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An efficient synthesis of 2-arylbenzothiazoles: A natural approach.

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ABSTRACT
An efficient, simple and green protocol has been developed for the synthesis of 2-arylbenzothiazole via condensation of 2-aminothiophenol with various types of aromatic aldehydes using tamarind juice as a natural catalyst. The key advantages of this method are mild reaction conditions, inexpensive catalyst, short period of time and high to excellent yield.

KEYWORDS
2-arylbenzothiazole, Aromatic aldehydes, Tamarind juice, 2-Aminothiophenol.

1. INTRODUCTION

2-Arylbenzothiazoles is an important class of heterocyclic compounds due to their wide range of applications [1–9] in medicinal, industrial, and agricultural chemistry, material chemistry and nonlinear optics. Benzothiazoles bearing substituents at C_2 position are of great interest as these structural frameworks have proved to be an important class of privileged bicyclic substructures owing to their potent utility as imaging agents for β-amyloid, antituberculotic, chemiluminescent agents, calcium channel antagonists, antitumor, antiparasitics and photosensitizers[10-16].

Because of their wide range of synthetic, industrial and pharmacological application, many methods for the preparation of benzothiazole are reported in the literature. Among these methods are the condensation of 2-aminothiophenol with substituted nitriles, carboxylic acids, aldehydes, acyl chlorides or esters [17]. A number of catalysts namely, (PmIm)Br [18], TMSCl [19], I_2 [20], $ZrOCl_2 \bullet 8H_2O$ [21], PCC [22], H_2O_2, CAN [23], electro oxidation [24], Baker's yeast [25], PTSA [26],Silica sulfuric acid [27], $FeCl_3$/montmorillonite K-10 [28], $Sm(OTf)_3$[29-30] , Lithium bromide [31] and nano BF_3/SiO_2[32].

Today, there is a great demand in organic synthesis for green and inexpensive acids instead of conventional mineral acids such as HF, H_2SO_4 and HCl in chemical processes. Mineral acids are corrosive and hazardous catalysts [33].Due to the presence of tartaric and ascorbic acid in the tamarind fruit extract is sour in taste which could act as an effective acid catalyst by activating the carbonyl group of the aldehydes in organic reactions. The fruits of *Tamarindus indica* the aqueous extracts can be easily prepared (*vide* experimental). Easy preparation, handling and availability, inexpensive, non-hazardous nature and easier waste disposal are among the most common characteristics that make it a green catalyst. Although, a variety of catalysts have been reported for the synthesis of 2-aryl benzothiazole most of them suffer from disadvantages such as long reaction times, forceful conditions, low yields, low selectivity, tedious workup, and use of toxic or expensive reagents. Consequently, a new procedure that avoids these drawbacks is desirable.

2. MATERIALS AND METHODS

2.1. Materials

All the chemicals were purchased from commercial suppliers either from S. D. Fine, Spectrochem and they were used without further purification. Melting points were recorded by the open tube capillary method and are uncorrected. The progress of the reaction was monitored by thin-layer chromatography (TLC) analytical silica gel plates (Merck 60 F250). ^{1}H NMR and ^{13}C NMR spectra were recorded on Bruker Avance (400 and 100 MHz, respectively) instrument in $CDCl_3$ solvent, chemical shifts are given in δ ppm relative to tetramethylsilane (TMS) and coupling constants (*J*) are expressed in Hertz (Hz).

2.2. Preparation of Tamarind Juice from the Fruits of Tamarindus Indica

The raw Tamarind fruit was purchased from the local market. The upper shell of unripped fruit and its inner grain were removed. The hard green material (10 g) was boiled with water (50 ml),

cooled and it was centrifuged using micro-centrifuge (REMI RM-12C). The tamarind fruits of the clear portion of aqueous extract (pH=3) was used as catalyst for the reactions.

2.3. General procedure for the synthesis of benzothiazoles

Tamarind Juice (2 mL) was added to a stirred solution of the aromatic aldehyde (1 mmol) and 2-aminothiophenol (1 mmol) in ethanol (3 mL) and the mixture was stirred at room temperature for appropriate time (Table 2). The progress of the reaction was monitored by thin layer chromatography (TLC) (Hexane: Ethyl acetate, 8:2), after completion of the reaction, solid products were isolated by filtration and the crude products was recrystallized from ethanol.

2.4. Selected spectral data

2-(4-Methylphenyl) benzothiazole (3b)

IR (KBr pallets): *V*max 3026, 2811, 2343, 1606, 1581, 1520 cm^{-1}.^{1}H NMR (400 MHz, $CDCl_3$): δ=8.00-8.06 (m,3H), 7.96 (d, 1H,*J* = 8.0 Hz),7.51 (t,1H, *J* = 8.4 Hz), 7.41 (t,1H, *J* = 8.4 Hz), 7.36 (d,2H, *J* = 8.1 Hz), 2.45 (s,3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ= 168.0, 154.2, 141.6, 135.0, 131.0, 129.7, 127.3, 126.2, 125.0, 122.9, 121.6 and 21.2.

