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Metal-Free Microwave-Assisted Decarboxylative Elimination for the Synthesis of Olefins

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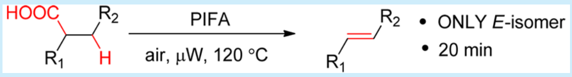
Supporting Information

ABSTRACT: A metal-free efficient synthesis of olefins via microwave-assisted direct decarboxylative elimination of arylacetic acids is described. This reaction, using commercially available reagent PIFA as oxidant, readily provides a variety of desired products in moderate to good yields.

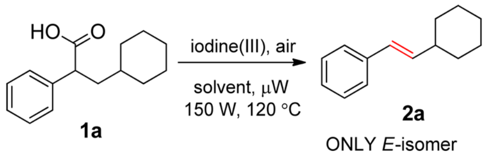


Direct decarboxylative transformations of carboxylic acids, which are usually considered as readily available, bench stable, and inexpensive feedstocks, provide a useful approach for chemical synthesis. In particular, decarboxylative couplings using transition-metal catalysts, such as Pd,[1] Ag,[2] Rh,[3] Cu,[4] and Ni,[5] have received significant attention. Recently, the utility of photoredox reagents including iridium complex[6] and Fukuzumi acridinium photooxidant[7] has emerged as an alternative strategy for direct decarboxylative functionalization of carboxylic acids.

Hypervalent iodine reagents are extensively used in organic synthesis as oxidants mainly due to their benign environmental quality, commercial availability, and easy handling. Although the efficient generation of a carbon-centered radical from a carboxylic acid is not easy, several methods for decarboxylative coupling reactions have been developed recently using iodine(III) derivatives, in combination with transition-metal[2d,8] or photoredox catalysis,[9,10] especially, Ag-catalyzed[2d] and photoinduced[10] decarboxylative alkynylation. Moreover, the iodine(III) dicarboxylate intermediates were produced in the photoredox system,[10d] followed by the formation of carbon-centered radicals. However, via a direct decarboxylative elimination of fatty acids to form olefins, there are only a few reports in which a transition-metal catalysis was employed.[11] Herein, we would like to report on metal-free direct decarboxylative elimination of arylacetic acids for the synthesis of olefins using iodine(III) reagents under microwave heat conditions.

We began by investigating the reaction parameters (Table 1). In the presence of air, commercially available iodine(III) reagents and organic solvents were screened under microwave irradiation conditions. In terms of chemical yield (only *E*-isomer found), PIFA ($PhI(OCOCF_3)_2$, phenyliodine bis(trifluoroacetate)) was determined as the best one with acetonitrile as the solvent (entries 1–6). The addition of acid or base did not improve the chemical yields (entries 7–9). When shortening the reaction time from 30 to 20 min, the chemical yield did not drop (entry 10). However, microwave irradiation for 10 min, no microwave heat, lower or higher reaction temperature, led to lower yields (entries 11–14).

Table 1. Optimization of Reaction Conditions[a]



entry	iodine(III)	solvent	*t* (min)	yield (%)[b]
1	PhIO	CH_3CN	30	<5
2	$PhI(OAc)_2$	CH_3CN	30	<5
3	PIFA	CH_3CN	30	85
4	PIFA	$PhCH_3$	30	10
5	PIFA	AcOEt	30	29
6	PIFA	DCE	30	52
7[c]	PIFA	CH_3CN	30	84
8[d]	PIFA	CH_3CN	30	40
9[e]	PIFA	CH_3CN	30	<5
10	**PIFA**	**CH_3CN**	**20**	**85**
11	PIFA	CH_3CN	10	63
12[f]	PIFA	CH_3CN	30	13
13[g]	PIFA	CH_3CN	20	<5
14[h]	PIFA	CH_3CN	20	79

[a] **1a** (0.20 mmol), iodine(III) (0.24 mmol), solvent (2 mL). [b] Isolated yield. [c] CF_3COOH (0.40 mmol). [d] *t*-BuOK (0.40 mmol). [e] K_2CO_3 (0.40 mmol). [f] Oil bath heat. [g] 100 °C. [h] 140 °C.

With the optimized reaction condition established, we first explored the substrate scope of aryl/diphenylacetic acids. As depicted in Figure 1, the reaction exhibited a broad generality, readily affording a variety of different aryl/diphenylvinyls in moderate to good yields. It should be noted that the direct decarboxylative elimination generated the sole *E*-olefins, which could be the thermodynamic products (**2b**–**2r**). Moreover, substituents or functional groups on the aromatic ring (**2b**–**2i**) or side chain (**2o**–**2r**) were well tolerated. We also observed that thienyl group (**2h**) or hydroxyl group (**2q**) led to a sharp

