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REDUCTIVE DECYANATION OF PYRIDINECARBONITRILES BY TITANIUM TRICHLORIDE

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Summary Titanium(III) chloride promotes reductive decyanation of 4-CN- and 2-CN-pyridine. The role of complex forming agents is discussed.

The functional N-oxide group of heterocyclic N-oxides and related compounds is reduced by $TiCl_3$ with two-electron change[1a,b,c] and various reductions of other systems have been reviewed[2]. Recently an "unusual synthesis" of 2,4-dibenzyl-tetrahydroquinoline from benzyl radical addition to quinoline in the presence of $TiCl_3$ has been reported by us[3]. Now we wish to show a further aspect of the reducing power of Ti(III) the reductive decyanation of pyridinecarbonitriles. Pyridine and cyanide are the only products in these reactions Decyanation is quantitative when the CN- group is at 4-position of the pyridine ring and yields based on $TiCl_3$ approach or reach 100% when complex forming agents are present during the reaction.

Some typical results are summarized in the Table

Table - Decyanation of 4-CN-pyridine

Molar ratio 4-CN-pyr/$TiCl_3$	Complex forming agent[d]	Pyridine (yields %[b])	Yields %[c] based on $TiCl_3$
1 : 1	-	20	40
0.5 : 1	-	52	52
0.25 : 1	-	91	45
0.125 : 1	-	quantitative	-
1 : 1	citrate (10 ml)[a]	39	78
0.5 : 1	" "	93	93
1 : 1	CH_3COOH (10 ml.)	50	quantitative
0.5 : 1	" "	quantitative	quantitative

a) conc 32 g. of $(NH_4)_2C_6H_6O_7$ per 100 ml of solution

b) yields based on starting 4-CN-pyridine

c) considering two-electron transfer per mole of 4-CN-pyridine

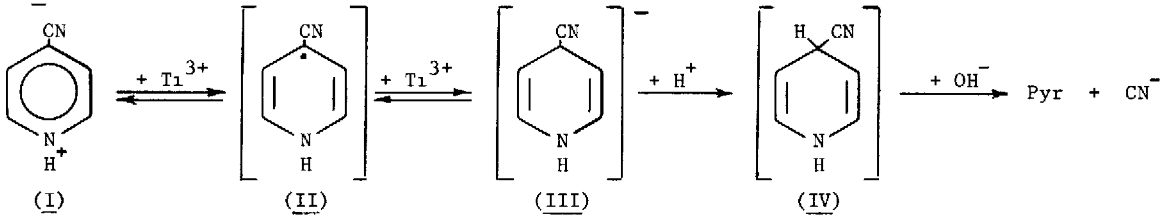
d) complexing agents are added to the starting solution before addition of dilute NaOH

If the CN- group is at the 2-position of the pyridine ring, decyanation and yields based on $TiCl_3$ never exceed 30 and 15% respectively 3-CN-pyridine does not give decyanation under all experimental conditions reported in the Table.

A mechanism which is consistent with these results is postulated in the Scheme

Scheme

Path 1



Path 2

$2\,(I) \overset{+\,2\,Ti^{3+}}{\rightleftharpoons} 2\,(II) \rightleftharpoons (I) + (III)$, $(III) \xrightarrow{+\,H^+} (IV) \xrightarrow{+\,OH^-} Pyr + CN^-$

A two step electron transfer to protonated 4-CN-pyridine (I) could lead to the anion (III) via the free radical (II) through Path 1 or 2 Proton abstraction from the solvent could produce the dihydro-intermediate (IV), which gives pyridine via base-catalyzed 1,4 elimination of HCN. The conversion of (II) directly to (IV) by combination with an hydrogen atom is rather improbable because of the lack of hydrogen-atom donor ability of the reaction medium. A mechanism via Path 2, already proposed by Kosower[4] for different 4-substituted pyridinyl radicals, would require a high concentration of (II) Two points should be emphatized

i) the radical stabilizing effect of the CN- group in the radical (II)[5a,b] (4-CN- > 2-CN- > 3-CN-) must be considered responsible for the quantitative, partial (30%) and no decyanation of 4-CN-, 2-CN- and 3-CN-pyridine respectively.

ii) the reductive power of Ti(III) is known to be higher when complex forming agents are present[1a] in the reaction and to be greater in acetate than in citrate medium[6]. This would appear the case for the reaction of 4-CN-pyridine in the absence of complex formation, yields based on $TiCl_3$ never exceed 52% while range between 78 - 93% and achieve 100% in the presence of citrate and acetic acid respectively

In our opinion, the driving force for the reaction studied involves both the stabilization of Ti(IV) state (as TiO_2 or Ti(IV)-complexes) and the rearomatization of (IV) by cyanide loss. Further experiments are in progress with the aim to extend this reaction to other substrates.

A typical experiment in the absence of complexing agents is as follows to a stirred solution of 4-CN-pyr (10 m mole), dist H_2O (15 ml.), 37% HCl sol (5 ml.) and 15% aq. $TiCl_3$ sol (10 m mole) is added dropwise a 10% NaOH sol. at 0°C under N_2 until pH 13-14 is reached. After work up, the reaction mixture is analyzed by G.L.C. Cyanide was detected by conductometric analysis

REFERENCES

1- a) R.T. Brooks and P D. Sternglanz, Anal. Chem. 31, 561 (1959), b) J.M McCall and R.E. Ten Brink, Synthesis, 335 (1975), c) B.W Cue et al., Org Prep and Proc Int 9, 263 (1977).
2- J. E McMurray, Accounts of Chem. Res. 7, 281 (1974).
3- O. Porta and G. Sesana, Tetrahedron Letters, 3571 (1978).
4- E.M. Kosower and A. Teurstein, J. Am. Chem Soc. 95, 6127 (1973).
5- a) R.A MacKay, J R Landolph and E J. Poziomek, J Am Chem Soc 93, 5026 (1971),
b) W.M. Schwarz, E.M. Kosower and I Shain, ibid 83, 3164 (1961).
6- I.M. Kolthoff, Rec Trav. Chim. 43, 772 (1924).

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