$Fe(NO_3)_3$•$9H_2O$-Catalyzed Aerobic Oxidative Deoximation of Ketoximes and Aldoximes under Mild Conditions

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Abstract

A mild, simple process for the effective aerobic oxidative deoximation of a wide range of ketoximes and aldoximes has been developed, which utilizes $Fe(NO_3)_3{\cdot}9H_2O$ as the single catalyst and molecular oxygen as the green oxidant. The environmentally benign protocol provides moderate to excellent yield and broad functional groups tolerance, and a valuable synthetic method for practical applications. According the relevant verification experiment, a plausible mechanism has been proposed.

Key words: Fe-catalyst, deoximation, molecular oxygen, aldoximes, ketoximes.

Introduction

As an important class of organic compounds in organic synthesis,[1] oximes play an important role in protecting groups [2] and are extensively used for the purification and characterization of carbonyl compounds.[3] The oximes can be prepared from noncarbonyl compounds as well as from carbonyl compounds.[4] The regeneration of carbonyl compounds from oximes provides an alternative method for the preparation of aldehydes and ketones.[5] Therefore, various methods, including acid-catalytic hydrolysis, oxidative and reductive deoximation, have been developed for these processes.[6] Among these methods, most of them, though they are efficient, are not free from drawbacks such as toxic and hazardous oxidants or reductants and large amounts of strong Lewis and Brönsted acids used in these systems being generally needed to be reduced, oxidized and neutralized, which usually causes serious environmental pollution. Besides, longer reaction time, low yield of products, difficulty in isolating the products and formation of over-oxidized products are also the problems.

In the past decades, there has been increasing interest in developing methods for transition metals and transition-metal complexes catalyzed an oxidation reactions employing oxygen as the terminal oxidant.[7] Especially iron element, as an exceedingly abundant metal on the earth,[8] has been attracted more attention on oxidation reactions. Remarkably, noteworthy efforts have been contributed to the biomimetic oxidation mediated by iron porphyrins to effectively activate O_2 in the past years.[9] Except for them, difficulties, to directly activate the O_2 by commercially available simple iron salts still exist, and only minority coupled catalytic systems have been developed, facilitating the aerobic oxidative procedures via a low-energy pathway by introducing some suitable electron-transfer mediators.[10] Since 2005, Liang's group has sequentially disclosed several efficient catalytic systems for aerobic oxidation of alcohols with the combination of $FeCl_3$, $NaNO_2$, and TEMPO or 4-acetamido-TEMPO.[11] Subsequently, Zhang and co-workers synthesized a novel bimagnetic imidazolium salt

[Imim-TEMPO][$FeCl_4$], which proved to be effective for oxidation of benzyl alcohols in the presence of $NaNO_2$.[12] The oxidative deoximation, especially using oxygen as the terminal oxidant, is an important transformation in organic synthesis for both environmental and economic advantages and many excellent examples have been continuously reported during the past years.[13] Currently, our group has developed an efficient deoximation system using O_2 as the green oxidant, $FeCl_3$/TEMPO as the catalysts without any other additives.[14a] And two years previously, we also had reported a novel system using $NaNO_2$ as the catalyst, O_2 as the terminal oxidant, and Amberlyst-15 as a recyclable initiator for oxidative cleavage of oximes to the corresponding carbonyl compounds.[14b] Besides, there are also some examples involving Fe-catalyzed aerobic oxidative deoximation reactions have been reported.[15] Notably, all these systematically studies have confirmed that $NaNO_2$, or TEMPO combines with Fe(III) salts is essential for the catalytic oxidation cycle, which encourages us to develop an easier system to proceed deoximation reaction. Herein, a $Fe(NO_3)_3{\cdot}9H_2O$-catalyzed aerobic oxidative deoximation system without any other extra additives might be established.

Experimental Section

General

Reagents were purchased at commercial quality and used without further purification unless otherwise stated. All ketone or aldehyde were purchased from Aladdin reagent Co., LTD (Shanghai). Iron nitrate nonahydrate, iron salts were purchased from Aladdin reagent Co., LTD (Shanghai) too. Yields of the products referred to isolated yields purified by column chromatography on silica gel (300-400 mesh) produced by Qingdao Marine Chemical Factory, Qingdao (China) with hexane and ethyl acetate (for ketoximes, 8:1 and for aldoximes, 6:1) to give the corresponding carbonyl compounds. NMR spectra were recorded on Bruker

AVANCE III 500MHz instrument with TMS as internal standard. Coupling constants were reported in Hertz (Hz). Melting points were measured with micro melting point apparatus and were uncorrected.

