Efficient Synthesis of Oxazolidin-2-one *via* (Chitosan-*Schiff* Base)cobalt(II)-Catalyzed Oxidative Carbonylation of 2-Aminoalkan-1-ols

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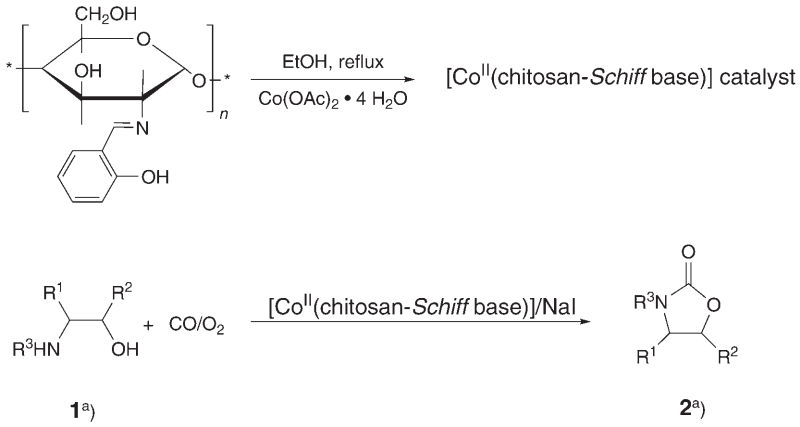
The (chitosan-*Schiff* base)cobalt(II) complex was found to be an efficient catalyst for the oxidative carbonylation (CO/O_2) of 2-aminoalkan-1-ols **1** to give oxazolidin-2-ones **2**, in the presence of NaI. The effects of promoters, temperature, solvents, and other reaction conditions were investigated in this study.

Introduction. – Oxazolidin-2-ones are important and versatile intermediates for fine chemicals, pharmaceuticals, pesticides, and herbicides [1–6]. Especially the chiral oxazolidin-2-ones have been widely used as chiral auxiliaries in many important asymmetric syntheses [7–14]. Many strategies for the synthesis of these compounds have been reported, including the phosgenation of the corresponding 2-aminoalkan-1-ols (α-amino alcohols) with toxic phosgene (Cl_2CO) or its derivatives [15–23]. The classical synthesis of these important N-containing carbonyl chemicals by phosgenation may cause serious pollution and equipment corrosion. In addition, the use of diethyl carbonate as phosgene substitute is relatively expensive for commercial applications. Consequently, the development of an efficient and environmentally friendly process for their production has recently attracted great interest in view of their important applications in industrial and academic fields. For example, the intramolecular oxidative cyclocarbonylation of 2-aminoalkan-1-ols has been developed, which utilizes the precious metal Pd as catalyst [24–28]. We found that $S_8/NaNO_2$ as a catalytic system was efficient for the oxidative carbonylation (CO/O_2) of 2-aminoalkan-1-ols and aliphatic amines [29]. Very recently, the (salen)cobalt complexes have also been found to be robust catalysts for this process by our group [30].

Chitosan, the most abundant natural amino polysaccharide, is produced by the deacetylation of chitin, which is one of the key constituents of the shells of crustaceans and is a by-product of the fishing industry. The flexibility of the material, insoluble in the vast majority of solvents, and capable of being cast into films and fibers from dilute acid, along with its inherent chirality, makes chitosan a support for various 'classical' transition-metal-catalyst precursors with excellent catalytic performance or easy product separation for many reactions [31–41]. We have previously reported that the (chitosan-*Schiff* base)copper complexes derived from chitosan and substituted salicylaldehydes were efficient catalysts for the cyclopropanation of styrene [42–44]. The (chitosan-*Schiff* base)cobalt(II) catalyst, easily prepared from chitosan-*Schiff* base (derived from salicylaldehyde (=2-hydroxybenzaldehyde)) and $Co(OAc)_2$, has been

successfully applied to the aerobic oxidation of cyclohexane [45]. In the present work, this (chitosan-*Schiff* base)cobalt(II) catalyst was tested for its catalytic ability in the oxidative carbonylation of 2-aminoalkan-1-ols **1** to form oxazolidin-2-ones **2** in high yields (*Scheme*).

