20M on acid-washed Chromosorb P; toluene, 9-ft FFAP, 90°; dibenzyl, diphenyl, 4-ft XF 1150, 130°.

Registry No.—Ia, 1876-22-8; Ib, 23042-72-0; Ic, 23042-73-1; Id, 23042-74-2.

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α Alkylation of Alkyl Alkanesulfonates

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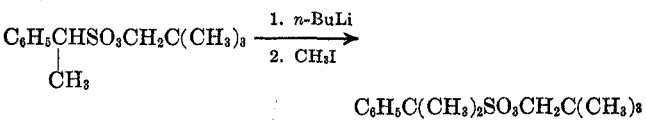
Recently, the facile α metalation (by *n*-butyllithium) and subsequent alkylation of alkyl α-toluenesulfonates were described.[1] Almost simultaneously, the α metalation and subsequent reactions of various sultones were reported.[2] The present work concerns the successful extension of our method of metalation and alkylation to simple alkyl alkanesulfonates.

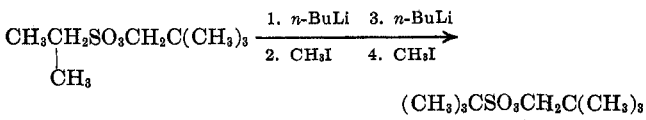
The metalation of the starting sulfonates shown in Table I proceeds quantitatively and apparently instantaneously at Dry Ice bath temperatures. The time required for subsequent alkylation is a function of the alkylating agent. Contrary to what may have been implied earlier,[1] *n*-butyllithium is a superior metalating agent over potassium hydride, which requires a much longer time for metalation and a more complicated work-up procedure.

Using the method described herein, all of the α hydrogens of an alkyl alkanesulfonate can be replaced by alkyl groups. Thus a useful route to esters of tertiary sulfonic acids is at hand.[3] For example, a derivative (**1**) of α-cumenesulfonic acid is easily prepared by alkylation, while the acid itself has probably not been prepared.[4]



1

Also, as shown in the preparation of neopentyl 2-methyl-2-propanesulfonate (**9b**), the metalation and alkylation can be repeated without isolation of the first-formed product (**9a**).



9b

From the examples given in Table I, it is evident that, regardless of the alcohol portion of the ester, at Dry Ice bath temperatures metalation α to the sulfonyl group is preferred over other possible reactions, *i.e.*, elimination or displacement. As reported by Durst,[2] however, if the solution of the metalated species is allowed to warm, to *ca.* −30°, rapid exothermic decomposition takes place. The decomposition products are unknown, but with α-lithio methyl methanesulfonate an intractable, syrupy oil that shows strong sulfonyl bands in the ir spectrum separates from the reaction mixture. Therefore, alkylations with 1-bromopropane, and presumably with others of the less reactive alkylating agents, cannot be speeded by simply allowing the reaction mixture to warm, but, rather, the time for alkylation must be greatly extended while the reaction mixture is kept well cooled.

Experimental Section[5]

Materials.—*n*-Butyllithium in hexane was purchased from the Foote Mineral Co. or from Alfa Inorganics, Inc. Tetrahydrofuran (Baker Analyzed Reagent) was used directly from freshly opened bottles, or after storage over Linde Molecular Sieves. The alkyl halides (Columbia), sulfonyl chlorides (Eastman), and neopentyl alcohol (Aldrich) were used as obtained. All reactions described herein were carried out in thoroughly dried equipment under a nitrogen atmosphere. Starting sulfonates, prepared as described below, were distilled shortly before use.

General Method for the Preparation of Starting Alkyl Alkanesulfonates.—To a benzene solution of 1.0 equiv of the alcohol and 1.03 equiv of triethylamine cooled in an ice bath, a benzene solution of 1.0 equiv of the sulfonyl chloride was added dropwise. After the addition was complete, triethylammonium chloride was filtered and washed with benzene. The combined filtrate and washings were extracted once with 10% HCl and thrice with distilled water, dried (Na_2SO_4), and evaporated *in vacuo*, yielding the crude ester. Vacuum distillation yielded the pure product.

Neopentyl methanesulfonate was prepared in 78.4% yield on a 0.50-mol scale according to the general procedure: bp 93.5–94.5° (9 mm); ir (neat) 2980 (CH) and 1360 and 1180 cm^{-1} (SO_3); nmr δ 0.98 [s, 9, $(CH_3)_3$], 2.98 (s, 3, CH_3), and 3.82 (s, 2, CH_2). The analytical sample was prepared by vpc.