General Procedure for Preparation of Oximes (1a-x)

A mixture of aldehyde or ketone (25.0 mmol), $NH_2OH \cdot HCl$ (1.5 eq.), CH_3COONa (2.5 eq.), ethyl alcohol (10.0 mL) and water (30.0 mL) were placed in a 100mL round-bottomed flask equipped with a magnetic stirrer. Then the mixture was stirred under reflux, the progress was monitored by TLC. After the reaction, the contents were poured into a beaker (250 ml). After cooling, the precipitate was filtered with suction, thoroughly washed with water and dried under vacuum, then recrystallization with ethyl alcohol to obtain a pure solid.

General Experimental Procedure for Deoximation to the Corresponding Carbonyl Compounds

Oximes (1.0 mmol), $Fe(NO_3)_3{\cdot}9H_2O$ (0.025 mmol) were introduced into an equipped with a 50 mL Schlenk flask magnetic stirrer and the flask was purged several times with oxygen (balloon filled). Then the solvent ($PhCH_3$ 4.0 mL) was injected into the flask and the reaction mixture was stirred at 37 ^{o}C for 1.5 hours. After the reaction was completed (which was monitored by TLC), the products referred to isolated yields purified by column chromatography on silica gel (300-400 mesh) with hexane and ethyl acetate (for ketoximes, 8:1 and for aldoximes, 6:1) to give the corresponding carbonyl compounds.

Acetophenone (2a): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.91 – 7.89 (d, *J* = 8.3 Hz, 2H), 7.53 - 7.46 (m, 1H), 7.42 - 7.36 (m, 2H), 2.53 (s, 3H).

4-Fluoroacetophenone (2b): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.94 – 7.91 (ddd, *J* = 8.0, 5.4, 1.5 Hz, 2H), 7.11 - 7.02 (m, 2H), 2.53 (s, 3H).

4-Chloroacetophenone (2c): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ -7.85 – 7.63 (m, 2H), 7.36 – 7.26 (dt, *J* = 9.1, 2.0 Hz, 2H), 2.54 (s, 3H).

4-Bromoacetophenone (2d): mp 50-51 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.81 – 7.79 (m, 2H), 7.60 – 7.57 (m, 2H), 2.57 (s, 3H).

3-Chloroacetophenone (2e): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.85 (d, J = 1.7 Hz, 1H), 7.78 – 7.76 (m, 1H), 7.48 - 7.45 (dt, J = 7.9, 2.0 Hz, 1H), 7.37 - 7.33 (td, J = 7.8, 1.3 Hz, 1H), 2.54 (s, 3H).

2,4-Dichloroacetophenone (2f): mp 33-34 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.54 (d, J = 8.3 Hz, 1H), 7.44 (d, J = 2.0 Hz, 1H), 7.31 (dd, J = 8.3, 2.0 Hz, 1H), 2.64 (s, 3H).

4-methoxyacetophenone (2g): mp 38-39 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.95 – 7.92 (m, 2H), 6.98 - 6.87 (m, 2H), 3.86 (s, 3H), 2.55 (s, 3H).

2-Hydroxyacetophenone (2h): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 12.26 (s, 1H), 7.68 (dd, J = 8.0, 1.4 Hz, 1H), 7.44 – 7.41 (m, 1H), 6.93 (d, J = 8.4 Hz, 1H), 6.87 – 6.84 (t, J = 7.6 Hz, 1H), 2.57 (d, J = 0.9 Hz, 3H).

3,4-Dimethoxyacetophenone (2i): mp 48-52 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.52 – 7.50 (m, 1H), 7.46 (s, 1H), 6.85 - 6.80 (m, 1H), 3.88 (d, J = 5.8 Hz, 6H), 2.50 (s, 3H).

4-Methylacetophenone (2j): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.85 - 7.80 (m, 2H), 7.22 (d, J = 7.9 Hz, 2H), 2.54 (s, 3H), 2.38 (s, 3H).

4-Phenylacetophenone (2k): mp 121-124 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 8.07 - 8.04 (m, 2H), 7.72 - 7.69 (m, 2H), 7.66 - 7.63 (m, 2H), 7.49 (td, J = 6.9, 1.6 Hz, 2H), 7.44 – 7.41 (m, 1H), 2.66 (s, 3H).

