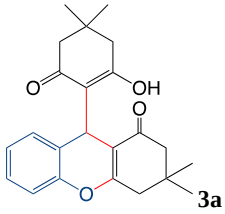
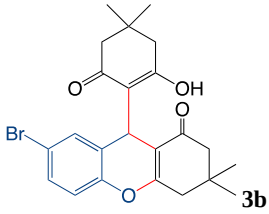
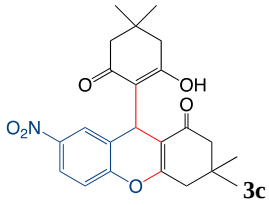
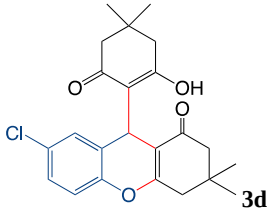
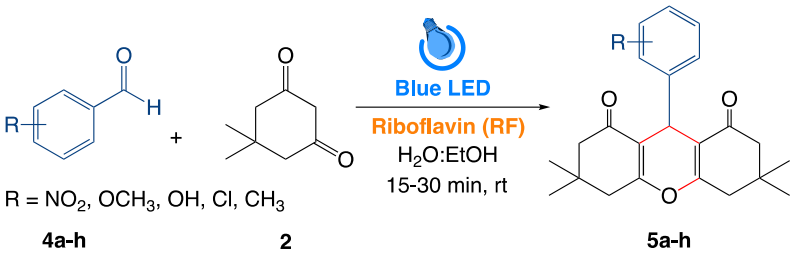
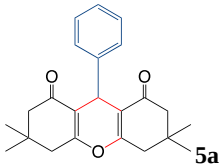
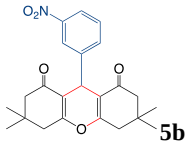
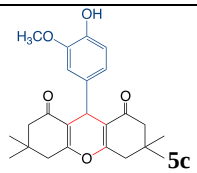
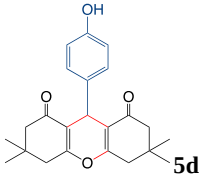
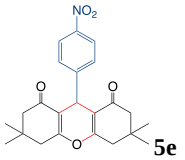
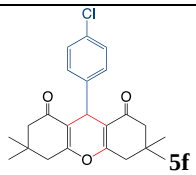
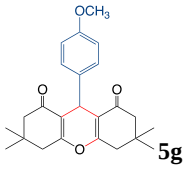
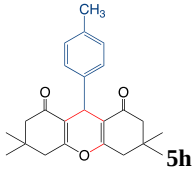
| Entry | Product | Time (min) | Yield % |
|---|---|---|---|
| 1 |  **3a** | 15 | 75 |
| 2 |  **3b** | 15 | 85 |
| 3 |  **3c** | 15 | 92 |
| 4 |  **3d** | 15 | 88 |

