



Transition metal-free protodecarboxylation of electron rich aromatic acids under mild conditions



Jingxian Fang¹, Dangui Wang¹, Guo-Jun Deng, Hang Gong^{*}

The Key Laboratory of Environmentally Friendly Chemistry and Application of the Ministry of Education, College of Chemistry, Xiangtan University, Xiangtan 411105, China

ARTICLE INFO

Article history:

Received 11 August 2017

Revised 12 October 2017

Accepted 14 October 2017

Available online 16 October 2017

Keywords:

Decarboxylation

Metal-free

Aromatic acid

Halogenation

ABSTRACT

A mild and practical method for the transition metal-free protodecarboxylation of aromatic acids using readily available and safe sodium persulfate as initiator was described. This environment-friendly decarboxylation approach was performed at 60 °C in ethanol and could easily scale up to the gram level with a good yield. In Particular, the tandem reactions of decarboxylation and halogenation were achieved by the addition of the corresponding halogenating reagents to the reaction system.

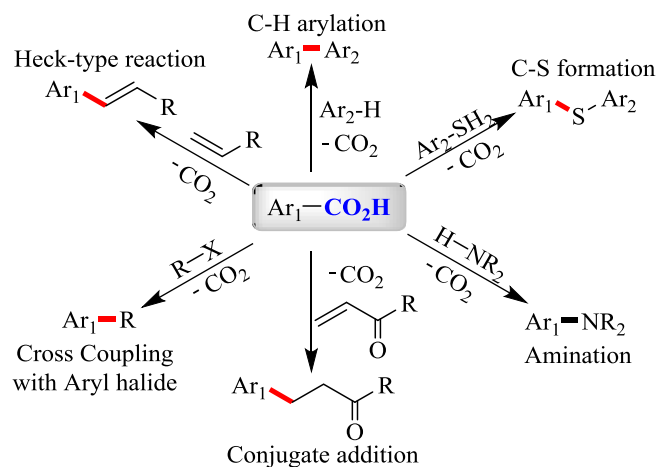
© 2017 Elsevier Ltd. All rights reserved.

Introduction

Inexpensive and readily available carboxylic acids often act as effective, green coupling partners to replace expensive and hard-to-preserve organometallic reagents in C–C bond formation reactions.¹ In such reactions, aromatic synthons are formed after decarboxylation and subsequently coupled with various coupling partners.² The decarboxylation of aromatic acids also plays a key role in oxidative coupling reactions, such as Heck-type reactions,³ C–H direct arylation,⁴ C–S formation,⁵ amination,⁶ allylation,⁷ conjugate addition,⁸ and other reactions (Scheme 1).⁹

However, these decarboxylation reactions currently suffer from the required harsh conditions because of the formation of unstable intermediates. Metal-catalyzed/promoted reactions at high temperature are the most common methods of aromatic acid protodecarboxylation (Scheme 2, A).¹⁰ Various transition metals, such as Cu, Ag, and Au, are applied in these strategies, and a reaction temperature exceeding 120 °C^{10a–d} or even 160 °C^{10e–i} is required. These transformations are also achieved under relatively mild reaction conditions in the presence of transition metals, such as Pd,^{11a,b} Rh,^{11c} Ag,^{11d,e} Cu,^{11f} Ir^{11g} and Hg,^{11h,i} which can reduce the reaction temperature to 70–120 °C (Scheme 2, B). In particular, Hg-mediated decarboxylation can be achieved under room temperature, but the requirement of stoichiometric amounts of highly toxic mercury salts is extremely harmful.^{11g,h} Additionally,

an increasing concern remains in pharmaceuticals and materials because of the difficulty of completely removing metal catalysts.¹² The metal-free procedure for this transformation is particularly advantageous (Scheme 2, C). In 2016, Miyake reported the DBU-catalyzed protodecarboxylation of aromatic acids, in which a high reaction temperature reaching 190–200 °C is required.^{13a} Strong acids, such as CF₃CO₂H, and Nafion-H, reportedly promote protodecarboxylation, and the reaction requires a reaction temperature of 162 °C and 100 °C,



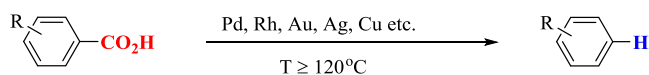
Scheme 1. Decarboxylative coupling/addition reactions.

* Corresponding author.

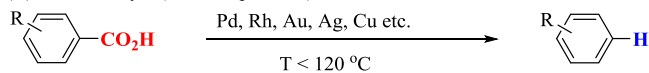
E-mail address: hgong@xtu.edu.cn (H. Gong).

¹ These authors are contributed equally.

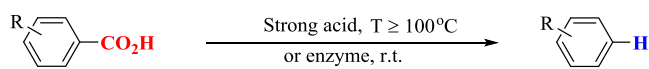
(A) Metal catalyst (high temperature):



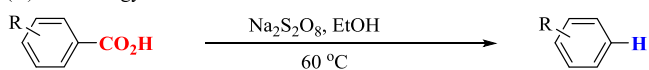
(B) Metal catalyst (mild temperature):



(C) Metal-free:



(D) Our strategy:



Scheme 2. Methods for the protodecarboxylation of aromatic acids and our strategy.

respectively.^{13b,c} Moreover, the corrosiveness of strong acid should not be ignored. Interestingly, the enzyme-catalyzed decarboxylation of aromatic acids was also reported by Nag.^{13d,e} They conducted the reactions in the juice of cucumber and fruits at room temperature respectively, and several phenolic acids were converted to the corresponding phenolic compounds. However, the substrate limitation was significant, and only three to four phenolic acids were achieved.