Propiophenone (2l): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.97 - 7.92 (m, 2H), 7.55 7.48 (m, 1H), 7.42 (t, J = 7.7 Hz, 2H), 2.97 (q, J = 7.2 Hz, 2H), 1.20 (t, J = 7.2 Hz, 3H).

4-Methylpropiophenone (2m): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.84 (d, J = 8.2 Hz, 2H), 7.21 (d, J = 8.5 Hz, 2H), 2.96 – 2.91 (q, J = 7.3 Hz, 2H), 2.37 (s, 3H), 1.21 – 1.18 (s, 3H).

1-Tetralone (2n): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.98 (dd, *J* = 7.8, 1.1 Hz, 1H), 7.41 (td, *J* = 7.5, 1.4 Hz, 1H), 7.24 (t, *J* = 7.6 Hz, 1H), 7.19 (d, *J* = 7.6 Hz, 1H), 2.90 (t, *J* = 6.1 Hz, 2H), 2.61 - 2.57 (m, 2H), 2.07 (dt, *J* = 12.7, 6.4 Hz, 2H).

Benzophenone (2o): mp 47-49 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.83 (dt, *J* = 8.4, 1.5 Hz, 4H), 7.63 – 7.59 (m, 2H), 7.52 - 7.48 (m, 4H).

4-Methylbenzophenone (2p) : mp 53-57 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.80 (dt, *J* = 8.4, 1.5 Hz, 2H), 7.76 - 7.72 (m, 2H), 7.62 - 7.56 (m, 1H), 7.52 - 7.46 (m, 2H), 7.30 (d, *J* = 7.9 Hz, 2H), 2.46 (s, 3H).

Benzaldehyde (2q): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 10.00 (s, 1H), 7.86 (dt, *J* = 8.3, 1.5 Hz, 2H), 7.63 - 7.58 (m, 1H), 7.50 (t, *J* = 7.6 Hz, 2H).

4-Methylbenzaldehyde (2r): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 9.97 (s, 1H), 7.78 (d, *J* = 8.1 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 2.45 (s, 3H).

3,4-Dimethylbenzaldehyde (2s): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 9.91 (s, 1H), 7.63 - 7.57 (m, 2H), 7.26 (d, *J* = 7.7 Hz, 1H), 2.31 (d, *J* = 4.0 Hz, 6H).

4-Chlorobenzaldehyde (2t): mp 48 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 9.98 (s, 1H), 7.83 - 7.80 (m, 2H), 7.52 - 7.49 (m, 2H).

4-Bromobenzaldehyde (2u): mp 55-58 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 9.97 (s, 1H), 7.76 - 7.73 (m, 2H), 7.69 - 7.66 (m, 2H).

1-Naphthaldehyde (2v): mp 1-2 °C. ^{1}H NMR (500 MHz, Chloroform-d) δ 10.34 (s, 1H), 9.26 (d, *J* = 8.6 Hz, 1H), 8.01 (d, *J* = 8.2 Hz, 1H), 7.90 - 7.85 (m, 2H), 7.68 – 7.65 (m, 1H), 7.58 - 7.52 (m, 2H).

2-Acethylthiopene (2w): liquid. ^{1}H NMR (500 MHz, Chloroform-d) δ 7.62 – 7.61 (m, 1H), 7.59 - 7.53 (m, 1H), 7.04 (dd, *J* = 4.9, 3.7 Hz, 1H), 2.47 (s, 3H).

2-Acethylfuran (2x): mp 29-30 °C. 1H NMR (500 MHz, Chloroform-d) δ 7.42 (d, J = 1.5 Hz, 1H), 7.00 (d, J = 3.6 Hz, 1H), 6.36 – 6.34 (dd, J = 3.5, 1.7 Hz, 1H), 2.27 (s, 3H).

