Orbital: The Electronic Journal of Chemistry
journal homepage: www.orbital.ufms.br
ISSN 1984-6428

| Vol 7 | | No. 2 | | April-June 2015 |

Full Paper

Tannic Acid an Efficient Catalyst for the Synthesis of 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one Derivatives

Deepak S. Kawade, Surekha N. Deshmukh, Jitendra B. Gujar, and Murlidhar S. Shingare*

Department of Chemistry, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad - 431004, Maharashtra, India.

Article history: Received: 29 December 2014; revised: 01 March 2015; accepted: 17 March 2015. Available online: 27 June 2015. DOI: http://dx.doi.org/10.17807/orbital.v7i2.683

Abstract: Tannic acid explore a highly efficient catalytic activity for the synthesis of 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one derivatives in excellent yields *via* cyclocondensation of aromatic aldehyde, β-naphthol and dimedone. Catalyst having advantages such as it is cheap and biodegradable and the protocol avoids the use of expensive catalyst and toxic solvent. We believe that this methodology is an efficient, simple, highly yielding, time saving and environmentally friendly.

Keywords: multicomponent reaction; solvent free; tannic acid; xanthenes derivatives

1. INTRODUCTION

In recent year paramount importance has been devoted to explore new methodologies for synthesis of bioactive heterocyclic under solvent free conditions. Many organic solvents have toxicity and volatile in nature particularly chlorinated hydrocarbon that are wildly used in large amounts for the organic transformation causes adverse effects to the environment [1, 2]. Therefore the development of solvent free catalytic reaction, high yielding and eco-friendly approach is highly desirable [3, 4].

Tertrahydrobenzo[a]xanthene motif exhibit good biological and pharmaceutical activities such as antibacterial, antiviral and anti-inflammatory activities. They have also employed as dye and p^H sensitive fluorescent material to monitor changes in intracellular pH [5-8]. Owing to the wide range of pharmacological and biological activities, the development of newer synthetic method enabling facile access to this heterocycle is still desirable. Several methods have been reported for the synthesis of xanthenes which includes by using poly(4-vinyl pyridinium) perchlorate [9], task specific acidic ionic liquid [NMP] H_2SO_4 [10], nano silica phosphoric acid [11], $HClO_4$-SiO_2 [12], proline triflate in water [13], Iodine [14], $InCl_3$ [15], $Sr(OTf)_2$ [16] and p-TSA [17]. Despite of the available methods less importance has been paid on the synthesis of 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one derivatives. However, these methods have a number of drawbacks which includes poor yields of product, harsh reaction condition, prolonged reaction times, high cost of catalyst and use of toxic organic solvents.

Therefore the development of safe easy environmentally benign method for the synthesis of 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one derivatives would be highly desirable.

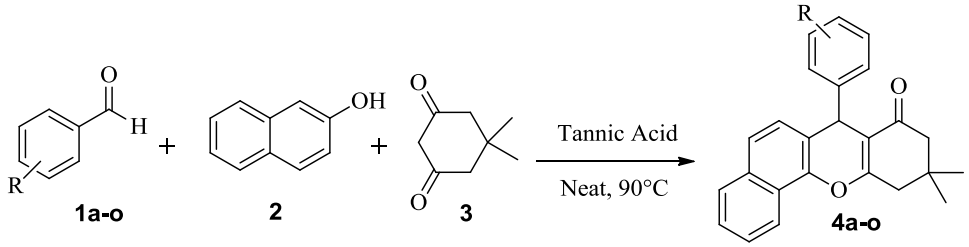
In recent year, Tannic acid has received considerable attention as an efficient catalyst for various organic transformations such as synthesis of imidazole derivatives [18], 1-amidoalkyl-2-naphthols,[19] and synthesis of benzodiepines derivatives [20].

