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OXIDATIVE CONVERSION OF ALDOXIMES INTO CARBOXYLIC ACID ESTERS

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Abstract: Aromatic and aliphatic aldoximes or their O-methyl ethers can be efficiently converted into the corresponding carboxylic acid esters by treatment with an alcoholic solution of 30% hydrogen peroxide in the presence of catalytic amounts of 2-nitrobenzeneseleninic acid. Primary alcohols give excellent to good yields, secondary ones - good to moderate, but with tertiary alcohols no esterification is obserwed.

Aldoximes, convenient to handle derivatives of aldehydes, are useful synthetic intermediates[1] and their oxidative transformations are also known[2]. Thereas the direct synthesis of esters from aldehydes via oxidation of in situ formed hemiacetals is well established[3], the direct conversion of aldoximes into carboxylic acid esters has not been realized. Our interest in the oxidation of aza derivatives of carbonyl compounds by activated hydrogen peroxide[4] prompted us to study the possibility of the title transformation.

Aldoximes 2, prepared in an usual way from the parent aldehydes (in 83-98% yield) are efficiently transformed

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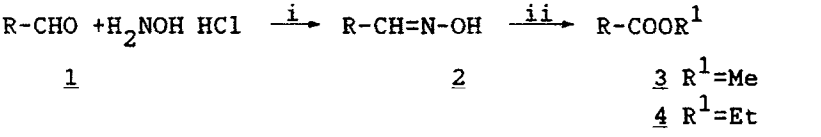
into the corresponding carboxylic acid esters 3 by oxidation with 30% aqueous hydrogen peroxide in the presence of catalytic amounts of 2-nitrobenzeneseleninic acid (2-NBSeA) using the respective alcohol as a solvent. The reaction was carried out for 1-5 days at 20°C or refluxing for 1-6 h.



i = AcONa, MeOH, 4h, reflux
ii = H_2O_2/catalyst, R^1OH, 20°C or reflux
catalyst = 2-NBSeA or SeO_2

1,2,3,4	R
a	C_6H_5
b	4-BrC_6H_4
c	4-FC_6H_4
d	3-ClC_6H_4
e	2-MeC_6H_4
f	3,4,5-$(MeO)_3C_6H_2$

1,2,3,4	R
g	3-$NO_2C_6H_4$
h	4-$NO_2C_6H_4$
i	p-phenylene
j	1-naphthyl
k	n-C_5H_{11}
l	n-C_7H_{15}

It should be noted that there were no oxidation of oximes 2a,b,f and g upon the treatment with methanolic 30% hydrogen peroxide without catalyst at 20°C even for 30 days, but the addition of catalytic amounts of selenium dioxide to this system activated the oxidant and brought about the formation of methyl esters. Regardless of the catalyst used at 20°C, the esters were obtained exclusively whereas at elevated temperature they were accompanied with minor amounts (less than 15% yield by GLC) of the parent aldehydes. Moreover,

oxidation of aldoximes with 30% hydrogen peroxide in the presence of 2-NBSeA in methylene dichloride, chloroform, tetrahydrofuran, acetonitrile, or acetic acid as a solvent gave the corresponding carboxylic acids in high yields. When the parent aldehydes 1a,b,e,g,j, or l were left with the same oxidation system in methanol, the corresponding carboxylic acids were also found as the only products formed, except for 1a and j, where the acids were obtained along with 11 i 18% of the corresponding methyl esters, respectively. The obtained results ensure us that this is aldoxime, not aldehyde -- a product of its possible hydrolysis, which undergoes the oxidative esterification. Furthemore, the O-methyl ethers of aldoximes were also oxidized in boiling methanol or ethanol to yield the corresponding esters as the only products.

$$\underset{\underline{2b,g}}{R\text{-}CH{=}N\text{-}OH} \xrightarrow{iii} \underset{\underline{5b,g}}{R\text{-}CH{=}N\text{-}OMe} \xrightarrow{iv} \underset{\underline{3b,g};\ \underline{4b,g}}{R\text{-}COOR^1}$$

iii = MeONa, MeOH, MeI, 20°C
iv=H_2O_2/catalyst, R^1OH,reflux
catalyst = 2-NBSeA or SeO_2

We believe that the catalyzed oxidation of aldoximes and its O-ethers proceeds through an intermediate which subsequently reacts with alcohol. Meanwhile, the reaction mechanism remains essentially unclear and possible intermediates are to be considered and verified. In order to learn about the scope of the transformation, we examined other primary and secondary alcohols and in all cases the corresponding carboxylic

acid esters were obtained in good to moderate yields. Tertiary alcohols did not give the esters and the acids were isolated in these cases.