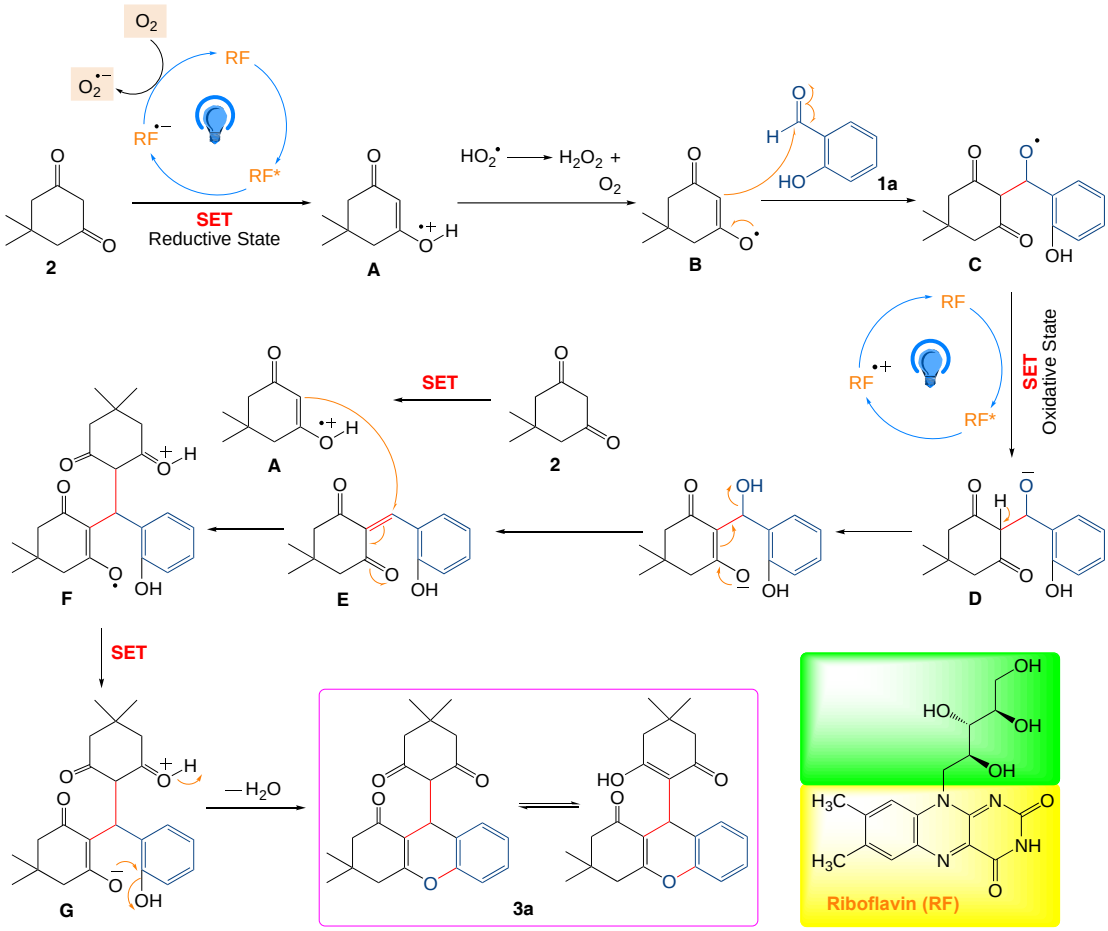
*Table 3*

Substrate Scope for Benzalaldehyde




| Entry | Product | Time (min) | Yield % |
|---|---|---|---|
| 1 |  **5a** | 15 | 92 |
| 2 |  **5b** | 20 | 62 |
| 3 |  **5c** | 30 | 51 |
| 4 |  **5d** | 25 | 55 |
| 5 |  **5e** | 15 | 85 |
| 6 |  **5f** | 15 | 82 |
| 7 |  **5g** | 20 | 65 |
| 8 |  **5h** | 20 | 63 |

On the basis of the literature review,[70–74] for the formation of the desired product a plausible mechanistic pathway is depicted in Scheme 2. Initially, riboflavin was converted to excited state riboflavin* upon irradiation of visible light, and this eosin riboflavin* underwent reductive quenching by dimedone **2** to afford the radical cation **A** and form an riboflvin radical anion, which further oxidized to the ground state via aerobic oxygen to forma superoxide radical anion $O_2^{-\cdot}$and complete the photoredox cycle. The generated radical cation **A** was deprotonated by $O_2^{-\cdot}$to give the radical **B**. Further, this radical **B** is reacted with aromatic aldehyde **1a** to form **C**, simultaneously riboflavin undergoes single electron transfer (SET) to generate compound **C** to **D**, which interchanges to **E**. The radical cation **F** is generated by second molecule of dimedone **2** via SET reacts with **E** to furnish compound **G**. Subsequently, **G** undergoes dehydration, leading to the desired compound **3a**. The formation of superoxide radical anion $O_2^{-\cdot}$ during the reaction was confirmed by detection of the resulting $H_2O_2$ by using KI/starch indicator.[75]




Scheme 2 – Plausible mechanism for synthesis of xanthene derivatives at room temperature.

## EXPERIMENTAL

All chemicals used are reagent grade, commercially available and were purchased from Sigma-Aldrich, Merck, Qualigens and used without any additional purification. Melting points were determined by open glass capillary method and are uncorrected. $^1$H NMR and $^{13}$C NMR spectra were recorded on a Bruker AVANCE DPX (400 MHz and 100 MHz) FT spectrometer in $CDCl_3$ using TMS as an internal reference (chemical shift in δ ppm). Mass spectra were recorded on JEOL SX-303 (FAB) mass spectrophotometer. Elemental analyses were carried out using a Coleman automatic C, H, N analyser.

### General Procedure for Synthesis of Xanthene derivatives (3a-d and 5a-h)

A well stirred solution of aromatic aldehyde (1mmol), dimedone (2mmol) and riboflavin (2 mol%) was taken in water-ethanol medium(1:1v/v) under blue LED (18 W, λmax 467 nm) irradiation, stirring was continued at room temperature for about 30 minutes after which the reaction mixture became milky and the reaction was monitored with TLC, extracted with ethyl acetate and the product was obtained as white solid.