Tannic acid is specific commercial form of tannin. Tannic acid is a naturally occurring plant polyphenol possing central glucose molecule, derivatized at its hydroxyl groups [19]. Tannic acid also employed as reducing agent, hydrogen donor and quinches of singlet oxygen.[19] It is weak acidity (pKa around 6) is due to the numerous phenol group in the structure.

By considering catalytical activity of tannic acid, we described an efficient method by employing tannic acid as an efficient catalyst for the synthesis of 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one

*Corresponding author. E-mail: prof_msshingare@rediffmail.com Tel.: +91 2402403311; fax: +91 2402403113.

derivatives by one pot cyclocondensation of aromatic aldehydes, β-naphthol and dimedone under solvent free condition (**Scheme 1).**



Scheme 1. Synthesis of 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one derivatives (**4a-4o**).

2. MATERIAL AND METHODS

All chemical were purchased from Aldrich chemical company and used without further purification. . ^{1}H NMR spectra were recorded on Bruker Advance 400, in DMSO in presence TMS as an internal standard.^{13}C NMR spectra recorded on Bruker DRX-300 in DMSO as solvent. Mass spectra were recorded on water UPLC TQD Mass spectrometer, showing $M^{+\cdot}$ peak. Melting points were recorded in open capillary method and uncorrected.

General procedure for the synthesis of 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one derivatives (4a-o)

A mixture of benzaldehyde (**1a**, 1mmol), β-naphthol (**2**, 1mmol), dimedone (**3,** 1 mmol) and tannic acid 10 mol % was stirred at 90°C under neat condition for 45 min (Table 4, entry-1). The progress of reaction was monitored by TLC, after completion of reaction mixture was cooled at room temperature and poured on crushed ice, the obtained crude solid product was filtered , dried and crystallized from ethanol to get corresponding 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one derivatives (**4a-o).**

Spectral data of some representative compounds are given here.

9,9-dimethyl-12-phenyl-8,9,10,12-tetrahydrotetraphen-11(7H)-one. **(4a):** White crystals, mp 147-149 °C; **^{1}H NMR** (DMSO-d_6, δ ppm): 0.94 (s, 3H, CH_3), 1.06 (s, 3H, CH_3), 2.24 (dd, 2H, CH_2), 2.55 (s, 2H, CH_2), 5.70 (S, 1H, CH), 7.34-7.46 (m,11 H, Ar-H). **^{13}C NMR** (75 MHz, DMSO): δ 27.16, 29.30, 32.30, 34.65, 41.38, 50.88, 114.3, 117.01, 117.6, 124.00, 124.87, 126.4, 127.0, 128.1, 128.5, 128.8, 129.01, 131.2. 131.49, 145.30, 147.98, 163.60, 195.96. **Mass** EI-MS *m/z* cal. 354.16, *m/z* obs. $[M^{+\cdot}+H]$ = 355.10

12-(3,4-dimethoxyphenyl)-9,9-dimethyl-9,10-dihydro-8H-benzo[a]xanthen-11(12H)-one.(4b): White crystals, mp 194-196 °C; **^{1}H NMR** (DMSO-d_6, δ ppm): 0.98 (s, 3H, CH_3), 1.12 (s, 3H, CH_3), 2.30 (s, 2H, CH_2), 2.57 (dd, 2H, CH_2), 3.75 (s, 3H, OCH_3), 3.80 (s, 3H, OCH_3), 4.75 (s, 1H), 6.65-8.00 (m, 9H, Ar-H). **^{13}C NMR** (75 MHz, DMSO): δ 27.08, 29.35, 32.26, 34.09, 41.42, 50.91, 55.65, 55.82, 110.75, 111.85, 114.34, 117.00, 117.73, 118.63, 120.41, 123.70, 124.92, 126.98, 128.37, 128.79, 131.43, 135.88, 147.75, 148.54, 198.9. **Mass** EI-MS *m/z* cal. 414.18, *m/z* obs. $[M^{+\cdot}+H]$ = 415.2.

