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Unexpected tosyl deprotection during osmium catalysed dihydroxylation

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Abstract—Depending on the double bond position, tosyl deprotection was observed during olefin dihydroxylation using osmium tetroxide, leading to triols.

The *p*-toluenesulfonate group (tosyl group) is widely used as a leaving group in elimination or substitution reactions. Conditions to recover the alcohol are most of the time drastic and thus limit its use as a protecting group. Among the different methods already published to perform such a deprotection,[1] the use of sodium amalgam,[2] low valent titanium,[3] Na-naphthalenide[4] or magnesium in methanol[5] have been reported. Microwave assisted conditions[6] or irradiation under UV light[7] via an electron-transfer reaction were also applied with success. Nevertheless, all these conditions are reductive ones. In the course of our study on natural product synthesis, we planned to replace a tosyl group by nucleophilic substitution after having performed dihydroxylation of a double bond close to this group, using osmium tetroxide. The diol thus obtained should be selectively protected. To our surprise, only a triol was isolated, resulting of the concomitant olefin dihydroxylation and deprotection of the tosyl group (Fig. 1).

Results are collected in Table 1.

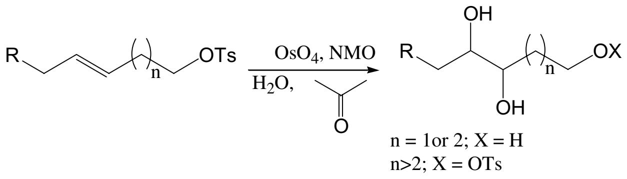

Figure 1.

This process has been applied to various substrates and under the aforementioned conditions either a triol, when 2 or 3 carbons are present between the tosyl group and the double bond (entries 1–4) or a diol, when the distance is higher (entries 5 and 6) or in the absence of a double bond (entry 7) was obtained. In the case of aryltoluenesulfonate groups (entries 8–10) no deprotection occurred and in the case of competition between an alkylsulfonate and an arylsulfonate group only the aliphatic alcohol was regenerated (entries 4, 9 and 10). Sulfonamide remained untouched (entry 12) while the mesyl group was also deprotected (entry 11) probably due to the well-known difference of strength between the N–SO_2 and the O–SO_2 bonds. In the case of compound depicted in entry 3, Sharpless AD-mix system was also tested leading to the triol. In view of understanding the mechanism, we performed several experiments: first, NMO alone was tried on product **1**, but no reaction occurred, the starting material was totally recovered. We also performed the reaction with *N*-methylmorpholine, the reduction product of NMO during the osmium oxidation catalytic cycle, without success. Intermolecular experiments, using 1-hexene and product **7** also failed. At this stage of our study, we assume that the formation of the generally admitted intermediate in OsO_4 catalytic dihydroxylation, the osmate ester **C**, close to the tosyl group is necessary to allow its deprotection (Fig. 2). This cyclic species **C** should be attacked by water, leading to the open hemi osmate ester **D** which thereafter should undergo a nucleophilic substitution by

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Keywords: Dihydroxylation; Tosyl group deprotection; Osmium tetroxide; Triol synthesis.

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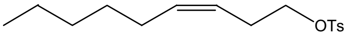
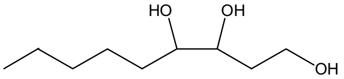
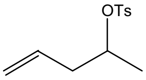
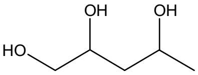
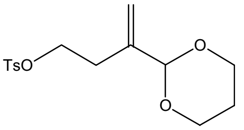
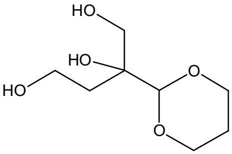
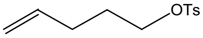
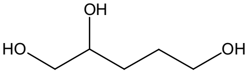
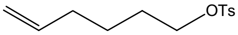
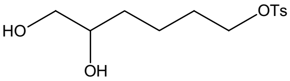
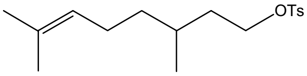
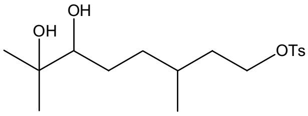
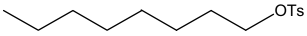
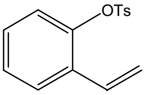
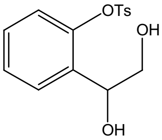
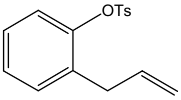
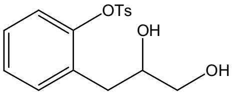
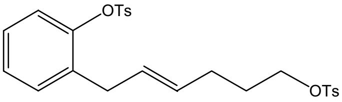
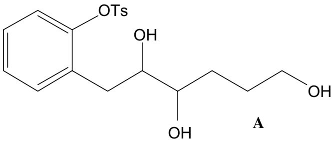
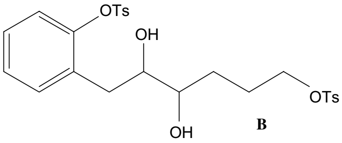
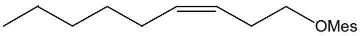
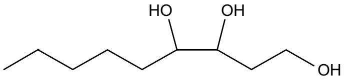
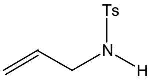
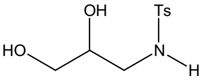
Table 1. Results of oxidation with OsO_4