Further for optimization of product yield in both series (Tables 2 and 3), the reaction was conducted in water-ethanol medium (1:1v/v), similar product was obtained with best result in same water-ethanol ratio for 15 minutes. Accordingly, aromatic aldehyde containing electron withdrawing and electron donating groups as well as halogenated groups were allowed to react with dimedone. In all cases xanthene derivatives were yielded in moderate to excellent quantities. The identification of all the products was confirmed by $^{1}H$ and $^{13}C$ NMR.

**Spectral data of synthesized compounds**[76]

***9-(2-Hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-Dimethyl-2,3,4,9-tetrahydroxanthen-1-one*** (**3a**): 75% yield; white solid, melting point (mp) 207–209 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 10.50 (s, 1H, -OH), 6.93-7.16 (m,4H, Ar-H), 4.65 (s, 1H, -CH), 2.54 (q, J = 17.7, 20.0 Hz, 2H, -$CH_2$), 2.35 (s, 2H, -$CH_2$), 2.30(s, 2H, -$CH_2$), 1.93 (q, J = 6.0, 16.4 Hz, 2H, -$CH_2$), 1.14 (s, 3H, -$CH_3$), 1.03 (s,3H, -$CH_3$), 0.92-1.23 (s,6H, 2-$CH_3$) ; $^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 200.40, 196.13, 170.53, 168.78, 151.04, 127.98, 127.52, 124.53, 118.31, 115.78, 111.07, 96.20, 50.58, 49.93, 43.24, 41.60, 32.33, 31.02, 29.85, 29.43, 27.79, 27.21, 26.42ppm. MS (ESI): m/z calcd. for $C_{23}H_{26}O_4$ $[M+H]^+$ = 366.18. Found %: C, 75.38: H, 7.16. Calculated, %: C, 75.36: H, 7.14.

***7-Bromo-9-(2-hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-dimethyl-2,3,4,9-tetrahydro-xanthen-1-one*** (**3b**): 85% yield; white solid, melting point (mp) 242–244 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 10.15 (s, 1H, -OH), 7.21–7.24 (dd, J = 1.9, 6.8 Hz, 1H, Ar-H), 7.08 (s, 1H, Ar-H), 6.87 (d, J = 8.7 Hz, 1H, Ar-H), 5.02 (s, 1H, -CH-), 2.28–2.59 (m, 6H, 3-$CH_2$), 1.95 (s, 2H, -$CH_2$),1.33 (s, 3H, -$CH_3$), 0.99–1.05 (m, 9H, 3-$CH_3$); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 195.65, 164.328, 148.794, 130.563, 129.103, 127.741, 116.932, 115.413, 110.34, 50.27, 40.65, 40.33, 40.05, 39.78, 39.22, 38.94, 38.66, 31.35, 31.27, 28.93,27.56, 26.30. MS (ESI): m/z calcd. for $C_{23}H_{25}BrO_4$ $[M+H]^+$ = 444.09. Found %: C, 62.03: H, 5.66. Calculated, %: C, 62.00: H, 5.63.

***7-nitro-9-(2-hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-dimethyl-2,3,4,9-tetrahydro-xanthen-1-one*** (**3c**): 92% yield; white solid, melting point (mp) 196–198 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 10.15 (s, 1H, -OH), 7.96–8.01 (dd, J=1.9, 6.8 Hz, 1H, Ar-H), 7.08 (s, 1H, Ar-H), 6.87 (d, J=8.7 Hz, 1H, Ar-H), 5.02 (s, 1H, -CH-), 2.28–2.59 (m, 6H, 3-$CH_2$), 1.95 (s, 2H, -$CH_2$),1.33 (s, 3H, -$CH_3$), 0.99–1.05 (m, 9H, 3-$CH_3$); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 195.65, 164.328, 148.794, 142.012, 130.563, 129.103, 127.741, 115.413, 110.34, 50.27, 40.65, 40.33, 40.05, 39.78, 39.22, 38.94, 38.66, 31.35, 31.27, 28.93,27.56, 26.30. MS (ESI): m/z calcd. for $C_{23}H_{25}NO_6$ $[M+H]^+$ = 411.17. Found %: C, 67.14: H, 6.12: N, 3.40. Calculated, %: C, 67.12: H, 6.10: N, 3.38.