Results and discussion

At outset of this study, we embarked on condition optimization with acetophenone oxime **1a** as model substrate, and the detailed results were summarized in **Table 1**. Surprisingly, the initial result shows that the desired product **2a** was formed in 83% yield when the reaction was carried out with 10 mol% $Fe(NO_3)_3{\cdot}9H_2O$, 1 atm O_2 as the oxidizing agent at 37 °C for 1.5 h (**Table 1**, entry 1). In following studies, other Fe catalysts such as $Fe(OAc)_3$, $FeCl_3$, $FeBr_3$ and $Fe(OTf)_3$ were also tried (**Table 1**, entries 2-5). Unfortunately, these catalysts showed any catalytic activity in this reaction, which indicates the essential of both Fe(III) and NO_3^- for this catalytic oxidative deoximation reaction. Aimed at further improve the reactivity, the amounts of $Fe(NO_3)_3{\cdot}9H_2O$ were further screened (**Table 1**, entries 6-10). It was found that with 2.5 mol% $Fe(NO_3)_3{\cdot}9H_2O$, the desired product **2a** was formed in 93% yield. When PhCl, Hexane, DCE, CH_3CN, or CCl_4 was used to replace toluene as the reaction medium, the yield of **2a** would be decreased (**Table 1**, entries 11-15 vs entry 8). Meanwhile, other solvents, like tert-amy alcohol, ethyl acetate (AcOEt) and cyclohexane were less effective for this transformation (for details see **Table S1** in **Supporting Information**). Furthermore, the factors of temperature (**Table 1**, entries 16 and 17) and the reaction time (**Table 1**, entries 18 and 19) all had significant influences to this reaction (for details see **Table S1** in **Supporting Information**). Meanwhile, we found that the reaction could not progress under N_2 (**Table 1**, entry 20) and also ineffective under an air which gained low yield (**Table 1**, entry 21), which means that oxygen plays an essential role in this proceed. Finally, it was noteworthy to emphasize that when the reaction was carried out with 4Å MS, the yield of desired product **2a** was obviously decreased (**Table 1**, entry 22).

Table 1. Optimization of reaction conditions.[a]

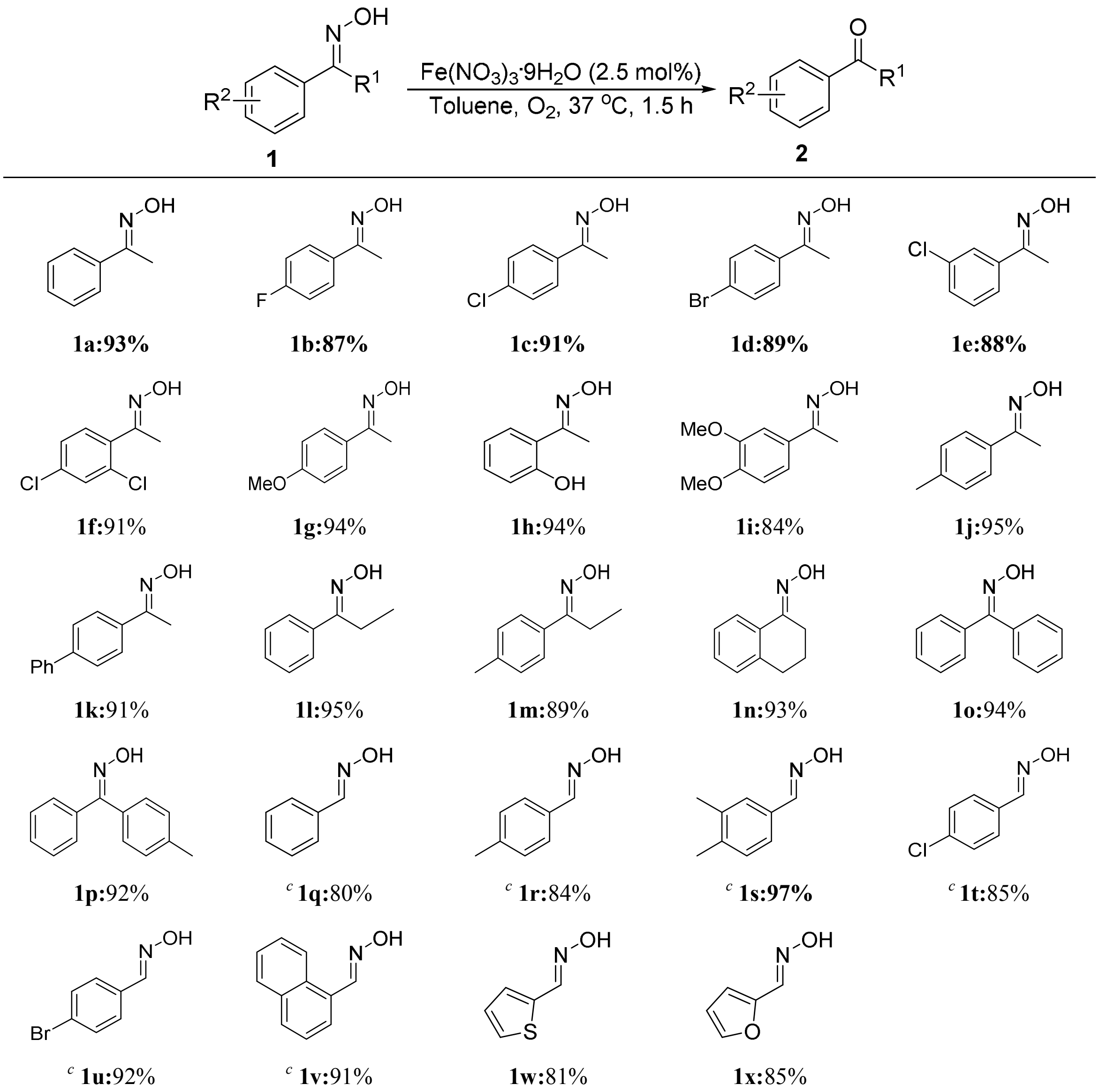
Entry	Solvent	[Fe]	Amt of [Fe] (mol %)	Yield[b] (%)
1	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	10	83
2	Toluene	$Fe(OAc)_3$	10	-
3	Toluene	$FeCl_3$	10	-
4	Toluene	$FeBr_3$	10	-
5	Toluene	$Fe(OTf)_3$	10	-
6	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	1.0	70
7	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	2.0	89
8	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	93
9	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	3.0	88
10	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	20	80
11	PhCl	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	69
12	Hexane	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	75
13	DCE	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	82
14	CH_3CN	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	77
15	CCl_4	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	52
16[c]	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	45
17[d]	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	61
18[e]	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	80
19[f]	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	93
20[g]	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	<10
21[h]	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	23
22[i]	Toluene	$Fe(NO_3)_3{\cdot}9H_2O$	2.5	54