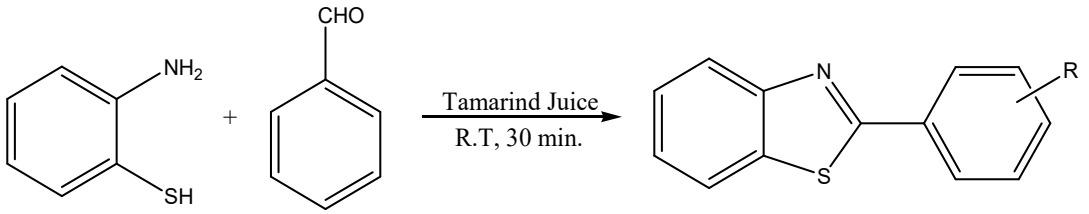
2-(4-Chlorophenyl)benzothiazole(3d)

IR (KBr pallets): *V*max 3081, 3032, 1613, 1593 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ= 8.06 (d, *J* = 8.2 Hz, 1H), 8.01 (d, *J* = 8.5 Hz, 2H), 7.88 (d, *J* = 8.0 Hz, 1H), 7.52 – 7.36 (m, 4H);^{13}C NMR (100 MHz, $CDCl_3$) δ= 166.6, 154.0, 137.0, 135.0, 132.1, 129.2, 128.7, 126.5, 125.4, 123.3, 121.6.

2-(4-N,N-Dimethylphenyl)benzothiazole(3g) IR (KBr)*/v*: 3355, 2358, 1598, 1478, 1210, 1017, 965, 743 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (t, *J* = 8.7 Hz, 3H), 7.83 (d, *J* = 7.9 Hz, 1H), 7.43 (t, *J* = 7.7 Hz, 1H), 7.30 (t, *J* = 7.6 Hz, 1H), 6.74 (d, *J* = 8.9 Hz, 2H), 3.05 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ= 168.8, 154.4, 152.2, 134.5, 128.9, 126.0, 124.2, 122.3, 121.4, 121.3, 111.7, 40.1.

3. RESULTS AND DISCUSSION

To explore the use of Tamarind Juice as a catalyst, reaction of benzaldehyde and 2-aminothiophenol for the preparation of 2-arylbenzothiazole was considered as a standard model reaction (Scheme 1). Model reaction was carried out in the absence of catalyst did not lead to desired product formation, indicating that intervention of catalyst was must for initiation of the reaction. To determine exact requirement of catalyst for the reaction, we investigated the model reaction using different amount of Tamarind Juice (Table 1). During this study, we observed that, 2 mL of tamarind juice proved to be an efficient catalyst to carry out the reaction smoothly. We further investigated the effect of solvents for the synthesis of 2-phenylbenzothiazole. During this study solvents like ethanol, water and aqueous ethanol were tested but, use of ethanol proved to be suitable solvent (Table 1). Encouraged by this result, in further set of experiments, in order to build the generality of the reaction, variety of electron-donating or electron-withdrawing substituted aromatic aldehydes were converted to 2-arylbenzothiazole derivatives in high to excellent yields (Table 2).

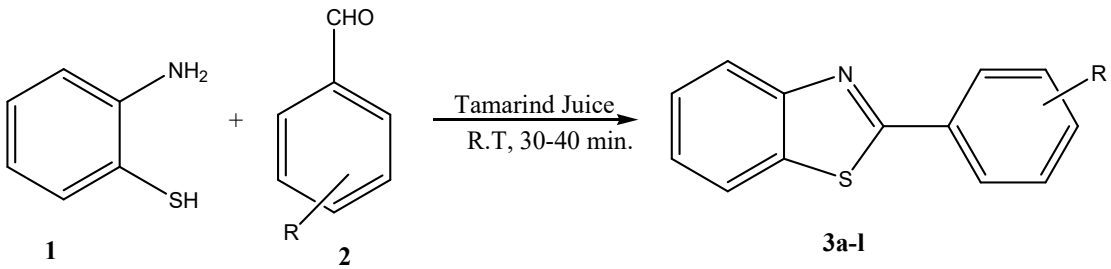


Scheme 1. synthesis of 2-phenylbenzothiazole.

Table 1. Effect of solvent and catalyst evaluation in synthesis of 2-phenylbenzothiazole at room temperature[a].

Entry	Solvent	Catalyst (mL)	Time (min.)	Yield %[b]
1	H_2O	------	60	Trace
2	H_2O:EtOH	1	50	65
3	EtOH	2	30	94
4	EtOH	3	30	94

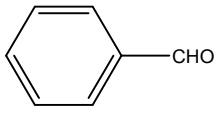
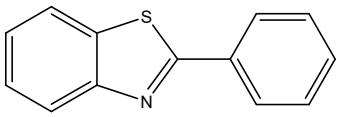
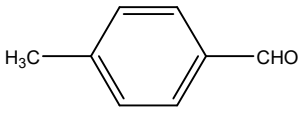
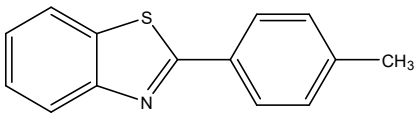
[a]Reaction conditions: benzaldehyde(1 mmol), 2-aminothiophenol (1 mmol), Tamarind Juice(2mL) at room temperature. [b]Isolated yields.