Scheme



1[a]) **2**[a])

[a]) For R^1, R^2, and R^3, see *Table 3*.

Results and Discussion. – *Effect of Iodide Promoters.* Iodine-containing compounds (*e.g.*, I_2, NaI, *etc.*) have been employed as promoters for a number of reactions in recent years, especially for oxidative carbonylation reactions involving the precious metal Pd as catalyst [26–28]. The efficiencies of the different iodide promoters for the catalytic oxidative carbonylation (CO/O_2) of 3-aminopropan-2-ol (**1b**, $R^1 = R^3 = H$, $R^2 = Me$) are shown in *Table 1*. Initially, the comparison experiments of oxidative carbonylation of **1b** were carried out by using the (chitosan-*Schiff* base)cobalt(II) catalyst with and without NaI: in the absence of NaI, only 70% conversion and 67% yield of oxazolidin-2-one **2b** were obtained (*Table 1*, *Entry 1*), while in the presence of NaI, a quantitative conversion was observed (*Table 1*, *Entry 3*). These results suggested that iodide-containing promoters were necessary in this oxidative carbonylation reaction to achieve high yields. A variety of possible promoters, I_2, NaI, C_4H_9I, CuI, LiI and KI, was investigated. The results in *Table 1* clearly show that NaI is the most efficient promoter.

Effects of Solvents and Temperature. Reaction solvents usually play a key role concerning the activity and selectivity of catalysts in catalytic reactions. For this reason, the effects of different solvents on the carbonylation reaction were also studied under the same conditions as those used to study the effect of promoters. As shown in *Table 2*, high catalytic activities were obtained in dipolar solvents, such as 1,4-dioxane (*Entries 1* and *2*). When other polar solvents, including MeOH, THF, or DMF were used, the catalyst showed comparatively poor activity, *i.e.*, the high polarity hampered this oxidative carbonylation process [26][27][46] (*Entries 3–6*). We also investigated the

Table 1. *Effect of Iodide Promoters for the Oxidative Carbonylation Reaction of 3-Aminopropan-2-ol* (**1b**; $R^1 = R^3 = H$, $R^2 = Me$)[a])

Entry	Promoter	Conversion [%]	Yield of **2b** [%][b])
1[c])	–	70	67
2[d])	NaI	–	–
3	NaI	100	98
4	KI	100	90
5	CuI	53	50
6	I_2	82	77
7	C_4H_9I	76	73
8	LiI	92	88

[a]) Reaction conditions: (Chitosan-*Schiff* base)cobalt(II) (60 mg), **1b** (10 mmol), promoter (0.2 mmol), temp. 120°, 1,4-dioxane (8 ml), *P*(CO) 5.75 MPa, $P(O_2)$ 0.25 MPa, and time 2.5 h. [b]) Yield determined by GC. [c]) Only the (chitosan-*Schiff* base)cobalt(II) was used. [d]) Only NaI was used.

effect of temperature on the reaction (*Table 2*, *Entries 1* and *2*). The results suggest that increasing the reaction temperature leads to a slightly increased yield.

Table 2. *Effects of Temperature and Solvents on the Oxidative Carbonylation Reaction of 3-Amino-propan-2-ol* (**1b**; $R^1 = R^3 = H$, $R^2 = Me$)[a])

Entry	Solvent	Temp. [°]	Conversion [%]	Yield of **2b** [%][b])
1	1,4-dioxane	100	100	92
2	1,4-dioxane	120	100	98
3	MeOH	120	58	52
4	1,2-dimethoxyethane	120	63	57
5	DMF	120	72	68
6	THF	120	55	48

[a]) Reaction conditions: (Chitosan-*Schiff* base)cobalt(II) (60 mg), **1b** (10 mmol), NaI (0.2 mmol), 1,4-dioxane (8 ml), *P*(CO) 5.75 MPa, $P(O_2)$ 0.25 MPa, and time 2.5 h. [b]) Yield determined by GC.