[a] Conditions: acetophenone oxime (1.0 mmol), [Fe] (2.5 mol%), 4 mL solvent, under 1 atm O_2, 1.5 h, in a 50 mL Schlenk flask. [b] Isolated yield. [c] 25 °C. [d] 50 °C. [e] 0.5 h. [f] 5 h. [g] Under N_2. [h] Under air. [i] Additive 4Å MS.

Having obtained the optimal reaction conditions, we further explored the generality of this transformation with respect to the ketoximes and aldoximes derivatives (**Scheme 1**). It was delightful to observe that all substrates tested could afford the desired products in moderate to excellent yields under the standard reaction conditions. Regardless of whether oximes were in electronic-donating or electronic-withdrawing groups on the benzene ring were well accommodated. For instance, the ketoximes bearing electronic-withdrawing haloarenes (F, Cl, Br) on the aromatic ring were all easily converted to the corresponding products with 87-91% yields (**Scheme 1**, **2b-2f**), and the others possessing electron-donating groups also gained the wonderful yields

(**Scheme 1**, **2g-2k**). Notably, the steric hindered oximes could underwent the deoximative transformation smoothly, giving ideal yields of the desired products (**Scheme 1**, **2l-2n**). To our delight, the desired products of heteroaromatic ketoxime were also obtained in good yields (**Scheme 1**, **2w**, **2x**). Surprisingly, aldoximes derivatives were oxidized to corresponding carbonyl compounds in excellent isolated yields when the temperature was raised to 60 °C (**Scheme 1**, **2q-2v**).

Scheme 1. Scope of keto- and aldoximes.[a,b]



[a] Conditions: oxime (1.0 mmol), $Fe(NO_3)_3 \cdot 9H_2O$ (2.5 mol%), 4 mL toluene, under 1 atm O_2, 1.5 h, in a 50 mL Schlenk flask. [b] Isolated yield. [c] 60 °C.

In further research, the gram-scale application of this methodology was also studied and acetophenone oxime **1a** was taken as a representative substrate. When the amount of the substrate was increased from 1 mmol (0.135 g) to 50 mmol (6.750 g) and the amount of $Fe(NO_3)_3{\cdot}9H_2O$ were not changed, to our delight, the desired product was isolated in 75%-93% yields (**Table 2**).

