An Efficient and Mild Procedure for the Preparation of Benzoic Acids via Oxidation of Aromatic Carbonyl Compounds by Employing *N*-Bromoimides and Mercuric Acetate System

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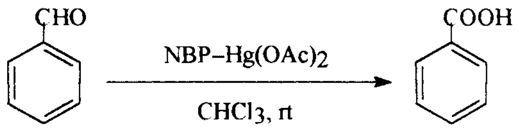
(Received April 23, 2001; CL-010374)

Aromatic carbonyl compounds are efficiently converted into the corresponding benzoic acids under mild reaction conditions by employing *N*-bromoimide and mercuric acetate in good to excellent yields. This procedure works efficiently at room temperature for aromatic aldehydes as well as aromatic ketones to give the corresponding benzoic acids.

Oxidation of carbonyl compounds into the corresponding carboxylic acids is one of the most important reactions in organic chemistry, as the carboxylic acids are versatile intermediates in a variety of synthetic transformations. In recent years oxidation of organic compounds under non-aqueous and aprotic conditions is emerging as a useful reaction. For this purpose various oxidants are reported in the literature.[1] Recently, carbonyl compounds are efficiently converted into carboxylic acids by using H_2O_2[2], sodium chlorite[3], and lithium hypochlorite–clorax as an oxidative mixture.[4] However, some of the reagents suffer from disadvantages such as instability, hygroscopicity, low selectivity, long reaction time, difficulty of preparation of the reagent, high cost, and need for a large excess of the reagent. Thus, a milder, selective and inexpensive reagent is still in demand.

It is well known that *N*-haloimides are useful reagents for oxidation of benzyl alcohols[5], α–hydroxy acids[6], methylbenzenes[7], and halogenation of alkenes[8]. A recent report by Rao et al[9] described the oxidative deamination of aliphatic amines to carbonyl compounds by *N*-bromophthalimide (NBP)–$Hg(OAc)_2$ system. However, oxidation of carbonyl compounds has not been studied.

We wish to report here an efficient and mild oxidation of aromatic carbonyl compounds to the corresponding carboxylic acids using the *N*-haloimides and $Hg(OAc)_2$ system.



1 a–q 2 a–q

We found that the treatment of aromatic carbonyl compounds with NBP–$Hg(OAc)_2$ in chloroform at room temperature afforded the corresponding carboxylic acids (benzoic acids) in quantitative yields[10] (Table 1). The oxidation of carbonyl compounds in the presence of NBP–$Hg(OAc)_2$ system proceeds rapidly to afford high yields of the corresponding carboxylic acids. All the products were characterized by IR, ^1H NMR, mass spectra, and other physical data or by comparison of their data with those of authentic samples.

Table 1. Preparation of benzoic acid from carbonyl compounds by employing *N*-haloimides and $Hg(OAc)_2$ system

Entry	Substrate	Product[a]	NBS		NBP	
			Reaction time/h	Yield/%[b]	Reaction time/h	Yield/%[b]
1a	Benzaldehyde	Benzoic acid	2	88	1.5	94
1b	2-Naphthaldehyde	2-Naphthoic acid	2	88	2	88
1c	4-Chlorobenzaldehyde	4-Chlorobenzoic acid	3	75	2	88
1d	2,6-Dichlorobenzaldehyde	2,6-Dichlorobenzoic acid	3	70	2	86
1e	2-Nitrobenzaldehyde	2-Nitrobenzoic acid	3	75	2	88
1f	2-Cyanobenzaldehyde	2-Cyanobenzoic acid	3	70	2	86
1g	Vanillin	Vanillic acid	3	72	1.5	88
1h	Salicylaldehyde	Salicylic acid	2.5	65	1.5	86
1i	4-Hydroxybenzaldehyde	4-Hydroxybenzoic acid	2.5	68	2	90
1j	3,4-Dimethoxybenzaldehyde	3,4-Dimethoxybenzoic acid	2.5	86	1.5	92
1k	2-Hydroxyacetophenone	Salicylic acid	2.5	76	2	88
1l	2,4-Dihydroxyacetophenone	2,4-Dihydroxybenzoic acid	2.5	80	2	86
1m	4-Hydroxyacetophenone	4-Hydroxybenzoic acid	2.5	82	2	92
1n	2-Cyanoacetophenone	2-Cyanobenzoic acid	2.5	86	1.5	92
1o	2-Nitroacetophenone	2-Nitrobenzoic acid	2.5	68	2	90
1p	Acetophenone	Benzoic acid	2.5	78	2	94
1q	Benzophenone	Benzoic acid	2.5	90	2	94