Oxidative Carbonylation of Various Substrates. Under the optimized reaction conditions, we examined the oxidative carbonylation of other 2-aminoalkan-1-ols than **1b**. The results summarized in *Table 3* established that the catalytic system (chitosan-*Schiff* base)cobalt(II)/NaI is applicable to the oxidative carbonylation of a variety of 2-aminoalkan-1-ols **1**, forming the corresponding oxazolidin-2-ones **2** in very high yields (*Entries 2–4*). Only in the case of 3-(2-hydroxyethyl)oxazolidin-2-one (**2g**), a slightly decreased yield of 74% was obtained (*Entry 7*).

In conclusion, (chitosan-*Schiff* base)cobalt(II) complex/NaI was established as an active catalyst for the oxidative carbonylation (CO/O_2) of 2-aminoalkan-1-ols and showed a similar activity as (salen)cobalt(II) complexes. Furthermore, chitosan is a very cheap and plentifully available natural polymer. This atom-economical methodology represents a viable and environmentally benign non-phosgene alternative to the use of toxic phosgene or its derivatives.

Table 3. *Oxidative Carbonylation of Different 2-Aminoalkan-1-ols* **1** *to Oxazolidin-2-ones* **2**[a])

Entry	2-Aminoalkan-1-ols	R^1	R^2	R^3	Product	Yield [%][b])
1	**1a**	H	H	H	**2a**	80
2	**1b**	H	Me	H	**2b**	94
3	**1c**	Me	H	H	**2c**	91
4	**1d**	Et	H	H	**2d**	90
5	**1e**	^{i}Pr	H	H	**2e**	82
6	**1f**	Me_2	H	H	**2f**	86
7	**1g**	H	H	CH_2CH_2OH	**2g**	74

[a]) Reaction conditions: (Chitosan-*Schiff* base)cobalt(II) (60 mg), 2-aminoalkan-1-ols (10 mmol), NaI (0.2 mmol), temp. 120°, 1,4-dioxane (8 ml), *P*(CO) 5.75 MPa, *P*(O_2) 0.25 MPa, and time 2.5 h. [b]) Yield of isolated material.

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Experimental Part

1. *General*. Carbon monoxide and oxygen with a purity of 99.9% were commercially available. Amino alcohols and other reagents were of anal. grade. (Chitosan-*Schiff* base)cobalt(II) catalyst was prepared according to a modified procedure of [45]; the metal content of (chitosan-*Schiff* base)cobalt(II) catalyst was 4.93%. Atomic absorption: *Hitachi-180-80* polarized *Zeeman* atomic absorption spectrophotometer. ^{1}H- and ^{13}C-NMR Spectra: *Varian Inova 400M* spectrometer; δ in ppm, *J* in Hz.

2. General Carbonylation Procedure. A 100 ml autoclave (magnetic stirring bar and automatic temp. control) was charged with the α-amino alcohol (10 mmol), the (chitosan-*Schiff* base)cobalt(II) catalyst (60 mg), NaI (0.2 mmol), and 1,4-dioxane (8 ml). Then the autoclave was pressurized with CO and O_2 to a total pressure of 6.0 MPa (CO 5.75 MPa and O_2 0.25 MPa) and placed in oil bath pre-heated at 120°. The mixture was stirred for 2.5 h at 120°. Then, the autoclave was cooled, excess gas purged, and the mixture filtered. Qualitative analyses were conducted with a *HP-6890/5973* GC/MS and quantitative analyses with an *Agilent-6820* GC.

3. Characterization of Products. Crude products **2** were easily purified by column chromatography (silica gel, hexane/acetone and hexane/Et_2O). All the products were characterized by ^{1}H- and ^{13}C-NMR.