Anal. Calcd for $C_6H_{14}O_3S$: C, 43.35; H, 8.49; S, 19.29. Found: C, 43.53; H, 8.58; S, 19.01.

Neopentyl ethanesulfonate was prepared in 90.0% yield on a 0.23-mol scale according to the general procedure: bp 58–60° (0.15 mm); ir (neat) 2970 (CH) and 1355 and 1175 cm^{-1} (SO_3); nmr δ 0.98 [s, 9, $(CH_3)_3$], 1.37 (t, 3, J = 8 Hz, CH_3), 3.12 (q, 2, J = 8 Hz, CH_2S), and 3.82 (s, 2, OCH_2), The analytical sample was prepared by vpc.

Anal. Calcd for $C_7H_{16}O_3S$: C, 46.69; H, 8.95; S, 17.79. Found: C, 46.57; H, 9.12; S, 17.61.

Methyl methanesulfonate was prepared in 60% yield on a 1.0-mol scale: bp 71–73° (5.0 mm) [lit.[6] bp 100.5–101.5° (25 mm)]; ir (neat) 1360 and 1185 cm^{-1} (SO_3); nmr δ 3.00 (s, 3, CH_3S) and 3.88 (s, 3, OCH_3).

Ethyl methanesulfonate was prepared in 65% yield on a 0.10-mol scale: by 78–79° (7.5 mm) [lit.[7] bp 85–86° (10 mm)]; ir (neat) 1350 and 1180 cm^{-1} (SO_3); nmr δ 1.39 (t, 3, J = 7 Hz, CH_2CH_3), 2.99 (s, 3, CH_3S), and 4.27 (q, 2, J = 7 Hz, OCH_2CH_3).

2-Propyl methanesulfonate was prepared in 68% yield on a 0.50-mol scale: bp 39–41° (0.15 mm) [lit.[8] bp 86–88° (12 mm)];

(1) W. E. Truce and D. J. Vrencur, *Can. J. Chem.*, **47**, 860 (1969).

(2) T. Durst and J. du Manoir, *ibid.*, **47**, 1230 (1969).

(3) The only other route to esters of this type is the reaction of a tertiary sulfonic acid with a diazo alkane, a method limited chiefly by the availability of the sulfonic acid: F. Asinger, B. Fell, and A. Commichau, *Chem. Ber.*, **98**, 2154 (1965); R. B. Scott, Jr., and W. S. Heller, *J Org. Chem.*, **31**, 1999 (1966).

(4) The preparation of α-cumenesulfonic acid has been claimed *via* treatment of cumene with the pyridine–sulfur trioxide complex. The product was characterized only by a nitrogen analysis of its S-benzylthiouronium derivative. See Y. S. Shabarov, R. Y. Levina, and V. K. Potapov, *Zh. Obshch. Khim.*, **32**, 3184 (1962); *J. Gen. Chem. USSR*, **32**, 3129 (1962).

(5) Melting and boiling points are uncorrected. Infrared spectra were recorded on an Infracord spectrophotometer. Nuclear magnetic resonance spectra were recorded on a Varian Associates A-60A spectrometer in deuteriochloroform with tetramethylsilane as internal standard. Microanalyses were performed by Dr. C. S. Yeh and staff.

(6) W. E. Bissinger, F. E. Kung, and C. W. Hamilton, *J. Amer. Chem. Soc.*, **70**, 3940 (1948).

(7) H. Billeter, *Chem. Ber.*, **38**, 2018 (1905).

(8) J. H. Markgraf, B. A. Hess, Jr., C. W. Nichols, and R. W. King, *J. Org. Chem.*, **29**, 1499 (1964).

TABLE I

$$R_1R_2CHSO_3R_4 \xrightarrow[R_3X]{n\text{-BuLi}} R_1R_2R_3CSO_3R_4 + LiX$$

Compd	R_1	R_2	R_3X	R_4	Yield, %	Bp, °C (mm)
1	C_6H_5	CH_3	CH_3I	$CH_2C(CH_3)_3$	89.8	107–109.5 (0.30)
2	H	H	CH_3I	$CH_2C(CH_3)_3$	87.9	58–60 (0.15)
3	H	H	CH_3I	CH_2CH_3	83.4	79.5–81 (8)
4	H	H	CH_3I	CH_3	89.0	73.5–74.5 (5)
5	H	H	CH_3I	$CH(CH_3)_2$	85.8	44–46 (0.15)
6	CH_3	H	CH_3I	$CH(CH_3)_2$	83.0	39–41 (0.25)
7	CH_3	CH_3	CH_3I	$CH(CH_3)_2$	84.5	35.5–36 (0.35)
8	H	H	$CH_3CH_2CH_2Br$	$CH_2C(CH_3)_3$	70.2	112–115 (5)
9a	CH_3	H	CH_3I	$CH_2C(CH_3)_3$	*a*	
9b	CH_3	CH_3	CH_3I	$CH_2C(CH_3)_3$	77.5	46–49 (0.20)