$$\underset{\underline{2b},\underline{d}}{R\text{-}CH{=}N\text{-}OH} \xrightarrow{v} \underset{\underline{6}\ R=4\text{-}BrC_6H_4;\ \underline{7}\ R=3\text{-}ClC_6H_4}{R\text{-}COOR^2}$$

$v = H_2O_2/2\text{-NBSeA (cat.)}, R^2OH, 20^oC \text{ or } 70\text{-}100^oC$

6	R^2
a	$n\text{-}C_3H_7$
b	$n\text{-}C_4H_9$
c	$iso\text{-}C_4H_9$

6,7	R^2
d	$PhCH_2$-
e	$-CH(CH_3)CH(CH_3)_2$
f	cyclohexyl

We conclude that all aldoximes of type 2 and their O-methyl ethers 5 can be converted directly into carboxylic acid esters of primary and secondary alcohols by oxidation with 2-NBSeA or SeO_2 activated hydrogen peroxide.

The results are summarized in Tables 1-3.

EXPERIMENTAL

Melting points (uncorrected) were determined on a Kofler hot-stage apparatus. TLC was performed on silica gel-60 precoated plates (Merck). Silica gel 60 Merck was used for column chromatography. Analytical GLC was carried out on a Perkin-Elmer F-11 apparatus equipped with FID using: (a) 2% Dexil on Chromosorb G, 1 m-glass column, (b) 10% Dexil on Chromosorb P, 3 m-metal column, (c) 15% Dexil on Chromosorb P, 3 m-metal column, or (d) 6% QF-1 on Gas-Chrom Q, 1 m-metal column, N_2 flow rate 50 mL/min. IR spectra were recorded on a Specord IR-75 spectrophotometer. ^{1}H-NMR spectra were recorded on a Tesla 100 MHz spectrometer.

Table 1. Esters 3 Prepared from Aldoximes 2 and Their Ethers 5

Product	Reaction Conditions Catalyst	Temp. (°C)	Time	Yield (%)	mp (°C), bp (°C/Torr), or GLC Retention Time (min) Found	Reported[6]
3a	2-NBSeA	20	2 d	85	83-85/21	96-98/24[8]
		65	1 h	72	4.6(180°C) 15% Dexil	
3b	2-NBSeA	20	2 d	88	79-80	81[8]
		65	1 h	70		
		65	36 h	87	(from Ether 5b)	
	SeO_2	20	4 d	65		
3c	2-NBSeA	20	2 d	71	2.8(200°C) 10% Dexil	195-197/760[9]
3d	2-NBSeA	20	3 d	78	5.6(200°C) 15% Dexil	114/18[8]
3e	2-NBSeA	20	3 d	76	6.2(180°C)	207-208/760[7]
		65	3 h	58	15% Dexil	
3f	2-NBSeA	20	1 d	71	80-81	82-84[7]
3g	2-NBSeA	20	2 d	80	80	78-80
		65	2 h	63		
		65	2 d	79	(from Ether 5g)	
	SeO_2	20	5 d	57		
3h	2-NBSeA	20	5 d	79	95	94-96[7]
	SeO_2	20	6 d	55		
3i	2-NBSeA	20	4 d	84	140-141	141-142[8]
3j	2-NBSeA	20	2 d	65	10.4(160°C) 2% Dexil	167-169/20[8]
	SeO_2	20	3 d	46		
3k	2-NBSeA	20	1 d	72	3.2(160°C) 15% Dexil	151/760[7]
3l	2-NBSeA	20	2 d	81	4.5(180°) 15% Dexil	194-195/760[7]
	SeO_2	20	3 d	65		

Table 2. Esters 4 Prepared from Aldoximes 2 and Their Ethers 5

Product	Reaction Conditions[10] Temp. °C	Time	Yield %	mp (°C), bp °C/Torr), or GLC Retention Time (min)[6] Found	Reorted
4a	20	5 d	90	5.8(180°)	87/10[8]
	78	1 h	70	15% Dexil	
4b	20	5 d	72	8.3(110°)	125/15[8]
	78	2 h	65	6% QF-1	
	78	50 h	82	(from Ether 5b)	
4c	78	2 h	57	3.4(200°)	142/12[9]
				10% Dexil	
4d	20	4 d	81	4.5(220°)	121/20[8]
				15% Dexil	
4e	20	2 d	75	8.0(180°)	220-221/731[7]
				15% Dexil	
4f	20	2 d	88	51-53	53-55[11]
4g	78	3 h	66	46	47[8]
	78	6 h	76	(from Ether 5g)	
4h	78	6 h	64	55-56	57[8]
4i	78	2 h	62	42	44[8]
4j	78	1 h	60	11.6(160°)	184/70[8]
				2% Dexil	
4k	20	24 h	76	3.4(160°)	168/760[7]
				15% Dexil	
4l	20	24 h	85	5.8(180°)	206-208/760[7]
				15% Dexil	