12-(4-methoxyphenyl)-9,9-dimethyl-9,10-dihydro-8H-benzo[a]xanthen-11(12H)-one. **(4d):** White crystals, mp 205-206 °C; **^{1}H NMR** (DMSO-d_6, δ ppm): 0.92 (s, 3H, CH_3), 1.09 (s, 3H, CH_3), 2.27 (dd, 2H, CH_2), 2.53 (s, 2H, CH_2), 3.62 (S, 3H, CH_3), 5.66 (S, 1H, CH), 6.65-8.01 (m,10 H, Ar-H). **^{13}C NMR** (75 MHz, DMSO): δ 27.02, 29.30, 32.29, 34.10, 41.38, 50.91, 55.07, 113.3, 114.41, 117.2, 117.09, 123.7, 124.6, 127.0, 128.10, 128.5, 129.31, 131.6. 131.80, 137.21, 147.68, 157.67, 163.30, 196.01. **Mass** EI-MS *m/z* cal. 384.46, *m/z* obs. $[M^{+\cdot}+H]$ = 385.30

12-(4-chlorophenyl)-9,9-dimethyl-9,10-dihydro-8H-benzo[a]xanthen-11(12H)-one. **(4g):** White crystals, mp 182-184 °C; **^{1}H NMR** (DMSO-d_6, δ ppm): 0.96 (s, 3H, CH_3), 1.12 (s, 3H, CH_3), 2.20 (dd, 2H, CH_2), 2.51 (s, 2H, CH_2), 5.59 (S, 1H, CH), 7.14-7.95 (m,10 H, Ar-H). **^{13}C NMR** (75 MHz, DMSO): δ 27.08, 29.35, 32.36, 34.18, 41.38, 50.91, 113.7, 116.09, 123.4, 124.09, 126.18, 128.2, 128.5, 129.1, 129.5, 131.3, 131.6. 132.01, 144.02, 146.07, 164.09, 197.18. **Mass** EI-MS *m/z* cal. 388.12, *m/z* obs. $[M^{+\cdot}+H]$ = 389.09

3. RESULTS AND DISCUSSION

Initially, the reaction of benzaldehyde (**1a**, 1mmol), β-naphthol (**2,** 1mmol) and dimedone (**3,** 1mmol**)** was considered as model reaction, to optimize the reaction condition at 90 °C. The results are summarized in Table 1. The model reaction was first carried out in absence of catalyst in water the reaction was not gave desired product even after prolonged reaction time, then we employed different catalysts for model reaction some catalysts (Table 1) can catalyze this reaction with moderate yields but we found that using tannic acid the desire product formed with higher yield that is 96% yield within 45 minutes (Table 1, entry 9). In addition ethanol, methanol, DMF, toluene, acetonitrile were also employed as solvent for model reaction. In these cases product (**4a)** was formed in very low yields (Table 1 entries 10-12).

Table 1. Optimization of catalysts and solvents for model reaction[a].

Entry	Catalyst	Solvent	Temp (°C)	Time (min)	% Yield[b]
1	None	Water	Reflux	180	50
2	None	Ethanol	Reflux	180	55
3	Camphor sulphonic acid	Water	Reflux	180	60
4	Camphor sulphonic acid	Ethanol	Reflux	180	65
5	Camphor sulphonic acid	Solvent free	90	180	70
6	Boric acid	Water	Reflux	180	56
7	Boric acid	Ethanol	Reflux	180	60
8	Boric acid	Solvent free	90	180	68
9	Tannic acid	Water	Reflux	180	70
10	Tanic acid	Ethanol	Reflux	180	74
11	**Tannic acid**	**Solvent free**	**90**	**45**	**96**
12	Tannic acid	DMF	Reflux	180	60
13	Tannic acid	Toulene	Reflux	180	62
14	Tannic acid	Acetonitrile	Reflux	180	54

[a]Reaction conditions: benzaldehyde (1 mmol), β-naphthol (1 mmol), dimedone (1 mmol) and 10 mol % catalyst. [b]Isolated yields.

