

Note

Selective oxidation of primary alcohols with quinolinium chlorochromate

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Selective oxidation of primary alcohol in the presence of a secondary alcohol with quinolinium chlorochromate (QCC) has been achieved with a mild, stable and very efficient reagent. Its mechanistic and comparative study with isoquinolinium chlorochromate (IQCC) has also been reported.

Though many reagents are available for the oxidation of alcohols, there still exists a need for developing new methods which show great selectivity, high yields and can be used under mild conditions. Chemoselective oxidation of a primary or a secondary hydroxyl group in the presence of both is a useful transformation in synthesis. A few methods are available for such selective oxidation of primary hydroxyl groups but there are several reports regarding the chemoselectivity of various reagents for the oxidation of secondary alcohols to the corresponding carbonyl compounds. Pyridine in combination with chlorine¹, tritylfuloroborate², silver carbonate³, sodium bromate⁴ in the presence of catalytic cerium ammonium nitrate or sodium hypochlorite⁵ in aq. acetic acid are suitable for the oxidation of secondary alcohols in the presence of primary alcohols. Potassium ruthenate⁶ in the presence of potassium peroxodisulfate selectively oxidizes allylic and benzylic alcohols but not the saturated alcohols. Recently we have found that SeO_2 , TBHP, SiO_2 (ref. 7) is a very good reagent for the oxidation of a primary allylic alcohol to the corresponding α , β -unsaturated aldehyde while secondary allylic, benzylic, saturated primary or secondary alcohols remain unaffected.

We have already reported⁸ that quinolinium chlorochromate, which resembles very much the well known pyridinium chlorochromate (PCC)⁹, possesses excellent selectivity to oxidise primary alcohols in the presence of secondary alcohols under normal reaction conditions. With this re-

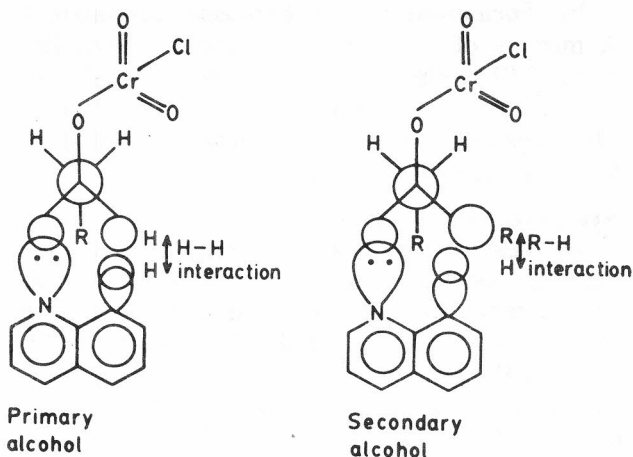


Chart I

gent primary alcohols undergo oxidation to the corresponding aldehydes in a reaction time of 1-2 hr, while it takes around 12 hr for the oxidation of secondary alcohols in almost 80-90% yields. This happens irrespective of the fact whether both hydroxyl groups are present in the same molecule or are present in different molecules. As a part of our ongoing studies we want to report additional details and some new findings relating to mechanistic and comparative study of oxidation of different alcohols with quinolinium chlorochromate (QCC) and isoquinolinium chlorochromate (IQCC). Quinolinium chlorochromate is a yellowish brown solid not appreciably hygroscopic. It is stable (their oxidation ability is the same after a few months of storage at ambient temperature) and possesses excellent selectivity to oxidise primary alcohols in the presence of secondary alcohols. This difference in the rate of oxidation is envisaged due to steric factors (see mechanism).

Mechanism

The detailed mechanism of oxidation is complex and is perhaps not very clear. It has, however, been reported¹⁰ that after the chromate ester formation the abstraction of hydrogen is intra or intermolecular which leads to the corresponding carbonyl compounds. If the abstraction is intramolecular then there should be no difference in the rate of oxidation of primary and secondary alcohol. On the other hand, if the proton abstraction is intermolecular it can then be assumed that

Table I—Oxidation of primary alcohols with quinolinium chlorochromate

Sl. No.	Alcohol	Product	Time*	% Conversion of alcohols		
				QCC*	PCC	IQCC
1.			1h	40	92	90
2.			1h	No Reaction	100	95
3.			1h	40	85	85
4.			1h	25	100	100
5.	$\text{CH}_3(\text{CH}_2)_3\overset{\text{C}_2\text{H}_5}{\text{C}}\text{HCH}_2\text{OH}$	$\text{CH}_3(\text{CH}_2)_3\overset{\text{C}_2\text{H}_5}{\text{C}}\text{HCHO}$	1h	20	100	95
6.			1h	30	100	95
7.			2h	80	—	—
			2h	—	95	90
8.			2h	—	98	95
9.			2h	—	90	90
10.			1h	40	90	85

All the compounds were isolated and identified by IR, NMR, elemental analysis and were estimated as their 2,4-dinitrophenylhydrazones

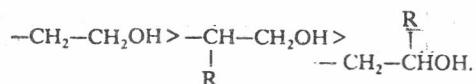
*The reaction was found to be complete in each case after 12 hr.

there will be steric interaction between the *peri*-hydrogen of quinoline and the group present on C (may be H or R) other than the H which has to be abstracted as depicted in Chart 1.