Table 3. Esters 6 and 7 Prepared from Aldoximes 2b,d and Various Primary and Secondary Alcohols

Product	Reaction Conditions[10] Temp. (°C)	Time	Yield (%)	mp (°C) or GLC Retention Time (min)[6]
6a	98	3 h	61	9.0(200°) 10% Dexil
6b	20	4 d	69	13.0(200°) 10% Dexil
6c	20	3 d	67	30-32
6d	100	6 h	78	Oil[12]
6e	100	4 h	53	13.2(200°) 10% Dexil
6f	100	6 f	41	28-30
7e	100	4 h	47	9.0(200°) 10% Dexil
7f	100	6 h	40	7.1 (160°) 2% Dexil

Aldoximes 2; General Procedure

Anhydrous sodium acetate (0.62 g, 7.5 mmol) is added to a solution or the aldehyde 1 (5 mmol) in methanol (30 ml) followed by the addition of hydroxylamine hydrochloride (0.52 g, 7.5 mmol) and the mixture is refluxed for 4 h and then filtered while hot. The crude oxime is obtained by filtration of the solid precipitate. In the case of nonprecipitation, the mixture is left overnight at 4°C and if the product does not crystallize, it is extracted with CH_2Cl_2 (50 mL), dried over $MgSO_4$, and the extract is evaporated to leave

the crude oxime. This product is recrystallizedo from the mixture of n-hexane - benzene (5:1 v/v) to give the E-isomer of oxime predominantly, as confirmed by ^{1}H-NMR.

1-Naphthaldehyde Oxime (2j).

A solution of hydroxylamine hydrochloride (5.2 g, 75 mmol) in water (50 mL) is added to 1-naphthaldehyde (7.8 g, 50 mmol) in pyridine (70 mL) and the mixture is refluxed for 8 h and then poured into the mixture of ice and conc. HCl (10 mL). The filtrated crude oxime is recrystallized from n-hexane, yield: 87%, mp 98°C. All aldoximes are known compounds and their physical data (mp, ^{1}H NMR, IR) are in agreement with those reported in literature[7,8,13-17].

Aldoxime O-methyl Ethers 5; General Procedure:

Metallic sodium (0.23 g, 10 mmol) is reacted with vigrously stirred EtOH (30 mL) and oxime 2 (5 mmol) is added to this solution. The mixture is left at room temperature for 30 min and then methyl iodide (1.42 g, 10 mmol) is added. The mixture is stirred for 4 h, then poured into water (100 mL). The product is isolated by extraction with CH_2Cl_2 (40 mL), the extract is dried over $MgSO_4$. Evaporation of the solvent leaves the crude product, which is purified by recrystallization from the appropriate solvent.

4-Bromobenzaldoxime O-methyl Ether (5b):

Yield 93%, mp 29-31°C (n-hexane).

C_8H_8BrNO calc. C 44.88, H 3.77, N 6.54, Br 37.33 (214.1) found 45.16 3.42 6.61 37.18

IR (KBr): ν = 1590 cm^{-1} (C=N).

^{1}H-NMR ($CDCl_3$/TMS): δ = 3.88 (s, 3H, CH_3); 7.33 (s,1H, CH=N-); 7.43 - 8.20 (m, 4H, ArH).

3-Nitrobenzaldoxime O-methyl Ether (5g):

Yield 97%, mp 52-53°C (n-hexane/benzene).

$C_8H_8N_2O_3$ calc. C 53.33, H 4.47, N 15.55
(180.2) found 53.72 4.60 15.79
IR (neat): ν = 1610 cm^{-1} (C=N).
^{1}H-NMR ($CDCl_3$/TMS): δ = 3.98 (s, 3H, CH_3); 7.60 (d, 1H, J=8 Hz, ArH); 7.85 (s, 1H, CH=N); 8.00 - 8.28 (m, 2H, ArH); 8.38 (s, 1H, ArH).

