Copper Mediated Conversion of Nitro Compounds to Aldehydes or Ketones by Dioxygen

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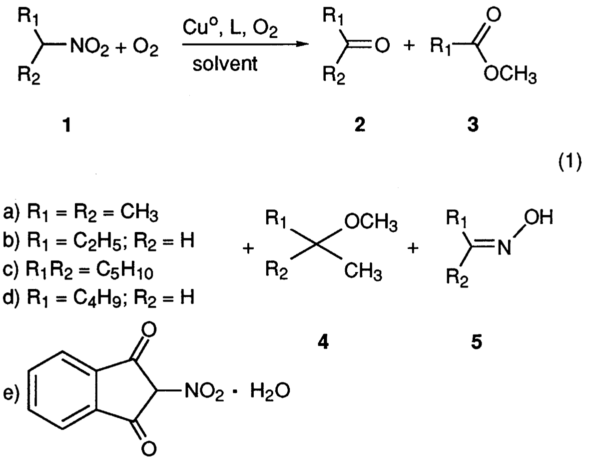
Primary and secondary nitro compounds are easily transformed to aldehydes or ketones by dioxygen catalyzed by metallic copper.

The conversion of nitro compounds to aldehydes or ketones can be carried out classically with the Nef reaction[1] and several alternative methods.[2] Among these are treatment of the nitro compound with aqueous $TiCl_3$,[3] cetyltrimethylammonium permanganate,[4] tin complexes and $NaHSO_3$,[5] activated dry silica gel,[6] or 30% H_2O_2-K_2CO_3,[7] and treatment of the conjugate base of the nitro compound with $KMnO_4$,[8] *t*-BuOOH and a catalyst,[9] ceric ammonium nitrate (CAN),[10] MoO_5-pyridine-HMPA,[11] or ozone.[12] The oxidative denitrification of nitro compounds by the iron-containing 2-nitropropane dioxygenase[13] of *Hanzenula mrakii* and other microorganisms can also be accomplished.

We wish to report a new oxidative copper catalyzed transformation of nitro compounds to carbonyl compounds by dioxygen.[14] In the presence of N-ligands such as N,N,N',N'-tetramethylethylenediamine (tmeda), 2,2'-bipyridine (bpy), and 1,10-phenantroline (phen) dioxygen and copper metal nitro compounds (**1**) are converted to carbonyl compounds (**2**) and nitrous acid in rather good yields (Eq. 1 and Table 1). If methanol is used as solvent the methyl esters (**3**) are also formed to a large extent along with minor byproducts (**4**, **5**).

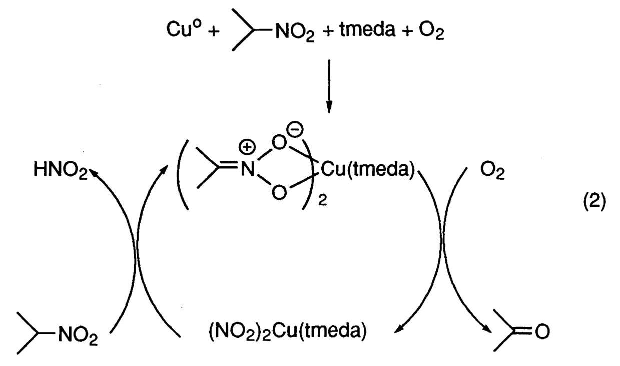


In these reactions copper metal reacts with the aci form of the primary or secondary nitro compound to give copper nitronate complexes. Similar reactions were reported for the reaction of Cu° with acidic compounds in the presence of air.[15] The nitronato copper compounds are then easily further oxygenated to give the carbonyl compounds and nitrous acid as postulated in Eq. 2. In the presence of molecular oxygen probably both copper(I) and copper(II) nitronates are formed and both of them

Table 1. Copper-catalyzed oxygenation of nitro compounds[a]