Oxazolidin-2-one (**2a**; $R^1 = R^2 = R^3 = H$) [27]: Colorless solid. ^{1}H-NMR ($CDCl_3$): 5.98 (br. *s*, 1 H); 4.45–4.41 (*m*, 2 H); 3.68–3.60 (*m*, 2 H). ^{13}C-NMR ($CDCl_3$): 160.7; 64.9; 40.6.

5-Methyloxazolidin-2-one (**2b**; $R^1 = R^3 = H$, $R^2 = Me$) [27]: Pale yellow oil. ^{1}H-NMR ($CDCl_3$): 6.52 (br. *s*, 1 H); 4.76–4.67 (*m*, 1 H); 3.67–3.63 (*m*, 1 H); 3.17–3.13 (*m*, 1 H); 1.40 (*d*, *J* = 6.4, 3 H). ^{13}C-NMR ($CDCl_3$): 160.5; 73.4; 47.4; 20.4.

4-Methyloxazolidin-2-one (**2c**; $R^1 = Me$, $R^2 = R^3 = H$) [27]: Pale yellow oil. ^{1}H-NMR ($CDCl_3$): 6.66 (br. *s*, 1 H); 4.44 (*t*, *J* = 8.0, 1 H); 4.00–3.90 (*m*, 1 H); 3.89 (*dd*, *J* = 8.3, 6.3, 1 H); 1.29 (*d*, *J* = 6.4, 3 H). ^{13}C-NMR ($CDCl_3$): 160.2; 71.6; 48.2; 20.7.

4-Ethyloxazolidin-2-one (**2d**; $R^1 = Et$, $R^2 = R^3 = H$) [30]: Pale yellow oil. ^{1}H-NMR ($CDCl_3$): 6.83 (br. *s*, 1 H); 4.43 (*t*, *J* = 8.4, 1 H); 3.99–3.96 (*m*, 1 H); 3.81–3.74 (*m*, 1 H); 1.61–1.50 (*m*, 2 H); 0.92 (*t*, *J* = 7.6, 3 H). ^{13}C-NMR ($CDCl_3$): 160.4; 69.9; 53.8; 28.1; 9.2.

4-Isopropyloxazolidin-2-one (**2e**; $R^1 = {}^i$Pr, $R^2 = R^3 = H$) [27]: Colorless solid. ^{1}H-NMR ($CDCl_3$): 6.35 (br. *s*, 1 H); 4.44 (*t*, *J* = 8.8, 1 H); 4.10 (*dd*, *J* = 8.8, 6.4, 1 H); 3.61–3.55 (*m*, 1 H); 1.75 (*sept. d*, *J* = 6.8, 6,8, 1 H); 0.94 (*d*, *J* = 6.8, 6 H). ^{13}C-NMR ($CDCl_3$): 160.2; 68.6; 58.3; 32.7; 18.0; 17.6.

4,4-Dimethyloxazolidin-2-one (**2f**; $R^1 = Me_2$, $R^2 = R^3 = H$) [30]: Pale yellow oil. ^{1}H-NMR ($CDCl_3$): 6.64 (br. *s*, 1 H); 4.02 (*s*, 2 H); 1.30 (*s*, 6 H). ^{13}C-NMR ($CDCl_3$): 159.4; 76.9; 55.2; 27.4.

3-(2-Hydroxyethyl)oxazolidin-2-one (**2g**; $R^1 = R^2 = H$, $R^3 = CH_2CH_2OH$) [30]: Colorless oil. ^{1}H-NMR ($CDCl_3$): 4.35–4.31 (*m*, 2 H); 3.78–3.76 (*m*, 2 H); 3.70–3.66 (*m*, 2 H); 3.39–3.36 (*m*, 2 H). ^{13}C-NMR ($CDCl_3$): 159.3; 62.1; 60.3; 46.8; 45.6.

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