Carboxylic Acid Esters 3, 4, 6, 7; General Procedure. 2-NBSeA[18] (0.03 g, 0.13 mmol) or SeO_2 (0.015 g, 13 mmol) is added to a solution of aldoxime 2 (5 mmol) or aldoxime O-methyl ether 5 (5 mmol) in the appropriate alcohol (30 mL) and then an aqueous 30% H_2O_2 solution (2 mL, 17.7 mmol) is added. The mixture is stirred at temperature and for the time given in Tables 1-3. Excess of H_2O_2 is decomposed by adding a strip of Pd on asbestos and the alcohol is distilled off under reduced pressure. The residue is dissolved in CH_2Cl_2 or $CHCl_3$ (140 mL), washed with saturated $NaHCO_3$ solution (3 x 30 mL) (catalyst: 2-NBSeA) or with H_2O (3 x 30 mL) (catalyst: SeO_2) and dried over Na_2SO_4 or K_2CO_3. The solvent is evaporated and the product is purified by recrystallization (3b, f-i, 4f-i) or column chromatography or, in the case of the increased reaction scale (90 mmol), distilled (3a, bp 83-85°C/21 Torr). Yields, mp's, bp's and other data are reported in Tables 1-3.

n-Propyl 4-Bromobenzoate (6a); yield: 61%; oil.
$C_{10}H_{11}BrO_2$ calc. C 49.40, H 4.56, Br 32.87
(243.1) found 49.20 4.83 32.50
IR (neat): ν = 1724 cm^{-1} (C=O).
^{1}H-NMR ($CDCl_3$/TMS): δ = 0.98 (t, 3H, J=8 Hz, $-CH_3$); 1.58-2.00 (m, 2H, $-CH_2-$); 4.24 (t, 2H, J=6 Hz, $-OCH_2-$); 7.54 and 7.88 (two d, 2 x 2H, J=8 Hz, A_2X_2 system, ArH).

n-Butyl 4-Bromobenzoate (6b); yield 69; oil.
$C_{11}H_{13}BrO_2$ calc. C 51.38, H 5.09, Br 31.08
(257.1) found 51.09 5.25 31.26

IR (neat): ν = 1722 cm^{-1} (C=O).
^{1}H-NMR ($CDCL_3$/TMS): δ = 1.03 (t, 3H, J=6 Hz, $-CH_3$); 1.25-1.83 (m, 4H, $-CH_2-$); 4.38 (t, 2H, J=6 Hz, $-OCH_2-$); 7.50-7.98 (m, 4H, ArH).

iso-Butyl 4-Bromobenzoate (6c);
yield 67%, mp 30-32°C (n-hexane).

$C_{11}H_{13}BrO_2$ (257.1)	calc.	C 51.38,	H 5.09,	Br 31.08
	found	51.42	4.80	31.21

IR (neat): ν = 1724 cm^{-1} (C=O).
^{1}H-NMR ($CDCl_3$/TMS): δ = 1.03 (d, 6H, J=4 Hz, $-CH_3$); 1.58-2.28 (m, 1H, CH); 4.09 (d, 2H, J=6 Hz, $-OCH_2-$); 7.54 and 7.89 (two d, 2 x 2H, J=6 Hz, A_2X_2 system, ArH).

Benzyl 4-Bromobenzoate 6d); yield 78%; oil.

$C_{14}H_{11}BrO_2$ (291.1).	calc.	C 57.75,	H 3.81,	Br 27.45

No satisfactory elemental analysis can be obtained due to the thermal unstableness of this product.
IR (neat): ν = 1723 cm^{-1} (C=O).
^{1}H-NMR ($CDCl_3$/TMS): δ = 4.60 (s, 2H, $-OCH_2-$); 7.24-7.62 (m, 9H, ArH).

1,2-Dimethylpropyl 4-Bromobenzoate (6e); yield 53%; oil.

$C_{12}H_{15}BrO_2$ (271.2)	calc.	C 53.25,	H 5.58,	Br 29.47
	found	53.01	5.61	29.30

IR (neat): ν = 1718 cm^{-1} (C=O).
^{1}H-NMR ($CDCl_3$)/TMS): δ = 0.96 (d, 6H, J=7 Hz, $-CH_3$); 1.26 (d, 3H, J=6 Hz, $-CH_3$); 1.74-2.02 (m, 1H, -CH); 4.84-5.10 (m, 1H, -OCH); 7.49-7.96 (m, 4H, ArH).

Cyclohexyl 4-Bromobenzoate (6f):
yield 41%; mp 28-30°C (n-hexane).