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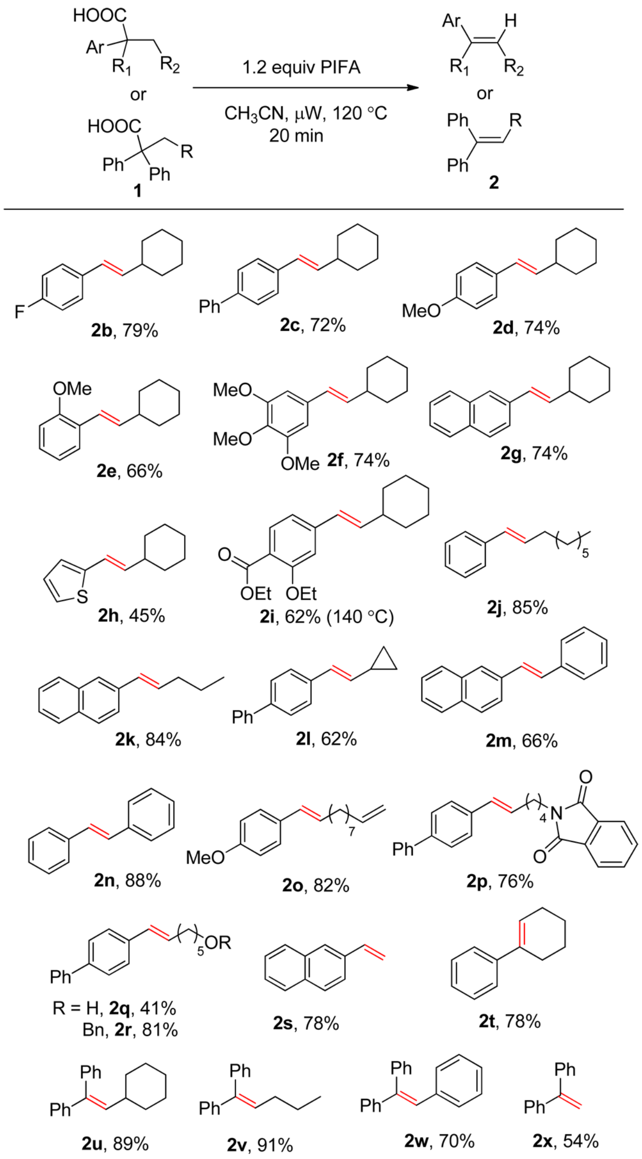
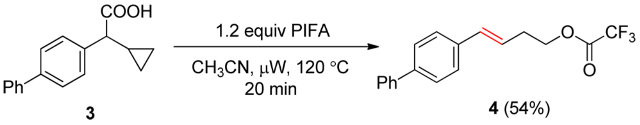


Figure 1. Substrate scope of aryl/diphenylacetic acids.

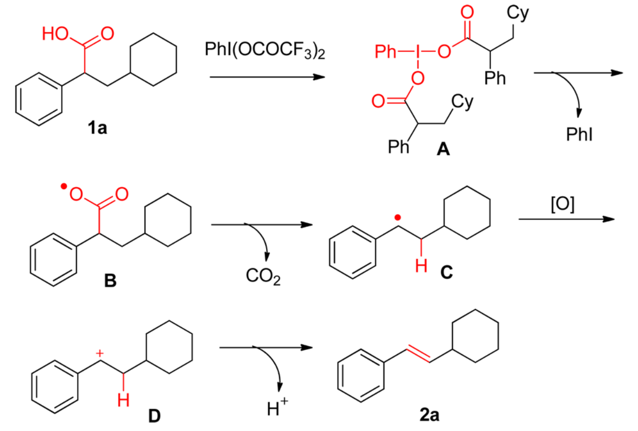
decrease of the yield. Higher reaction temperature was required to achieve olefin **2i**. When treating diphenylacetic acids with the same reaction condition, it also furnished the desired products in satisfactory yields (**2u**−**2x**).

To probe the mechanism of this decarboxylative elimination, arylacetic acid **3** with a cyclopropyl group was subjected to the optimized condition (Scheme 1). This reaction gave a cyclopropyl ring opening product **4**, suggesting that a radical-mediated process was involved. On the basis of the above results, a postulated mechanism is depicted in Scheme 2. The reaction of **1a** and PIFA provides iodine(III) dicarboxylate intermediate A,[9a,10d] which is liable to furnishing carboxylic radical **B**, followed by generating the corresponding carbon radical C and the release of CO_2. Subsequent oxidation[8] and elimination give corresponding olefin **2a**.

Scheme 1. Reaction of Cyclopropyl Acid 3

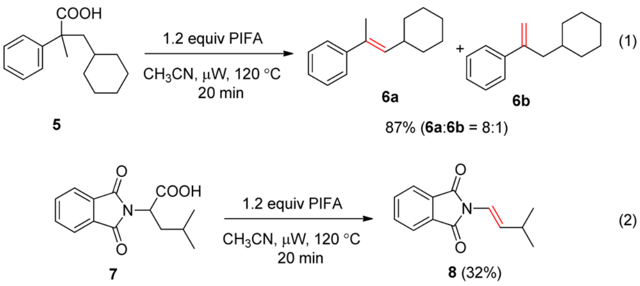


Scheme 2. Proposed Mechanism



In addition, we conducted the decarboxylative elimination of substrate **5**, which could be subject to proton leaving at the methyl site or methylene site (Scheme 3, eq 1). As expected, this reaction afforded an inseparable mixture of **6a** and **6b** with fair regioselectivity. Using phthalimide-protected amino acid instead of arylacetic acid as the substrate (Scheme 3, eq 2) also afforded the desired olefin **8**.

Scheme 3. Reactions of 5 and 7



In conclusion, we have developed the first example of a metal-free direct decarboxylative elimination for the synthesis of olefins under microwave irradiation conditions. The reaction, in the presence of commercially available PIFA, readily afforded a variety of aryl/diphenylvinyls in moderate to good yields. Preliminary mechanistic investigations suggested a radical process could be involved in the decarboxylative elimination reaction.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.orglett.5b03069.

Experimental details, characterizations, and copies of ^1H and ^{13}C NMR spectra for new compounds (PDF)

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Notes

The authors declare no competing financial interest.

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