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Na-Y Zeolite, an Efficient Catalyst for the Methoxymethylation of Alcohols

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Abstract: A variety of hydroxy compounds react with methoxymethyl chloride in the presence of catalytic amount of Na-Y zeolite to afford the corresponding methoxymethyl ethers (MOM ethers) in excellent yields.

The last decade has witnessed considerable upsurge of interest in the area of zeolite induced organic transformations.[1] In a series of publications from our group,[2] we have exploited the catalytic potential of zeolites for various organic synthetic transformations, e.g. thioacetalization of carbonyl compounds, sulfoxidation of thioethers, deketalization, tetrahydropyranylation of alcohols and oxidative cleavage of tosylhydrazones. In continuation, we wondered whether the Coulombic interaction between zeolite frame Na^+ and organic protective halide (MOMCl) could create sufficient polarization, which in turn could be applied for the protection of alcohols. Here, we report an unprecedented, convenient and heterogeneous catalytic methodology for methoxymethylation of alcohols using Na-Y zeolite in near netural conditions.

The protection of hydroxyl group as MOM ether is a commonly used transformation in synthetic organic chemistry.[3] Although a wide variety of methods for its preparation employing number of catalysts and dimethoxymethane as reagent have been developed,[4] the literature describing the direct alkylation of an alcohol using chloromethyl methyl ether is rather limited. Thus, when the alcohols were treated with MOM chloride in the presence of catalytic amount of Na-Y zeolite (UCIL, Bombay), the corresponding MOM ethers were obtained in good to excellent yields (Table 1). In a typical reaction procedure, a mixture of hydroxy compound (5 mmol), methoxymethyl chloride (7.5 mmol) and Na-Y zeolite (0.25 parts by mass to that of substrate) in dichloromethane (10 ml) was refluxed with stirring for the indicated length of time (Table 1). The reaction was monitored by GC and/or TLC. After the reaction was complete, the zeolite was filtered off. The organic layer was washed with 10% $NaHCO_3$, H_2O, brine and dried (Na_2SO_4). Removal of solvent and subsequent silica gel column chromatography using pet ether : ethyl acetate (95:5) as eluent, gave the pure MOM ether. As a control experiment, the use of other zeolites such as H-ZSM-5, mordenite, 4Å and 5Å molecular sieves failed to accomplish above transformation. The results with H-Y zeolite were also not encouraging due to higher concentration of acid sites. It is noteworthy that the isomerization of double or triple bond in case of allylic and acetylenic compounds is not observed (Table 1, entries 3,4). Mention must be made here that tertiary alcohol which is prone to olefinic dehydration,[4] is also smoothly converted to MOM ether (Table 1, entry 10) and no dehydration occured.

In conclusion, from commercially available Na-Y zeolite, a facile heterogeneous catalytic method for methoxymethylation of a variety of alcohols has been developed. The obvious advantages of heterogeneous catalysis in terms of easy separation, consistent yields and recyclability of the catalyst are noteworthy. Thus, the present catalytic method in near neutral conditions should be a useful addition to synthetic organic chemistry.

Dedicated to Dr.S.Rajappa on the occasion of his 60th Birthday.

Table 1 : Methoxymethylation of Alcohols induced by Na-Y zeolite

Entry	Substrate	Reaction time (h)	MOM-ether[a] (% yields[b])
1	n-Hexanol	4	90
2	2,2-Dimethylpropane-1,3-diol	6	74
3	Allyl alcohol	4	91
4	Propargyl alcohol	4	89
5	Benzyl alcohol	6	80
6	Tetrahydrofurfuryl alcohol	4	85
7	2-Butanol	4	89
8	Cyclohexanol	4	86
9	(-)-Menthol	6	70
10	tert-Butanol	6	70

(a) Products were characterized by IR, ^1H NMR and MS spectra.[5] (b) Yields refer to isolated pure products.

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5. Selected spectroscopic data for MOM-ethers from entries 4,5,8 and 10 in Table 1.

Propargyl MOM-ether (entry 4) : IR υ max/cm^{-1} (Neat) : 3250, 2920, 2860, 2310, 1440, 1360, 1250, 1160, 1150, 1100, 1050; ^1H-NMR ($CDCl_3$) δ : 2.43 (m, 1H, $C\equiv C\underline{H}$); 3.4 (s, 3H, $OC\underline{H}_3$); 4.25 (d, 2H, $C\equiv C\text{-}C\underline{H}_2$), 4.85 (s, 2H, $O\text{-}C\underline{H}_2\text{-}O$); MS. m/e : 100 ($M^+$), 85, 69, 39.

Benzyl MOM-ether (entry 5) : IR υ max/cm^{-1} (Neat) : 3100, 3040, 2960, 2900, 1600, 1450, 1360, 1320, 1270, 1170, 1100, 1050; ^1H-NMR ($CDCl_3$) δ : 3.5 (s, 3H, $OC\underline{H}_3$), 4.75 (s, 2H, $C_6H_5C\underline{H}_2\text{-}O$), 4.9 (s, 2H, $O\text{-}C\underline{H}_2\text{-}O$), 7.2 - 7.6 (m, 5H, Ar-$\underline{H}$); Ms. m/e : 152 ($M^+$), 137, 121, 91.

Cyclohexyl MOM-ether (entry 8) IR υ max/cm^{-1} (Neat) : 2960, 2860, 1450, 1380, 1270, 1120, 1140; ^1H-NMR ($CDCl_3$) δ : 1.0 -2.1 (m, 11H, cyclohexyl-$\underline{H}$), 3.42 (s, 3H, $OC\underline{H}_3$), 4.68 (s, 2H, $O\text{-}C\underline{H}_2\text{-}O$); MS. m/e : 144 ($M^+$), 129, 113, 83.

***t*-Butyl MOM-ether** (entry 10) : IR υ max/cm^{-1} (Neat) : 3080, 3000, 2320, 1440, 1280, 1120, 1030; ^1H-NMR ($CDCl_3$) δ : 1.6 (s, 9H, $(C\underline{H}_3)_3C$), 3.4 (s, 3H, $OC\underline{H}_3$), 4.85 (s, 2H, $O\text{-}C\underline{H}_2\text{-}O$); MS. m/e : 118 ($M^+$), 103, 87, 57.

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