[a] Intermediate product not isolated.

ir (neat) 1350 and 1185 cm^{-1} (SO_3); nmr δ 1.40 [d, 6, J = 7 Hz, $CH(CH_3)_2$], 2.98 (s, 3, CH_3S), and 4.90 [septet, 1, J = 7 Hz, $CH(CH_3)_2$].

Neopentyl 1-phenylethanesulfonate was prepared as described in ref 2 by the methylation of neopentyl α-toluenesulfonate in a procedure identical with that described below, bp 110–113° (0.25 mm).

General Procedure for the α Alkylation of Alkyl Alkanesulfonates.—The starting sulfonate was dissolved in tetrahydrofuran (*ca.* 10 ml per 1 g of sulfonate), and the solution was cooled in a Dry Ice–isopropyl alcohol bath. *n*-Butyllithium in hexane solution was then added from a syringe (1.1 equiv of *n*-butyllithium were used for all but the methyl ester, with which 1.0 equiv was used). After *ca.* 15 min, the alkylating agent was added dropwise and stirring was continued at Dry Ice bath temperatures for 1–2 hr with methyl iodide and for 12 hr with *n*-propyl bromide as alkylating agent. The reaction was then quenched with water, the resulting suspension was extracted with chloroform, and the chloroform extracts were combined, dried, and evaporated *in vacuo*, yielding the crude product. Careful vacuum distillation yielded the pure product.

Neopentyl α-cumenesulfonate (1) was prepared in 89.8% yield on a 0.0175-mol scale from neopentyl 1-phenylethanesulfonate and methyl iodide: bp 107–109.5° (0.30 mm); ir (neat) 3000 (CH) and 1350 and 1190 cm^{-1} (SO_3); nmr δ 0.82 [s, 9, $(CH_3)_3$], 1.92 [s, 6, $C_6H_5C(CH_3)_2$], 3.50 (s, 2, OCH_2), and 7.2–7.8 (m, 5, C_6H_5).

Anal. Calcd for $C_{14}H_{22}O_3S$: C, 62.19; H, 8.20; S, 11.86. Found: C, 62.42; H, 8.33; S, 11.58.

Neopentyl ethanesulfonate (2) was prepared in 87.9% yield on a 0.010-mol scale from neopentyl methanesulfonate and methyl iodide. The product was identical in all respects with that prepared from neopentyl alcohol and ethanesulfonyl chloride as described above.

Ethyl ethanesulfonate (3) was prepared in 83.4% yield on a 0.010-mol scale from ethyl methanesulfonate and methyl iodide: bp 79.5–81° (8 mm) [lit.[8] bp 101.5–102.5° (18 mm)]; ir (neat) 1350 and 1170 cm^{-1} (SO_3); nmr δ 1.4 (t, 6, J = 7 Hz, CH_3CH_2S and CCH_2CH_3), 3.14 (q, 2, CH_3CH_2S), and 4.30 (q, 2, OCH_2CH_3).

Methyl ethanesulfonate (4) was prepared in 89.0% yield on a 0.064-mol scale from methyl methanesulfonate and methyl iodide: bp 73.5–74.5° (5 mm) [lit.[9] bp 70–72° (7 mm)]; ir (neat) 1350 and 1174 cm^{-1} (SO_3); nmr δ 1.38 (t, 3, J = 7 Hz, CH_3CH_2), 3.16 (q, 2, J = 7 Hz, CH_2), and 3.88 (s, 3, OCH_3).

2-Propyl ethanesulfonate (5) was prepared in 85.8% yield on a 0.10-mol scale from 2-propyl methanesulfonate and methyl iodide: bp 44–46° (0.15 mm) [lit.[9] bp 71–73° (5 mm)]; ir (neat) 1350 and 1174 cm^{-1} (SO_3); nmr δ 1.36 (t, 3, J = 7 Hz, CH_3CH_2), 1.38 [d, 6, J = 6.5 Hz, $CH(CH_3)_2$], 3.08 (q, 2, J = 7 Hz, CH_3CH_2), and 4.90 [septet, 1, J = 6.5 Hz, $CH(CH_3)_2$].