[a] All products were characterized by IR. ^1H NMR and Mass spectra.
[b] Isolated yields.

To check the generality of oxidative properties of *N*-haloimides, the reactions were carried out using *N*-bromosuccinimide (NBS) in place of NBP. It was observed that the reactions were slower and it took longer time in case of NBS compared to NBP. Thus, it is evident that NBP is a more efficient oxidising agent than NBS. The reactions failed to proceed in the absence of *N*-haloimides, even after a longer period under refluxing conditions. Thus, *N*-haloimides are necessary for the reaction. It is also observed that the reactions were sluggish in the absence of $Hg(OAc)_2$. Thus, it is assumed that $Hg(OAc)_2$ is acting as a co-oxidant.

While optimizing the reaction conditions for the oxidation of carbonyl compounds, it was noticed that the yields were maximum with a 1:1:1 (substrate:NBP:$Hg(OAc)_2$) stoichiometric ratio. A variety of aprotic solvents such as dichloromethane, 1,2-dichloroethane, and acetonitrile were screened. However, none of these solvents were superior to chloroform.

Halo-aromatic aldehydes showed remarkable selectivity in giving the corresponding carboxylic acids (1c–1d) without any dehalogenation and other carbonyl compounds with oxidizable funtional groups (1f–1n) were selectively oxidized into the corresponding carboxylic acids without affecting the substituent. It is also worth mentioning that benzophenone was also oxidized smoothly into benzoic acid (1q) as the main product without the formation of phenol under the above reaction conditions. It is observed that neither electron donating group nor electron withdrawing group affects the yield of the product.

This procedure proved satisfactory even with bifunctional substrates such as phthalaldehyde, diacetylbenzene which were efficiently oxidized into the corresponding phthalic acids in good yields. The results demonstrate the synthetic utility of this method.

In conclusion, the present study demonstrates the novelty of NBP–Hg(OAc)$_2$ combination system which shows unique selectivity and constitutes a useful alternative to the commonly accepted procedure for the synthesis of benzoic acids. Moreover, this simple, mild and efficient method affords various benzoic acids in excellent yields without formation of any undesirable side products.

One of the authors A. Anjum. thanks Nawab Shah Alam Khan, Chairman and Nawab Mahboob Alam Khan, Secretary of Nawab Shah Alam Khan Centre for Post Graduate Studies and Research, Mallepally, for their constant encouragement.

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10 A typical procedure is as follows: To a solution of benzaldehyde (1a) (1 mmol) in chloroform (20 cm^3) was added *N*-bromophthalimide (1 mmol) and Hg(OAc)$_2$ (1 mmol) and the reaction mixture was stirred for 2–3 h at rt. After completion of reaction as indicated by TLC, the reaction mixture was washed with water (25 cm$^3 \times 2$). The organic layer was separated and dried over Na$_2$SO$_4$. Evaporation of the solvent under vacuum and purification by column chromatography using ethyl acetate:hexane (3:7) as eluent gave the pure benzoic acid (2a) in 94% yield : mp 120–122 °C; ^{1}H NMR(CDCl$_3$) δ 7.2–8.2 (m, ArH, 5H) 11.4 (COOH, 1H), MS *m/z* 121, 105, 77.