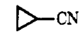
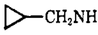
TABLE I
ISOLATED YIELDS OF AMINES AND ALCOHOLS

Reactant	Moles	Reductant[a]	Product	% yield
CD_3CO_2D	1.0	$LiAlH_4$	CD_3CH_2OH	80–90[b]
$CH_3CH_2CO_2H$	0.1	$LiAlH_4$	$CH_3CH_2CH_2OH$	85[c]
$CH_3CD_2CO_2H$	0.26	$LiAlH_4$	$CH_3CD_2CH_2OH$	76
CH_3CD_2CN	0.11	$LiAlH_4$	$CH_3CD_2CH_2NH_2$	55
CD_3CH_2CN	0.64	$LiAlH_4$	$CD_3CH_2CH_2NH_2$	50
$(CH_3)_2CHCN$	0.12	$LiAlD_4$	$(CH_3)_2CHCD_2NH_2$	83
$(CH_3)_2CDCO_2CH_2CH_2OC_4H_9$	1.2	$LiAlH_4$	$(CH_3)_2CDCH_2OH$	78
$(CD_3)_2CDCN$	0.1	$LiAlH_4$	$(CD_3)_2CD—CH_2NH_2$	81
$CH_3CH_2CH_2CN$	0.24	$LiAlD_4$	$CH_3CH_2CH_2CD_2NH_2$	67
$CH_3CH_2CD_2CN$	0.11	$LiAlH_4$	$CH_3CH_2CD_2CH_2NH_2$	86
$CH_3CD_2CH_2CN$	0.09	$LiAlH_4$	$CH_3CD_2CH_2CH_2NH_2$	76
$CD_3CH_2CH_2CN$	0.13	$LiAlH_4$	$CD_3CH_2CH_2CH_2NH_2$	82
	1.0	$LiAlH_4$		75

[a] All reductions were effected in diethylene glycol diethyl ether and quenched with butoxyethanol or diethylene glycol monoethyl ether. [b] Contaminated with CH_3CH_2OH. [c] Contaminated with ~5% CH_3CH_2OH.

ing) to a stirred mixture of lithium aluminum hydride (or deuteride) (1 mole)[9] in diethylene glycol diethyl ether[10] (500 ml). The mixture was then heated for 1 hr at 100°. Hydrolysis with *n*-butoxyethanyl alcohol (360 g, 3 mol) was effected at 0–10°. A short distilling column was inserted and the product directly distilled.[11] The product was usually of sufficient purity for use in further chemical transformations. Further purification was accomplished by redistillation or in the case of amines, the amine hydrochloride was prepared.

Registry No.—Lithium aluminum hydride, 1302-30-3; lithium aluminum deuteride, 14128-54-2.

Acknowledgment.—The authors are grateful for financial support from the National Science Foundation (Grant No. GP-3976).

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[9] In all cases, reduction of nitriles, acids, or esters, 1 mole of complex hydride was used per mole of oxidant.

[10] The diethylene glycol diethyl ether was distilled over calcium hydride or preferably lithium aluminum hydride.

[11] This distillation requires elevated pot temperatures, probably as a result of hydrogen bonding of the product with the monoalkyl glycol ether or Lewis acid-base complexing with the complex metal alcoholate. It is recommended that a portion of material be collected above the boiling point of product (glpc check) and that this be redistilled in order to obtain the maximum yield.

Anomalies in the Acetylation of *o*- and *p*-Xylenes[1]

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In the course of another investigation it became necessary to prepare 3,4-dimethylacetophenone (**1**). The material prepared from the aluminum chloride-catalyzed reaction of acetic anhydride and *o*-xylene following the standard procedure[2,3] was unexpectedly found (*via* glpc analysis)[4] to be a two-component mixture of 3,4-dimethylacetophenone (**1**, 52%) and 2,4-dimethylacetophenone (**2**, 48%).