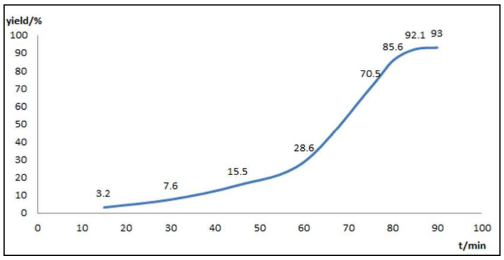
Table 2. Gram-scale test for deoximation of acetophenone oxime.[a]

Entry	Substrate (mmol)	Amt of $Fe(NO_3)_3{\cdot}9H_2O$ (mol %)	Toluene (ml)	Time (h)	Yield [b] (%)
1	1	2.5	2	1.5	93
2	10	2.5	4	3	86
3	20	2.5	4	8	81
4	50	2.5	5	12	75

[a] Conditions: acetophenone oxime, $Fe(NO_3)_3{\cdot}9H_2O$, $PhCH_3$, under 1 atm O_2. [b] Isolated yield.

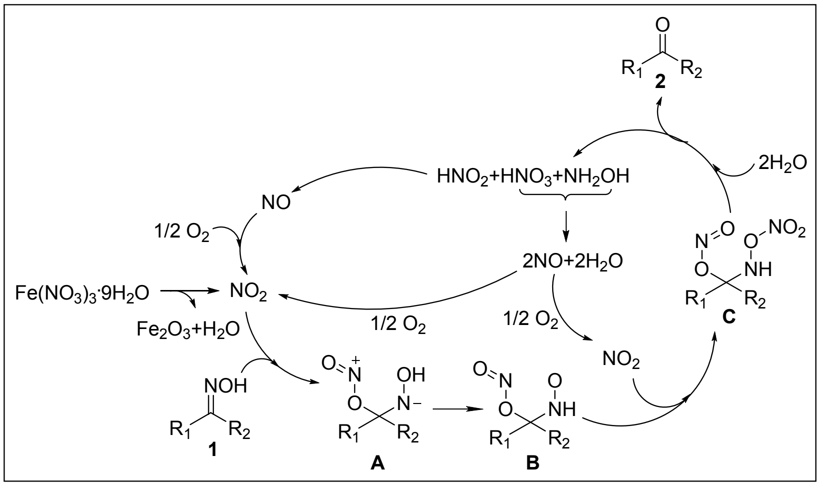
To gain insight into the mechanism, we conducted the rate control experiments for deoximation of acetophenone oxime (**Scheme 2**). It is obviously that the oxidative deoximation proceeded sluggishly during the first 60 minutes, mainly because of the slow process of NO_3^- to NO_2^-. But the rest of the deoximative transformation proceeded very fast, indicating that NO was released from the cleavage of the reactant oxime for accelerating the catalytic process. Since the released NO could be easily oxidized to NO_2 by molecular oxygen and reacted with water to provide NO_3^-, we did some detection of the NO_3^- concentration in aqueous phase by Ionic Chromatography. To our delight, a great quantity of NO_3^- was detected after the reaction, which in some degree confirmed our hypothesis of the generation of NO.

Scheme 2. Experiments on the rate of deoximation.



On the basis of these observations and our related reports in the literature,[14-16] a plausible mechanism is proposed, as outlined in **Figure 1**. Initially, trace of $Fe(NO_3)_3{\cdot}9H_2O$ was decomposed into Fe_2O_3 and nitrogen dioxide (NO_2),[16b] which was to stand for a single electron.[14b] Then the high active species NO_2 reacts with C=N double bonds of the oxime to produce an intermediate **A**. This intermediate **A** can subsequently through a proton transfer process to form species **B**, which is then attacked by NO_2 to give an active material **C**. Subsequent hydrolysis of **C** generates the carbonyl compound **2** as well as HNO_2, HNO_3 and NH_2OH. The HNO_2 is unstable and release NO, meanwhile the oxidative HNO_3 and reductive NH_2OH can also interact to generate NO. They can both be reoxidized to NO_2 by oxygen and continue the catalytic cycle.

Figure 1. Plausible mechanism for aerobic oxidative deoximation catalyzed by $Fe(NO_3)_3{\cdot}9H_2O$.



Conclusion

In conclusion, we disclosed an efficient and simple $Fe(NO_3)_3{\cdot}9H_2O$-catalyzed aerobic oxidative deoximation of ketoximes and aldoximes under mild condition in the presence of inexpensive and green oxygen molecule, and a plausible aerobic oxidative deoximation mechanism has been proposed. In addition, the environmentally benign protocol shows moderate to excellent yields and broad functional groups tolerance.

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Supporting Information

Supplementary information are available with the article through the journal Web site.