***7-Chloro-9-(2-hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-dimethyl-2,3,4,9-tetrahydro-xanthen-1-one*** (**3d**): 88% yield; white solid, melting point (mp) 229–230 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 10.50(s, 1H, -OH), 7.09 (dd, J = 2.2, 2.6 Hz, 1H, Ar-H), 6.91–6.97 (m, 2H, Ar-H), 4.61 (s, 1H, -CH), 2.52 (q, J = 17.3, 18.5 Hz, 2H, -$CH_2$), 2.37 (d, J = 4.9 Hz, 2H, -$CH_2$), 2.30 (s, 2H, -$CH_2$), 1.96 (s, 2H, -$CH_2$), 1,14 (s, 3H, -$CH_3$), 1.00–1.05 (m, 9H, 3-$CH_3$); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 198.9, 180.9, 162.2, 152.1, 129.6, 128.4, 126.6, 125.3, 118.5, 115.7, 108.8, 51.6, 46.8, 43.9, 30.5, 30.2, 28.4, 27.5. MS (ESI): m/z calcd. for $C_{23}H_{25}ClO_4$ $[M+H]^+$ = 400.14. Found %: C, 68.91: H, 6.29. Calculated, %: C, 68.90: H, 6.26.

***3,3,6,6-Tetramethyl-9-benzene-1,8-dioxo-octahydroxanthene*** (**5a**): 92% yield; white solid, melting point (mp) 200–202 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 0.97 (s, 6 H, 2 × $CH_3$), 1.11 (s, 6 H, 2 × $CH_3$), 2.22 (dd, 4 H, *J* = 1.6 Hz, *J* = 2.4 Hz, 2× $CH_2$, H-4, H-5), 2.47(s, 4 H, 2 ×$CH_2$, H-2, H-7), 4.68 (s, 1 H, H-9), 7.23 (m, 5 H, Ar-H);$^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 198.9, 155.1, 142.2, 129.4, 129.1, 128.7, 125.8, 113.9, 56.1, 51.6, 44.6, 39.1, 30.6, 27.5. MS (ESI): m/z calcd. for $C_{23}H_{26}O_3$ $[M+H]^+$ = 350.19. Found %: C, 78.83: H, 7.48. Calculated, %: C, 78.81: H, 7.45.

***3,3,6,6-Tetramethyl-9-(-3 nitro phenyl)-1,8-dioxo-octahydroxanthene*** (**5b**): 62% yield; white solid, melting point (mp) 184–186 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 0.99 (s, 6H), 1.12 (s, 6H), 2.16 (d, 2H), 2.26 (d, 2H), 2.51 (t, 4H), 4.83 (s, 1H), 7.50 (d, 1H), 7.60 (d, 1H), 8.10 (d, 1H) 8.28 (s, 1H); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 27.7, 29.6, 32.6, 32.8, 41.2, 51.0, 114.9, 123.8, 129.8, 146.8, 152.0, 163.5, 196.7. MS (ESI): m/z calcd. for $C_{23}H_{25}NO_5$ $[M+H]^+$ = 395.17. Found %: C, 69.86: H, 6.37: N, 3.54. Calculated, %: C, 69.84: H, 6.35: N, 3.51.

***3,3,6,6-Tetramethyl-9-(4-hydroxy3 methoxyphenyl)-1,8-dioxo-octahydroxanthene*** (**5c**): 51% yield; white solid, melting point (mp) 294–296 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 0.97 (s, 6H), 1.07 (s, 6H), 2.09-2.25 (m, 4H), 2.44 (s, 4H), 3.70 (s, 3H), 4.64 (s, 1H), 6.51 (d, J = 7.4 Hz, 1H), 7.04 (d, J = 7.4 Hz, 2H), 7.17 (s, 1H); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 27.4, 29.2, 30.9, 32.3, 40.8, 50.7, 115.3, 115.9, 129.3, 135.4, 154.8, 162.5, 197.4. MS (ESI): m/z calcd. for $C_{24}H_{28}O_5$ $[M+H]^+$ = 396.48. Found %: C, 72.71: H, 7.12. Calculated, %: C, 72.70: H, 7.10.

***3,3,6,6-Tetramethyl-9-(4-hydroxyphenyl)-1,8-dioxo-octahydroxanthene*** (**5d**): 55% yield; white solid, melting point (mp) 253–255 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 0.97 (s, 6H), 1.07 (s, 6H), 2.09-2.25 (m, 4H), 2.44 (s, 4H), 4.64 (s, 1H), 6.51 (d, J = 7.4 Hz, 2H), 7.04 (d, J = 7.4 Hz, 2H), 7.17 (s, 1H); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 27.4, 29.2, 30.9, 32.3, 40.8, 50.7, 115.3, 115.9, 129.3, 135.4, 154.8, 162.5, 197.4. MS (ESI): m/z calcd. for $C_{23}H_{26}O_4$ $[M+H]^+$ = 366.18. Found %: C, 75.38: H, 7.15. Calculated, %: C, 75.36: H, 7.12.

