Note

Sulphuric acid adsorbed on silica gel: An efficient catalyst for the protection and deprotection of alcohols with dihydropyran

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Alcohols are tetrahydropyranylated in the presence of sulphuric acid adsorbed on silica gel in dichloromethane in good to excellent yields. Addition of methanol brings about the complete deprotection.

3, 4-Dihydro-2H-pyran (DHP) has been widely utilized as a protective group for hydroxy compounds requiring protic or Lewis acids as typical promoters. More recently the tetrahydropyranylation process (THP ethers) has been performed under environmentally friendly conditions with minimum purification requirements. These include use of heterogenous catalysts such as montmorillonite K-10, sulfonated charcoal, H-Y zeolite, zinc chloride, enirocat EPZG, and natural kaolinite clay. Moreover a bentonitic clay has been used to deprotect THP ethers. However, none of these catalysts is claimed to give protection as well as deprotection of hydroxy compounds but one. Taking into account the increasing demand for new and cleaner chemical process we undertook a study directed towards discovering new catalytic application of supported acid.

The synthetic utility of supported reagents has been demonstrated during the past ten years. As a result many reactions can be now carried out cleanly and rapidly under mild conditions by using reagents which have been previously adsorbed on inorganic supports. Silica gel has been one of the most used inorganic supports in organic synthesis.

In this paper we present the protection of hydroxy compounds as THP ethers and removal of the protective group over sulphuric acid adsorbed on silica gel in aprotic (CH$_2$Cl$_2$) and protic (MeOH) solvents, respectively.

The catalyst is easily prepared by mixing chromatographic grade silica gel (Merck, Kieselgel 60, 70-230 mesh) with 3% of its weight of 98% sulphuric acid dissolved in acetone.

The tetrahydropyranylation procedure involves the treatment of a solution of an alcohol in anhydrous dichloromethane with two equivalents of 3, 4-dihydro-2H-pyran in the presence of catalytic amounts of acidic silica gel; a complete conversion into the corresponding THP ether is observed within 5-10 min at room temperature. This procedure is quite general for primary, secondary, allylic and benzylic alcohols (Table I).

Deprotection of tetrahydropyranyl group is also observed by addition of MeOH to the mixture of tetrahydropyranyl ether and catalyst under reflux condition. A variety of tetrahydropyranyl ethers were deprotected using catalytic amounts of sulphuric acid adsorbed on silica gel (Table I).

Experimental Section

All products were known and their physical data compared with those of known samples.

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>Protection in CH$_2$Cl$_2$</th>
<th>Deprotection in MeOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period (min)</td>
<td>Yield (%)</td>
<td>Period (Min)</td>
</tr>
<tr>
<td>Benzyll</td>
<td>5</td>
<td>95</td>
</tr>
<tr>
<td>4-Methylbenzyl</td>
<td>5</td>
<td>93</td>
</tr>
<tr>
<td>2-Nitro-5-methylbenzyl</td>
<td>10</td>
<td>82</td>
</tr>
<tr>
<td>4-Nitrobenzyl</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>α-Phenylethyl</td>
<td>5</td>
<td>90</td>
</tr>
<tr>
<td>Benzhydrol</td>
<td>10</td>
<td>74</td>
</tr>
<tr>
<td>Cinnamyl</td>
<td>10</td>
<td>82</td>
</tr>
<tr>
<td>Cyclohexanol</td>
<td>10</td>
<td>88</td>
</tr>
<tr>
<td>2-Butanol</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>1-Octanol</td>
<td>10</td>
<td>85</td>
</tr>
<tr>
<td>Allyl</td>
<td>10</td>
<td>80</td>
</tr>
</tbody>
</table>

Yields refer to isolated products. The products were identified by comparison with authentic samples.
Adsorption of sulphuric acid on silica gel. A solution of concentrated sulphuric acid (2 mL) in acetone (20 mL) is added to a suspension of silica gel (100 g, Merck 60, 70-230) in acetone (200 mL) at room temperature for 1 hr, the solvent is removed in a rotatory evaporator under reduced pressure. The yellow brown powder is obtained which can be stored in a desiccator for long period of times without any appreciable loss of activity.

Tetrahydropyranylation of alcohols: General procedure. Sulphuric acid adsorbed on silica gel (15 mg) was added to a solution of hydroxy compound 1a-k. (3.5 mmoles) and 3, 4-dihydro-2H-pyran (2.7 mmoles) in dichloromethane (15 mL). The mixture was stirred at room temperature for the specified period (Table I). Progress of the reaction is monitored by TLC. After completion of the reaction which usually takes 1-10 min, the catalyst is removed by filtration and 1-2 drops of triethylamine added. The solvent is removed in a rotatory evaporator under reduced pressure and the residue purified by chromatography on a short column of silica gel using hexane-ethyl acetate as solvent to afford the product in 80-95% yield (Table I).

Deprotection of THP-Ether: General procedure. A methanolic (15 mL) solution of THP-ether (5 mmoles) and sulphuric acid on silica gel (20 mg) is refluxed for the appropriate period. The catalyst is filtered and to the filtrate 1-2 drops of triethylamine added. The solvent is evaporated under reduced pressure. The crude product is directly placed over a short column of silica gel to afford the corresponding alcohol in 78-93% yields.

References
(c) Kocienski P J, Protecting Groups, (George Thieme Verlag, New York), 1994.
(b) Mourig Thoas, J Scientific American, 1992, 82.
(c) Sheldon R A, Chem Ind, 1997, 12.