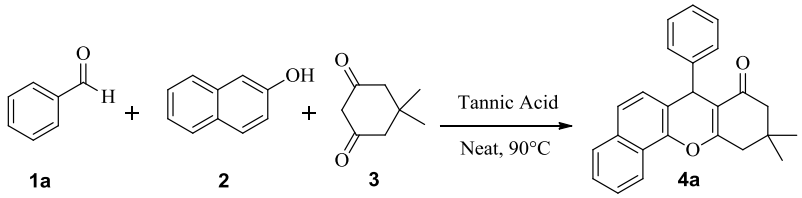
In recent year, more emphasis has been paid on solvent free synthesis, so we performed model reaction under solvent free condition we observed that the reaction was completed within 45 min and gave excellent yields of the products when using tannic acid under solvent free condition (Table1, entry 9).

Then to optimize the amount of catalyst, the model reaction was tested at different mol% of catalyst, summarized in Table 2. They reveal that at 10 mol% of tannic acid was employed for model reaction we observed that the reaction preceded smoothly and gave product (**4a)** in highest yield (Table 2, entry 2). Further increases the mol% of tannic acid did not lead to considerable change in the yield and reaction times.

Table 2. Effect of mol% of Tannic acid on model reaction[a]

Entry	Catalyst (Mol %)	Time (Min)	% Yield[b]
1	5	55	91
2	**10**	**45**	**96**
3	15	45	96
4	20	45	96
5	25	45	96

[a]Reaction conditions: benzaldehyde (1 mmol), β-naphthol (1 mmol), dimedone (1 mmol) and 10 mol % Tannic acid under neat condition at 90°C. [b]Isolated yields.



Scheme 2. Standard model reaction.

To find out optimum reaction temperature, we performed the model reaction at different temperature for the synthesis of (**4a)** with 10 mol% tannic acid under neat condition. (Table 3), We found that, the reaction did not proceeded at room temperature, then we increase temperature by 40, 50, 60, 70, 80, and 90°C for model reaction. We found that the model reaction proceeded smoothly and complete conversation of reactant to desire product (**4a**) in 96% yield within 45 min. (Table 3 entry 6). Further increasing in temperature did not affect the product yield.

Under optimized condition, we performed series of 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one derivatives. The results are summarized in Table 4. In order to furnish the versatility of this protocol, various types of aromatic aldehydes were used to synthesize corresponding xanthenes derivatives.

Table 3. Effect of temperature on model reaction[a].

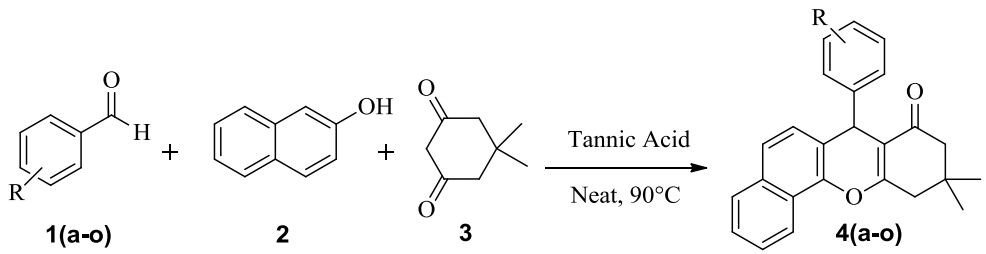
Entry	Temperature (°C)	Time (min)	% Yield[b]
1	40	180	No reaction
2	50	180	No reaction
3	60	180	50
4	70	120	90
5	80	55	94
6	**90**	**45**	**96**

[a]Reaction conditions: benzaldehyde (1 mmol), β-naphthol (1 mmol), dimedone (1 mmol) and 10 mol % Tannic acid under neat condition at 90°C. [b]Isolated yields.

The nature of electron withdrawing or donating substituent on the aromatic ring did not show any significant difference in the yield of xanthene derivatives.