$C_{13}H_{14}BrO_2$ (282.2)	calc.	C 55.43,	H 5.00,	H Br 28.32
	found	55.10	5.26	28.68

IR (neat): ν = 1714 cm^{-1} (C=O).
^{1}H-NMR ($CDCl_3$/TMS): δ = 1.22-2.04 (m, 10H, $-CH_2-$); 4.82-5.14 (m, 1H, -OCH); 7.52 and 7.87 (two d, 2 x 2H, J=8 Hz, A_2X_2 system, ArH.

1,2-Dimehylpropyl 3-Chlorobenzoate (7e): yield 47%; oil.
$C_{12}H_{15}ClO_2$ calc. C 63.50, H 6.67, Cl 15.64
(226.7) found 63.90 7.08 15.33
IR (neat): ν = 1722 cm^{-1} (C=O).
^{1}H-NMR ($CDCl_3$/TMS: δ = 0.90 (d, 6H, J=8 Hz, $-CH_3$); 1.21 (d, 3H, J=6 Hz, $-CH_2$); 1.60-1.96 (m, 1H, -CH); 4.80-5.04 (m, 1H, -OCH); 7.20-7.48 (m, 3H, ArH); 7.94 (s, 1H, ArH).
Cyclohexyl 3-Chlorobenzoate (7f): yield 40% oil.
$C_{13}H_{14}ClO_2$ calc. C 65.49, H 5.94, Cl 14.92
(237.7) found. 65.10 5.72 15.08
IR (neat): ν = 1722 cm^{-1} (C=O).
^{1}H-NMR ($CDCl_3$/TMS) δ = 1.00-2.00 (m, 10H, $-CH_2-$); 4.84-5.10 (m, 1H, -OCH); 7.21-7.96 (m, 4H, ArH).

REFERENCES AND NOTES

1. Tennant, G., in: Comprehensive Organic Chemistry, Barton, D., Ollis, W.D., (eds.), Vol. 2, Pergamon Press,Oxford, 1979, chapt. 8; Metzger, H., in: Houben--Weyl, Vol. X/4, Georg Thieme Verlag, Stuttgart, 1968.
2. Henry, P.M., Lange G.L., in: The Chemistry of Double--bonded Functional Group, Patai, S., (ed.) Suppl. A, Part 2, Interscience, New York 1977, p. 1067; Freeman,J.P., Chem. Rev., 1973, 73, 283, and references citedtherein.
3. For recent examples of the oxidation of aldehydes to esters, see: Lichtenthaler, F.W., Jarglis, P., Lorenz, K., Synthesis, 1988, 790; Williams, D.R., Klinger D.F., Allen, E.E., Lichtenthaler, W.F., Tetrahedron Lett. 1988, 29, 5087; McDonald, C., Holcomb,H., Kennedy, K., Kirkpatrick, E., Leathers,T. Vanemon, P., J. Org. Chem., 1989, 54, 1213; Al Neirabeyeh, M., Pujol, M.D., Tetrahedron Lett., 1990, 31, 2273.

4. Said, S.B., Skarzewski, J., Mlochowski, J., Synthesis, 1989, 223.
5. Shriner, R.L., Fuson, R.C., Curtin, D.Y., The Systematic Identification of Organic Compounds, 4th ed., John Wiley, New York, 1956, p. 254; Vogel, A., Textbook of Practical Organic Chemistry, 4th ed., Longman, London, 1980, p. 1113.
6. GLC retention times are allowed by temperatures and columns used.
7. Aldrich Cataloque of Fine Chemicals, 1990-1991.
8. CRC Handbook of Chemistry and Physics, Weast R.C., (ed.) 65th ed., CRS Press, Boca Raton, Fl., 1984.
9. Bowden, S., Watkins, T.F., J. Chem. Soc., 1940, 1249.
10. 2-NBSeA used as a catalyst.
11. Herzig, J., Monatsh. Chem., 1912, 33, 846.
12. TLC: Rf 0.78, hexane/EtOAc (3:1).
13. Arndt, F., Rose, J.D., J. Chem. Soc., 1953, 5.
14. Bardy, O.L., McHught, G.P., J. Chem. Soc. 1924, 551.
15. Wuyts, H., Koeck, H., Bull. Soc. Chim. Belg., 1932, 41, 196.
16. Mauthner, F., Ber. Dtsch. Chem. Ges., 1908, 41, 2530.
17. Bengelsdorf, I.S., J. Org. Chem., 1958, 23, 242.
18. 2-NBSeA was prepared according to the procedure reported in Kloc, K., Mlochowski, J., Syper, L., Liebigs Ann. Chem., 1989, 811.

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