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Table 1. Optimization of reaction conditions.[a]

Entry	Solvent	[Fe]	Amt of [Fe] (mol %)	Yield[b] (%)
1	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	10	83
2	Toluene	$Fe(OAc)_3$	10	-
3	Toluene	$FeCl_3$	10	-
4	Toluene	$FeBr_3$	10	-
5	Toluene	$Fe(OTf)_3$	10	-
6	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	1.0	70
7	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	2.0	89
8	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	2.5	93
9	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	3.0	88
10	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	20	80
11	PhCl	$Fe(NO_3)_3\cdot 9H_2O$	2.5	69
12	Hexane	$Fe(NO_3)_3\cdot 9H_2O$	2.5	75
13	DCE	$Fe(NO_3)_3\cdot 9H_2O$	2.5	82
14	CH_3CN	$Fe(NO_3)_3\cdot 9H_2O$	2.5	77
15	CCl_4	$Fe(NO_3)_3\cdot 9H_2O$	2.5	52
16[c]	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	2.5	45
17[d]	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	2.5	61
18[e]	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	2.5	80
19[f]	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	2.5	93
20[g]	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	2.5	<10
21[h]	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	2.5	23
22[i]	Toluene	$Fe(NO_3)_3\cdot 9H_2O$	2.5	54

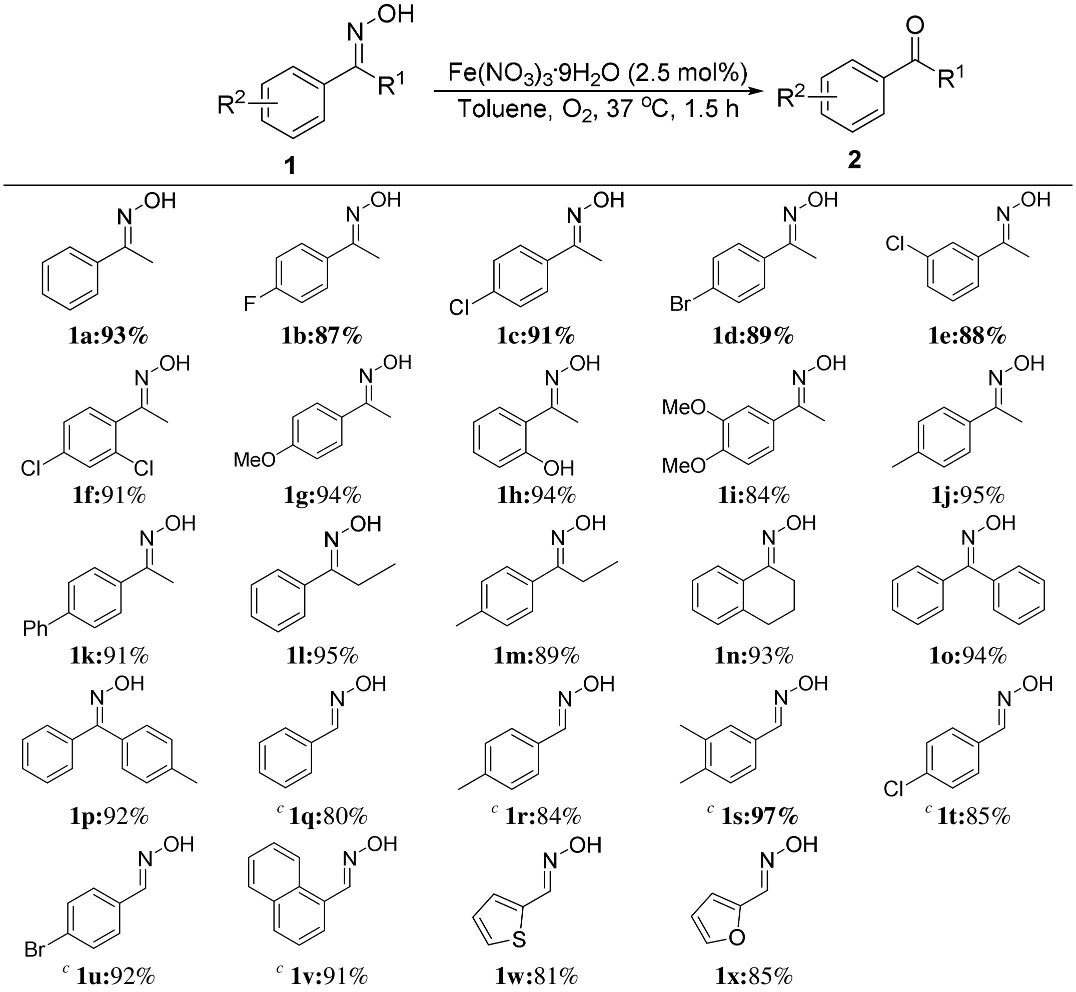
[a] Conditions: acetophenone oxime (1.0 mmol), [Fe] (2.5 mol%), 4 mL solvent, under 1 atm O_2, 1.5 h, in a 50 mL Schlenk flask. [b] Isolated yield. [c] 25 °C. [d] 50 °C. [e] 0.5 h. [f] 5 h. [g] Under N_2. [h] Under air. [i] Additive 4Å MS.