Run	Substrate	Ligand	Solvent	Time h	Conversion %	Products[b] % 2	3
1	**1a**	-	-	28	12	~100	-
2	**1a**	phen	MeOH	28	42	28	71[c]
3	**1a**	phen	MeCN	30	24	~100	-
4	**1a**	phen	DMF	47	43	~100	-
5	**1a**	bpy	MeOH	28	44	29	69[d]
6	**1a**	bpy	MeCN	30	54	~100	-
7	**1a**	bpy	DMF	47	37	~100	-
8	**1a**	tmeda	MeOH	28	70	41	57[e]
9	**1a**	tmeda	MeCN	30	49	~100	-
10	**1a**	tmeda	DMF	47	71	~100	-
11	**1a**	tmeda	Py	28	67	~100	-
12	**1b**	tmeda	DMF	47	60	~100	-
13	**1b**	tmeda	Py	28	90	~100	-
14	**1c**	tmeda	DMF	47	66	~100	-
15	**1c**	tmeda	Py	28	67	~100	-
16	**1d**	tmeda	Py	28	21	~100	-
17	**1d**	tmeda	DMF	28	28	~100	-
18	**1e**	tmeda	DMF	28	30	~100[f]	-

[a] Conversions and yields were determined by glc; the remainder is starting material. [b] Characterized by mass spectrometry. [c] The **5a** was also formed in ca. 1% yield. [d] The **5a** was also produced in ca. 2% yield. [e] One % of **4a** and 1% of **5a** was formed. [f] Indantrione hydrate was also formed.



can be oxygenated to the desired products. Their reaction with dioxygen is probably a radical process. The solvent has a profound effect on the effectivity of the reaction. More coordinating solvents as well as donor N-ligands accelerate the reaction remarkably.

The reaction can also be carried out catalytically at high nitropropane copper ratios (~ 40 : 3) in a very efficient way (Figure 1). In these experiments Cu°, tmeda, and 2-nitropropane are pretreated fist under O_2 to give a homogeneous solution in about 5-10 min. Thereafter the reaction takes place and is followed by GLC.[14] The analysis of the results of the oxygenation of 2-nitropropane in the presence of copper metal and tmeda in DMF shows that reactions (3-5) take place. At high tmeda or O_2 concentration the formation of oxime is less favored. Preliminary kinetic measurements of the reaction suggest that rate constants for reaction (3) and for the consecutive reactions (4-5) can be separated and determined. A detailed treatment of the kinetic studies will be published in a separate full paper.

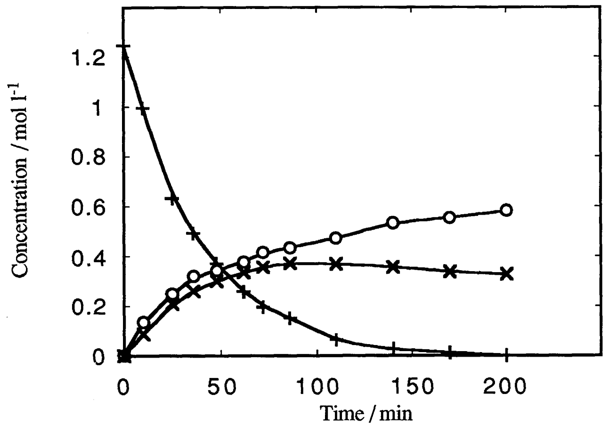
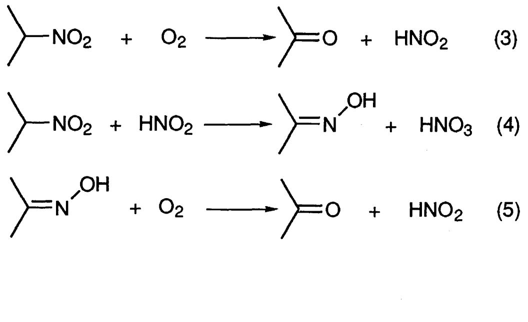


Figure 1. Typical oxygenation of 2-nitropropane (+) to acetone (o) and oxime (x) in DMF. Catalyst (Cu°) 191 mg, 2-nitropropane 3.6 cm^3, tmeda 0.45 cm^3, DMF 30 cm^3, O_2 pressure 706 mmHg, temperature 95 °C.



The catalytic reaction mimics the biological oxidative degradation of nitro compounds and provides an alternative preparative method for their conversion to carbonyl compounds. In this sense the copper-catalyzed oxygenation of nitropropane seems to be the first model reaction for an intermolecular dioxygenase enzyme action.

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References and Notes

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