If this theory is correct then the rate of oxidation of primary and secondary alcohols should be same if we use pyridine (no reference is available which mention the difference in the rate of oxidation of primary and secondary alcohols with PCC) or isoquinoline in which the nitrogen lone-pair orbital is free of any steric interaction with the *peri*-hydrogen in comparison to quinoline where this type of interaction exists.

Keeping this in mind, isoquinolinium chlorochromate (IQCC) was prepared, which is a brownish black solid, m.p. 73-75°C. It is interesting to mention that all the oxidations with this reagent underwent smoothly and no difference in the rate of oxidation of primary and secondary alcohols was observed, thereby supporting the above theory.

In order to explore this reaction as well as the proposed mechanism, a comparison of the rate of oxidation of primary and secondary alcohols with all the three reagents viz., PCC, QCC and IQCC was undertaken. As is evident from Table I, the rate of oxidation as well as the yields are comparable when PCC and IQCC were used as the oxidising agents under similar reaction conditions, whereas no reaction took place with QCC in case of secondary alcohols (entry 2, 8, 9). Primary alcohols having substitution(s) at C-2 and C-3 were oxidised (QCC) from zero to 70% under the reaction conditions (entry 1,3,4,5,6,7,10). From these studies it may be concluded that the rate of oxidation of alcohol is very much sensitive to substitutions on the subsequent carbons which may be attributed to the increased strain in the transition state (I) and the suggested order of rate of oxidation is



Experimental Section

Preparation of quinolinium chlorochromate (QCC). Quinoline (13 mL, 109 mmole) was added dropwise to a cooled (0°C) stirred mixture of chromium trioxide (10 g, 100 mmole) and conc. HCl (11 mL), in water (10 mL). The yellowish brown solid obtained was collected in a sin-

tered glass funnel and dried *in vacuo* affording 22.4 g (77%) of reagent, m.p. 65-66°C (Found: C, 40.28; H, 3.09; N, 5.19. Calc. C, 40.67; H, 3.01; N, 5.27%).

Preparation of isoquinolinium chlorochromate (IQCC). Isoquinoline (26 mL, 218 mmole) was gradually added to a cooled stirred solution of chromium trioxide (20 g, 200 mmole) in water (20 mL) and conc. HCl (22 mL). The brownish black solid was collected on a sintered glass funnel and dried *in vacuo* affording 42.4 g (73%) of IQCC, m.p. 73-75°C (Found: C, 40.36; H, 2.90; N, 5.20. Calc. C, 40.67; H, 3.01; N, 5.27%).

General procedure of oxidation. In a dry 50 mL round bottom flask, QCC (1.27 g, 4.7 mmole) was suspended in anhyd. dichloromethane (20 mL). The solution of alcohol (4 mmole) in anhyd. dichloromethane was added all at once to a magnetically stirred suspension. The mixture was stirred for the time as indicated in Table I. The progress of the reaction was monitored by TLC. After the period as mentioned in Table I, it was diluted with *n*-hexane (15 mL), allowed to stand at room temp for 10 min and then passed through a short column of silica gel. The solvent was evaporated leaving the product (purity checked by ¹H NMR) product mixtures which was separated by column chromatography using silica gel as adsorbent.

Following the similar procedure oxidation with isoquinolinium chlorochromate was done.

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References

- 1 Wisha J & Zarecki A, *Tetrahedron Lett*, **1974**, 3059.
- 2 Jung ME & Brown RW, *Tetrahedron Lett*, **1978**, 2771.
- 3 McKillop A & Young DW, *Synthesis*, **1979**, 401.
- 4 Tomoika H, Oshima K & Nozaki H, *Tetrahedron Lett*, **23**, **1982**, 539.
- 5 Stevens R V, Chapman K T, Stubbs C A, Tam W W & Albizati K F, *Tetrahedron Lett*, **23**, **1982**, 4647.
- 6 Kim K S, Kim S J, Song Y H & Hahn CS, *Synthesis*, **1987**, 1017.
- 7 Kalsi P S, Chhabra B R, Singh J, Vig R, *Synlett*, **1992**, 425.
- 8 Singh J, Kalsi P S, Jawanda G S & Chhabra B R, *Chem & Ind*, **1986**, 751.
- 9 Corey E J & Suggs J W, *Tetrahedron Lett*, **1975**, 2647.
- 10 Carruthers W, *Some modern methods of organic synthesis*, 3rd Edn (Cambridge University Press, Cambridge), **1986**, p.352.