Table 2. Gram-scale test for deoximation of acetophenone oxime.[a]

Entry	Substrate (mmol)	Amt of $Fe(NO_3)_3 \cdot 9H_2O$ (mol %)	Toluene (ml)	Time (h)	Yield [b] (%)
1	1	2.5	2	1.5	93
2	10	2.5	4	3	86
3	20	2.5	4	8	81
4	50	2.5	5	12	75

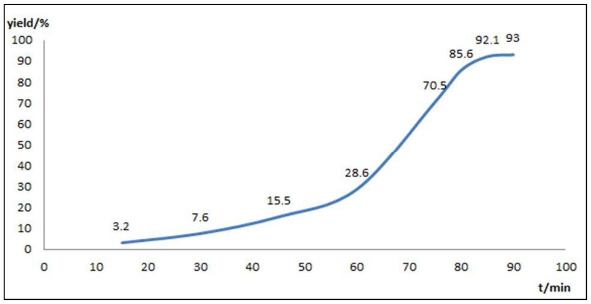
[a] Conditions: acetophenone oxime, $Fe(NO_3)_3 \cdot 9H_2O$, $PhCH_3$, under 1 atm O_2. [b] Isolated yield.

Scheme 1. Scope of keto- and aldoximes.[a,b]



[a] Conditions: oxime (1.0 mmol), $Fe(NO_3)_3 \cdot 9H_2O$ (2.5 mol%), 4 mL toluene, under 1 atm O_2, 1.5 h, in a 50 mL Schlenk flask. [b] Isolated yield. [c] 60 °C.

Scheme 2. Experiments on the rate of deoximation.



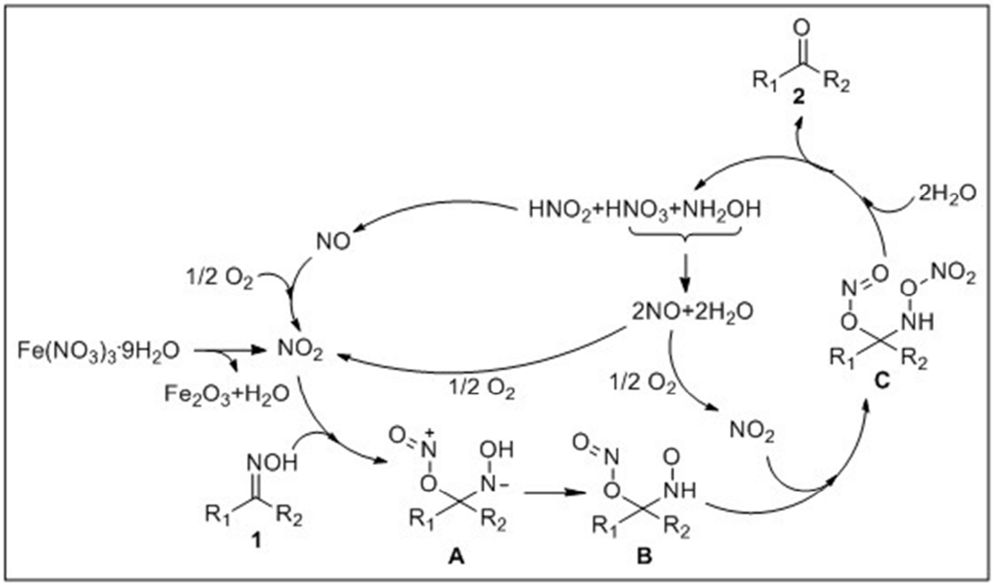
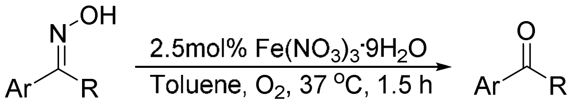


Figure 1.

147x87mm (96 x 96 DPI)



1

2

R = H, AAlkyl or Aryl

24 examples
up to 97% yield
without other additives