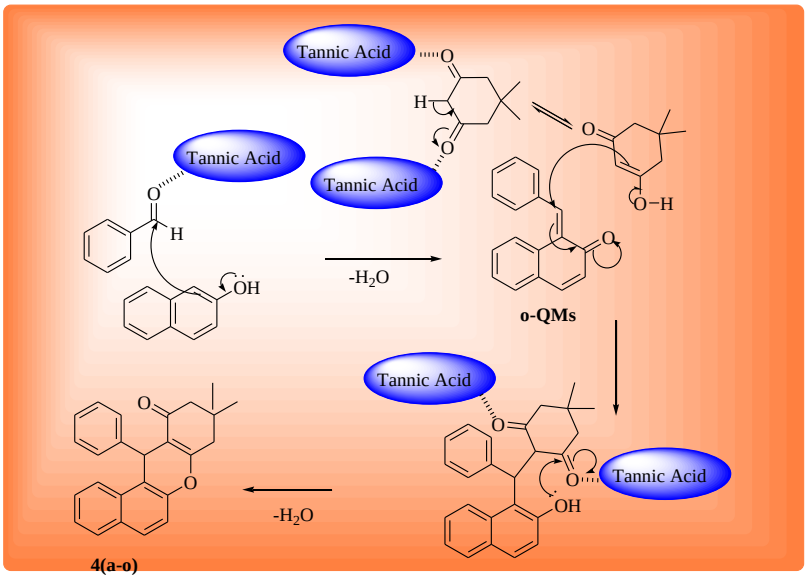
The plausible mechanism for catalytic activity of tannic acid in the synthesis of compound (**4a-o**) should be postulated, as shown in (**Scheme 3).**

Table 4. Tannic acid catalyzed synthesis of **4a-o**[a].



Entry	Product	Aldehyde R	Time (Min)	Yield[b]	Melting point (°C)	
					Found	Reported
1	**4a**	C_6H_5	45	96	147-149	149-150 [14]
2	**4b**	3,4–$(OMe)_2$-C_6H_3	55	94	194-196	198-199 [11]
3	**4c**	4-Me-C_6H_4	58	93	173-175	174-176 [14]
4	**4d**	4-OMe-C_6H_4	55	95	202-204	205-206 [14]
5	**4e**	4-F- C_6H_4	45	92	184-186	184-186 [10]
6	**4f**	2-Cl- C_6H_4	50	90	175-177	177-178 [21]
7	**4g**	4-Cl- C_6H_4	45	94	180-182	182-184 [21]
8	**4h**	3-OH- C_6H_4	58	91	238-240	240-241 [15]
9	**4i**	2-NO_2- C_6H_4	50	94	220-222	222-224 [21]
10	**4j**	4-NO_2- C_6H_4	48	89	232-234	234-235 [14]
11	**4k**	3-NO_2- C_6H_4	48	92	234-236	235-236 [14]
12	**4l**	4-OH- C_6H_4	54	93	148-150	150-151 [14]
13	**4m**	4-Br- C_6H_4	50	88	186-188	186-187 [14]
14	**4n**	2-OMe-C_6H_4	55	88	160-162	163-165 [15]
15	**4o**	2,4-$(Cl)_2$- C_6H_3	60	87	175-178	178-180 [15]

[a]Reaction conditions: Aromatic aldehyde (1 mmol), β-naphthol (1 mmol), dimedone (1 mmol) and 10 mol % Tannic acid under neat condition at 90°C. [b]Isolated yields.



Scheme 3. Plausible mechanism for synthesis of xanthene derivatives.