2-Propyl 2-propanesulfonate (6) was prepared in 83.0% yield on a 0.0723-mol scale from 2-propyl ethanesulfonate and methyl iodide: bp 39–41° (0.25 mm); ir (neat) 1350 and 1175 cm^{-1} (SO_3); nmr δ 1.42 (d, 6, J = 6 Hz, four methyl groups of the two isopropyl groups), 3.25 (septet, 1, J = 6 Hz, HCS), and 4.92 (septet, 1, J = 6 Hz, OCH). The analytical sample was prepared by vpc.

Anal. Calcd for $C_6H_{14}O_3S$: C, 43.35; H, 8.49; S, 19.29. Found: C, 43.12; H, 8.55; S, 19.00.

2-Propyl 2-methyl-2-propanesulfonate (7) was prepared in a 84.5% yield on a 0.050-mol scale from 2-propyl 2-propanesulfonate and methyl iodide: bp 35.5–36° (0.35 mm); ir (neat) 1315 and 1145 cm^{-1} (SO_3); nmr δ 1.39 [s, 9, $(CH_3)_3$], 1.37 [d, 6, J = 6 Hz, $(CH_3)_2CH$], and 4.91 [septet, 1, J = 6 Hz, $CH(CH_3)_2$]. The analytical sample was prepared by vpc.

Anal. Calcd for $C_7H_{16}O_3S$: C, 46.64; H, 8.95; S, 17.78. Found: C, 46.76; H, 9.11; S, 17.50.

Neopentyl 1-butanesulfonate (8) was prepared in 70.2% yield on a 0.060-mol scale from neopentyl methanesulfonate and 1-bromopropane: bp 112–115° (5 mm); ir (neat) 3000 (CH) and 1360 and 1175 cm^{-1} (SO_3); nmr δ 0.98 [s, 9, $(CH_3)_3$], 0.90–2.0 (m, 7, $CH_3CH_2CH_2$), 3.12 (t, 2, CH_2S), and 3.85 (s, 2, OCH_2). The analytical sample was prepared by vpc.

Anal. Calcd for $C_9H_{20}O_3S$: C, 51.89; H, 9.68; S, 15.39. Found: C, 51.74; H, 9.84; S, 15.39.

Neopentyl 2-methyl-2-propanesulfonate (9b).—Neopentyl ethanesulfonate (3.60 g, 0.020 mol) was dissolved in 40 ml of THF and the solution was cooled in a Dry Ice–isopropyl alcohol bath. *n*-Butyllithium (0.020 mol) was added, and, after 10 min of stirring, methyl iodide (2.84 g, 0.020 mol) was added. After 25 min of additional stirring, the process was repeated; *i.e.*, *n*-butyllithium (0.022 mol) was added, and 10 min later an additional 0.022 mol of methyl iodide was added followed by 25 min of stirring. The reaction mixture was then worked up in the usual manner, yielding 3.22 g (77.5%) of the title compound that partially solidified after distillation: bp 46–49° (0.20 mm); ir (neat) 3000 (CH) and 1335 and 1150 cm^{-1} (SO_3); nmr δ 0.93 [s, 9, $OCH_2C(CH_3)_3$], 1.42 [s, 9, $(CH_3)_3CS$], and 3.83 (s, 2, OCH_2). The analytical sample was prepared by vpc.

Anal. Calcd for $C_9H_{20}O_3S$: C, 51.89; H, 9.68; S, 15.39. Found: C, 52.15; H, 9.81; S, 15.19.

Registry No.—**1**, 23230-57-1; **2**, 23230-58-2; **3**, 23230-59-3; **4**, 23214-45-1; **5**, 23214-46-2; **6**, 23263-79-8; **7**, 23214-47-3; **8**, 23214-48-4; **9b**, 23214-49-5; neopentyl methanesulfonate, 16427-42-2; methyl methanesulfonate, 66-27-3; ethyl methanesulfonate, 62-50-0; 2-propyl methanesulfonate, 926-06-7; neopentyl 1-phenylethanesulfonate, 22457-17-6.

Acknowledgment.—The authors are grateful to the Public Health Service for financial support of this work under Research Grant CA-04536-11 from the National Cancer Institute.

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