Entry	Substrate	Product	Conversion, % (isolated yield, %)
1	 **1**		100 (83)
2	 **2**		100
3	 **3**		92[a] (90) 60[b]
4	 **4**		100 (70)
5	 **5**		100
6	 **6**		100
7	 **7**	—	0
8	 **8**		100
9	 **9**		100
10	 **10**	 **A**  **B**	100 (A: 43) (B: 27)
11	 **11**		100 (80)
12	 **12**		100[c]

Conditions: see typical procedure.

[a] After 4 h, using 10% OsO_4, NMO.

[b] After 60 h using AD-mixβ, 0.2% OsO_4.

[c] 1% of OsO_4 was added after 4 h of reaction.

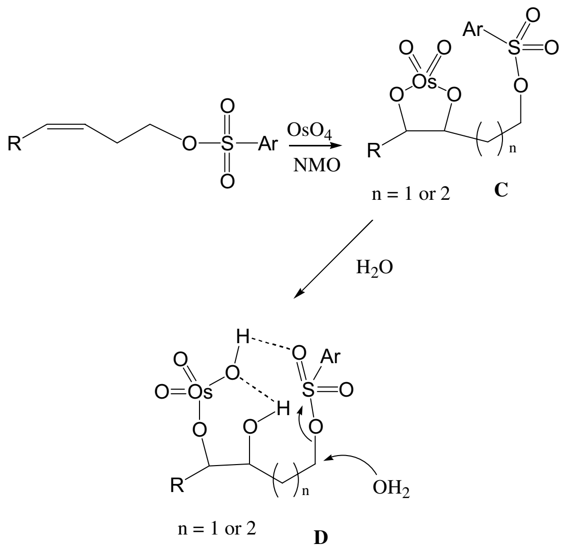


Figure 2.

a second molecule of water, thus liberating the tosyl group. Assistance of the osmium part of **D** via hydrogen bond should also be considered to explain the necessity of proximity between the tosyl group and the double bond to ensure the deprotection. This proposed mechanism is consequent with experimental results obtained with arylsulfonates which were totally recovered, nucleophilic substitution being impossible on aryl sp^2 carbons (entries 8–10).

In conclusion, we have shown here that the tosyl group can be cleaved during a dihydroxylation procedure (OsO_4/NMO system), so long as the C=C bond is close enough to the sulfonate function, leading to a triol.

In a typical procedure, 0.16 mmol of a substrate bearing both a tosyl group and a double bond was dissolved in a volume/volume mixture of acetone/water (0.8 mL of each). *N*-Methyl morpholine-*N*-oxide (NMO, 0.16 mmol) and 1% of OsO_4 in water (4 wt %) were added and the reaction mixture allowed to stir at room temperature for 20 h. After extraction with AcOEt and drying with $MgSO_4$, the crude mixture was analysed by ^{1}H NMR, to control the presence or not of the tosyl group. Column chromatography on silica (AcOEt/petroleum ether: 50/50) could be performed to isolate the reaction product with good yield.

References and notes

1. Greene, T. W.; Wuts, P. G. M. *Protecting Groups in Organic Synthesis*, 3rd ed.; Wiley: New York, 1999.
2. Ranganathan, R.; Larwood, D. *Tetrahedron Lett.* **1978**, *19*, 4341.
3. Nayak, S. K. *Synthesis* **2000**, 575.
4. Suzuki, H.; Unemoto, M.; Hagiwara, M.; Ohyama, T.; Yokoyama, Y.; Murakami, Y. *J. Chem. Soc., Perkin Trans. 1* **1999**, 1717.
5. Sridhar, M.; Kumar, B. A.; Narender, R. *Tetrahedron Lett.* **1998**, *39*, 2847.
6. Sabitha, G.; Abraham, S.; Subba Reddy, B. V.; Yadav, J. S. *Synlett* **1999**, 1745.
7. Pete, J. P.; Portella, C. *Bull. Soc. Chim. Fr.* **1980**, *5–6*, 275; Nishida, A.; Hamada, T.; Yonemitsu, O. *J. Org. Chem.* **1988**, *53*, 3387.