The reaction is thought to proceed; firstly, the tannic acid increases the electrophilicity of carbonyl carbon of aromatic aldehyde that will enhance the rate of condensation with β-naphthol, which leads to formation of ortho-quinone methides intermediate. Then it will reacted with dimedone *via* Michael addition followed by addition of phenolic hydroxyl group to the carbonyl carbon lead to cyclic hemiketal which on dehydration gave desire product **(4a).**

4. CONCLUSION

In conclusion, we explore an efficient methodology for the synthesis of 12-aryl-8,9,10,12-tetrahydrobenzo[a]xanthen-11-one derivatives in presence of tannic acid as catalyst under the solvent free condition. The advantage of this method over existing one are high excellent yields, easy work up procedure, low cost of tannic acid and reduced reaction time. This methodology provides access to compound that is useful in heterocyclic synthesis

5. ACKNOWLEDMENTS

The Emeritus Scientist Scheme awarded to MSS by the Council of Scientific and Industrial Research, New Delhi is gratefully acknowledge. The DSK also thanks to Head, Department of Chemistry, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad for providing laboratory facilities and SAIF, CDIR, Lukhnow for providing spectral data.

6. REFERENCES AND NOTES

[1] Nelson, W. M. *Oxford University Press, Oxford* **2003**.
[2] Liu, J.; Chen, J.; Zhao, J.; Zhao, Y.; Li.; Zhang, H. *Synthesis* **2003**, *17*, 2661. [CrossRef]
[3] Tanaka K.; Toda, F. *Chem. Rev*. **2000**, *100*, 1025. [CrossRef]
[4] Cave, G. W. V.; Raston, C. L.; Scott, J. L. *Chem. Commun*. **2001**, 2159. [CrossRef]
[5] Zhang, Z.-H.; Tao, X.-Y. *Aust. J. Chem*. **2008**, *61*, 77. [CrossRef]
[6] Zhang, Z.-H.; Liu, Y.-H. *Catal. Commun*. **2008**, *9*, 1715. [CrossRef]
[7] Li, J.-J.; Tao, X.-Y.; Zhang, Z.-H. *Phosphorus, Sulfur Silicon Relat. Elem*. **2008**, *183*, 1672. [CrossRef]
[8] Darviche, F.; Balalaie, S.; Chadegani, F. *Synth. Commun*. **2007**, *37*, 1059. [CrossRef]
[9] Nader, G. K.; *Polycycl. Aromat. Comp*. **2014**, *34*, 493. [CrossRef]
[10] Singh, H.; Kumari, S.; Khurana, J. M. *Chinese Chem. Lett*. **2014**, *25*, 1336. [CrossRef]
[11] Bamoniri, A.; Mirjalilib, Bi Bi F.; Nazemiana S. *Current Chem. Lett.* **2013**, *2*, 27. [CrossRef]
[12] Wu, L; Wu,Y;•Yan, F;Fang, L. *Monatsh Chem.* **2010**, *141*, 871. [CrossRef]
[13] Li, J; Lu, L; Su, W. *Tetrahedron Lett.* **2010**, *51*, 2434. [CrossRef]
[14] Wang, R. Z.; Zhang, Li. F; Cui, Z. S. *Synthetic Commun*, **2009**, *39*, 2101. [CrossRef]
[15] Nandi G. C.; Samai, S.; Kumar, R.; Singh, M. S. *Tetrahedron*, **2009**, *65*, 7129. [CrossRef]
[16] J. Li,. Tang, W.; Lu, L.; Su, W. *Tetrahedron Lett.* **2008**, *49*, 7117. [CrossRef]
[17] Khurana, J. M.; Magoo, D. *Tetrahedron Lett*. **2009**, *50*, 4777. [CrossRef]
[18] Shitole, N. V.; Shitole, B. V.; Kakde, G. K.; Shingare, M. S. *Orbital: Electron. J. Chem.*, **2013**, *5*, 1. [Link]
[19] Singh, R. K.; Duvedi, R. *Arabian J. Chem*. **2014**, In Press. [CrossRef]
[20] Sandhar. A.; Singh R. K. *Asian J. Chem.* **2012**, *24*, 5643.
[21] Foroughifar, N.; Mobinikhaledi, A.; Moghanian, H. *Int. J. Green Nanotechnol.* **2009**, *1*, 57. [CrossRef]