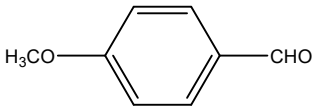
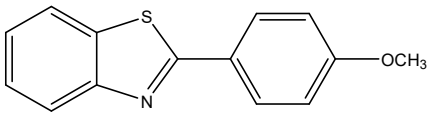
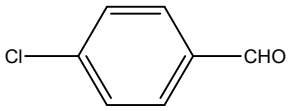
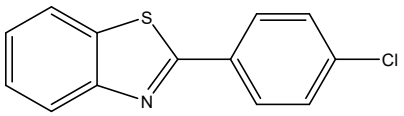
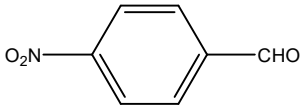
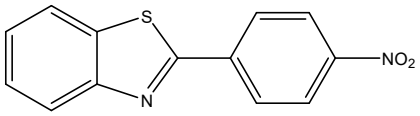
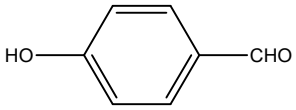
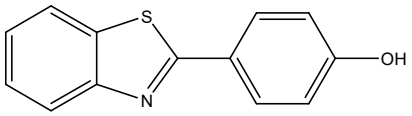
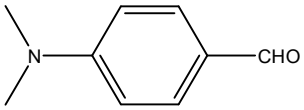
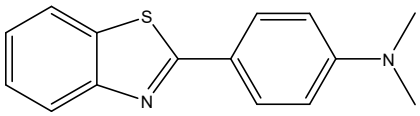
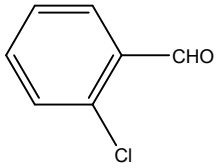
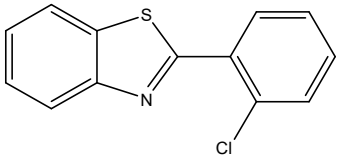
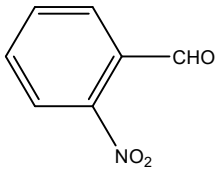
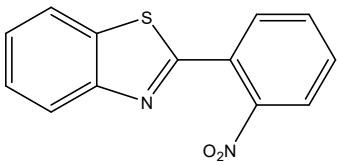
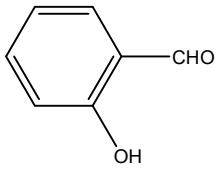
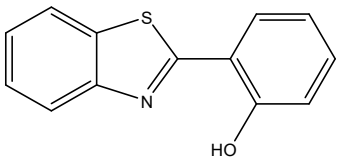
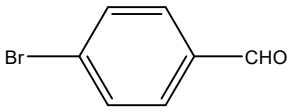
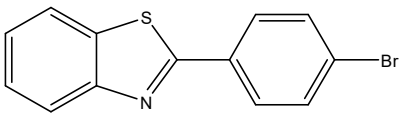
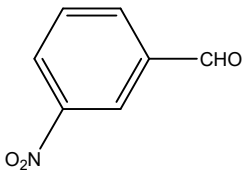
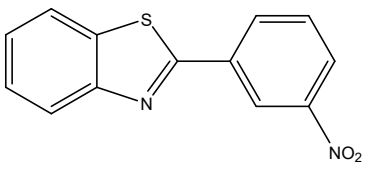


1 **2** **3a-l**

Scheme 2. Synthesis of 2-arylbenzothiazole.

Table 2. Synthesis of 2-arylbenzothiazole in the presence of Tamarind Juice[a].

Entry	Aldehydes	Products	Time (min.)	Yield[b] (%)	M.P°C [Ref.]
3a			30	94	112-114 [14]
3b			35	96	80–82 [27]

3c			35	94	125-126 [14]
3d			30	96	114–116 [27]
3e			32	96	224-226 [14]
3f			40	92	228–230 [27]
3g			35	95	172–174 [27]
3h			35	90	74-76 [14]
3i			35	91	122–123 [27]
3j			40	87	130–132 [27]
3k			35	95	130-132 [27]
3l			35	91	182-184 [14]

[a] Reaction of aldehyde 1 (1 mmol), 2-aminothiophenol 2 (1 mmol), and Tamarind Juice (2 mL)in ethanol (3 mL), at room temperature. [b]Isolated yields.

4. CONCLUSION

In summary, in this paper we report synthesis of 2-arylbenzothiazoles from the condensation of 2-amniothiophenol and various types of aromatic aldehydes catalyzed by *Tamarind Juice* in mildness of the reaction conditions, short reaction times, high to excellent yields, easy workup and eco-friendly of the catalyst are noteworthy advantages of these methods.

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