***3,3,6,6-Tetramethyl-9-(4-nitrophenyl)-1,8-dioxo-octahydroxanthene*** (**5e**): 85% yield; white solid, melting point (mp) 178–180 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 0.99 (s, 6H), 1.12 (s, 6H), 2.16 (d, 2H), 2.26 (d, 2H), 2.51 (t, 4H), 4.83 (s, 1H), 7.48 (d, 2H), 8.08 (2H, 2H); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 27.7, 29.6, 32.6, 32.8, 41.2, 51.0, 114.9, 123.8, 129.8, 146.8, 152.0, 163.5, 196.7. MS (ESI): m/z calcd. for $C_{23}H_{25}NO_5$ $[M+H]^+$ = 395.17. Found %: C, 69.86: H, 6.37: N, 3.54. Calculated, %: C, 69.84: H, 6.35: N, 3.51.

3,3,6,6-Tetramethyl-9-(4-chlorophenyl)-1,8-dioxo-octahydroxanthene (**5f**): 82% yield; white solid, melting point (mp) 230–232 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 0.97 (s, 6 H, 2×$CH_3$), 1.11 (s, 6 H, 2× $CH_3$), 2.25(dd, 4 H, *J* = 1.6 Hz, *J* = 3.6 Hz, 2×$CH_2$, H-4, H-5), 2.51 (s, 4 H, 2 $CH_2$, H-2, H-7), 4.65 (s, 1 H, H-9), 7.27–7.45 (m, 4 H, ArH); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ (ppm) 198.8, 155.1, 140.3, 131.5, 130.5, 128.8, 113.9, 51.6, 44.6, 30.6, 27.5. MS (ESI): m/z calcd. for $C_{23}H_{25}ClO_3$ $[M+H]^+$ = 384.15. Found %: C, 71.77: H, 6.55. Calculated, %: C, 71.75: H, 6.52.

***3,3,6,6-Tetramethyl-9-(4-methoxyphenyl)-1,8-dioxo-octahydroxanthene*** (**5g**): 65% yield; white solid, melting point (mp) 244–246 °C; $^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) 1.01 (s, 6H), 1.12 (s, 6H), 2.18 (d, J = 16.4 Hz, 2H), 2.25 (d, J = 16.4 Hz, 2H), 2.48 (s, 4H), 3.75 (s, 3H), 4.72 (s, 1H), 6.77 (d, J = 8.8

Hz, 2H), 7.22 (d, J = 8.8 Hz, 2H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ (ppm) 27.3, 29.3, 30.9, 32.2, 40.9, 50.8, 55.1, 113.5, 115.8, 129.3, 136.5, 157.9, 162.1, 196.5. MS (ESI): m/z calcd. for $C_{24}H_{28}O_4$ $[M+H]^+$ = 380.20. Found %: C, 75.76: H, 7.42. Calculated, %: C, 75.74: H, 7.40.

***3,3,6,6-Tetramethyl-9-(4-methyl phenyl)-1,8-dioxo-octahydroxanthene*** (**5h**): 63% yield; white solid, melting point (mp) 250–252 °C; $^1$H NMR (400 MHz, $CDCl_3$): δ (ppm) 0.97 (s, 6 H, 2 × $CH_3$), 1.11 (s, 6 H, 2 × $CH_3$), 2.16 (m, 3H-$CH_3$), 2.22 (dd, 4 H, *J* = 1.6 Hz, *J* = 2.4 Hz, 2×$CH_2$, H-4, H-5), 2.47(s, 4 H, 2 ×$CH_2$, H-2, H-7), 4.68 (s, 1 H, H-9), 6.80 (d, 2H, Ar-H),7.02 (d, 2 H, Ar-H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ (ppm) 198.9, 155.1, 142.2, 129.4, 129.1, 128.7, 125.8, 113.9, 56.1, 51.6, 44.6, 39.1, 30.6, 27.5, 21.2. MS (ESI): m/z calcd. for $C_{24}H_{28}O_3$ $[M+H]^+$ = 364.20. Found %: C, 79.09: H, 7.74. Calculated, %: C, 79.06: H, 7.72.

## CONCLUSION

In summary, we have reported an efficient, green, riboflavin induced visible light mediated, simple and convenient approach for synthesizing xanthene derivatives. This reported synthetic protocol incorporates broad substrate scope relevancy, reduction in time with moderate to excellent yield of desired xanthene derivatives. This green synthetic pathway operates at room temperature that is superior to other available synthetic protocols and will play a vital role in organic and medicinal synthesis of target compound. This synthesis expands the selection of substrates for photoredox reactions utilising visible light by fulfilling the basic concept of green chemistry.

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