With this background, the development of metal-free protodecarboxylation of aromatic acids under safe, environmentally friendly, and mild conditions continues to attract attention. In this paper, a persulfate-induced strategy for the metal-free protodecarboxylation of aromatic acids in ethanol under mild reaction conditions is described (Scheme 2, D).

Results and discussion

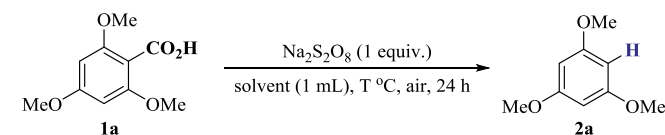
The direct C–H trifluoromethylation of arene in water–acetonitrile was recently reported by our group.¹⁴ When 2,4,6-trimethoxybenzoic acid was used as substrate, no trifluoromethyl group-substituted benzoic acid was detected, but the protodecarboxylation product was found at excellent yield (GC yield = 99%). Encouraged by this result, we immediately investigated the protodecarboxylation of aromatic acid.

First, various solvents were screened using 2,4,6-trimethoxybenzoic acid as substrate and sodium persulfate (1.0 equiv) as initiator at 60 °C in an air atmosphere (Table 1, entries 1–8). Excellent yield was achieved when dichloromethane, toluene, or ethanol was used as solvent (entries 4, 5, and 7). Considering the environmental impact and price, ethanol was selected as solvent in this conversion. The amount of sodium persulfate was studied (entries 7, 9–11). A high yield of 85% still could be obtained when 0.5 equiv. of sodium persulfate was used. The result did not improve with further increase in the amount of sodium persulfate. In particular, this transformation could not be conducted in the absence of sodium persulfate (entry 11). Afterward, the reaction temperature was checked (entries 7, 12, and 13). The reaction was found to be sensitive to temperature; a markedly low yield was obtained when the reaction temperature was reduced or increased (entries 12 and 13). The reaction was finished within 18 h (entries 14 and 15).

With the reliable protodecarboxylation of aromatic acids in hand [sodium persulfate (1.0 equiv.) at 60 °C in ethanol (1 mL) under air for 18 h], the substrate scope was then explored (Table 2). The reaction proceeded well when trimethoxy-substituted aromatic acids were used as substrates. The desired products were obtained at good to excellent yields (2a–j). However, this transfor-

Table 1

Selected optimization results.^a



Entry	Solvent (mL)	T (°C)	Yield (%)
1	CH ₃ CN	60	18
2	H ₂ O	60	41
3	EtOAc	60	7
4	DCM	60	90
5	Toluene	60	88
6	Acetone	60	34
7	EtOH	60	92
8 ^b	EtOH/H ₂ O	60	43
9 ^c	EtOH	60	85
10 ^d	EtOH	60	90
11 ^e	EtOH	60	7
12	EtOH	50	7
13	EtOH	70	70
14 ^f	EtOH	60	88
15 ^g	EtOH	60	92(85)

^a Unless otherwise noted, all reactions were conducted on a 0.1 mmol scale with 1 equiv. Na₂S₂O₈ in a sealed tube in 1 mL solvent under air at 60 °C for 24 h. Yields are detected by ¹H NMR using CH₃NO₂ as internal standard.

^b EtOH:H₂O = 1:1 (v:v).

^c 0.5 equiv. Na₂S₂O₈ is used.

^d 1.5 equiv. Na₂S₂O₈ is used.

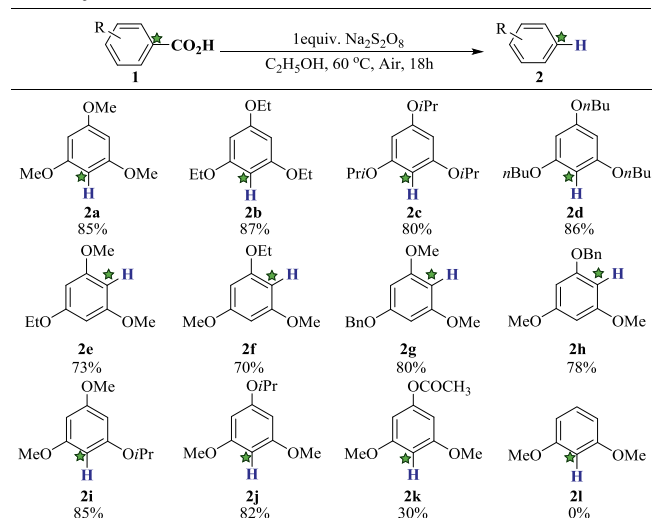
^e Without Na₂S₂O₈.

^f Reaction time is 12 h.

^g Reaction time is 18 h. The isolated yield was given in brackets.

Table 2

Decarboxylative of benzoic acid derivatives.^a



^a Unless otherwise noted, all reactions were conducted on a 0.1 mmol scale with Na₂S₂O₈ (1 equiv.) in a sealed tube in C₂H₅OH (1 mL) under an atmosphere of air for 18 h. The green star marked position is the original location of carboxyl. The isolated yield were presented.

mation was highly dependent on the electronic degree of the substrate. Even when a single methoxy group was changed to acetoxy group, the yield sharply decreased to 30% (2k). With 2,6-dimethoxybenzoic acid as substrate, no corresponding product could be found (2l). The results of other less electron-rich aromatic

Download English Version:

<https://daneshyari.com/en/article/7831347>

Download Persian Version:

<https://daneshyari.com/article/7831347>

[Daneshyari.com](https://daneshyari.com)