Acetyl chloride in various solvents has also been widely used to effect acetylation of aromatic hydrocarbons.[5] The general procedure[6] for acetylation using acetyl chloride is the addition of an equimolar mixture of acetyl chloride–aromatic hydrocarbon to a stirred mixture of 1 mol of aluminum chloride in carbon disulfide. Ferric chloride has also been used as the catalyst in this method.[7] In the acetic anhydride procedure,[2,3] the anhydride (1 mol) is added dropwise to a stirred mixture of the aromatic hydrocarbon (1.25 mol) and aluminum chloride (2.8 mol) in carbon disulfide. Another useful technique introduced by Baddeley[8] and later used extensively by Brown[9] for acetylation of the methylbenzenes involves the addition of a homogenous solution of a 1:1 molar complex of acetyl chloride–aluminum chloride in ethylene chloride to a solution of the aromatic hydrocarbon (1 mol) in ethylene chloride. Since 2,4-dimethylacetophenone (**2**) was a major product from the reaction of acetic anhydride with *o*-xylene, it was felt that this reaction should be investigated to determine its origin and that a general survey of acetylation procedures would be useful. The results of this investigation are presented in Table I.

The unexpected product **2** which occurs both from acetic anhydride acetylation (acetic anhydride addition) of *o*-xylene or *p*-xylene is not a result of isomerization of the acetophenones, but it does arise by prior isomerization of the *o*- or *p*-xylenes to *m*-xylene presumably through the more stable σ-complex of *m*-xylene.[10] This was demonstrated by running a series of reactions in which the acetic anhydride was present in catalytic amounts (Table II). Little or no 2,4-dimethylaceto-

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[1] Financial support (Grant No. 1348-AL) from the Petroleum Research Fund is gratefully acknowledged.

[2] (a) C. R. Noller and R. Adams, *J. Amer. Chem. Soc.*, **46**, 1889 (1924); (b) R. Adams and C. R. Noller in "Organic Syntheses," Coll. Vol. I, John Wiley and Sons, Inc., New York, N. Y., 1941, p 109.

[3] In fact 3,4-dimethylacetophenone was previously prepared by this method. *Cf.* W. P. Campbell and M. D. Soffer, *J. Amer. Chem. Soc.*, **64**, 417 (1942).

[4] The mixture could also be separated by fractional distillation. *Cf.* Experimental Section.

[5] P. H. Gore in "Friedel-Crafts and Related Reactions," Vol. III, Part 1, G. A. Olah, Ed., Interscience Publishers, Inc., New York, N. Y., 1964, Chapter XXXI.

[6] (a) C. F. H. Allen, "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1943, p 3. (b) A. Claus and R. Wollner, *Ber.*, **18**, 1856 (1885).

[7] (a) W. H. Perkin, Jr., and J. F. S. Stone, *J. Chem. Soc.*, **127**, 2275 (1925); (b) C. S. Marvel, J. H. Saunders, and C. G. Overberger, *J. Amer. Chem. Soc.*, **68**, 1085 (1946).

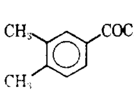
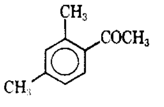
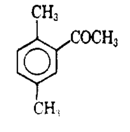
[8] G. Baddeley, *J. Chem. Soc., Suppl. 1*, S99 (1949).

[9] (a) H. C. Brown, G. Marino, and L. M. Stock, *J. Amer. Chem. Soc.*, **81**, 3310 (1959); (b) G. Marino and H. C. Brown, *ibid.*, **81**, 5929 (1959).

[10] (a) D. A. McCaulay, B. H. Shoemaker, and A. P. Lien, *Ind. Eng. Chem.*, **42**, 2103 (1950); (b) H. C. Brown and J. D. Brady, *J. Amer. Chem. Soc.*, **74**, 3570 (1952).

TABLE I

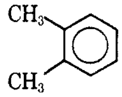
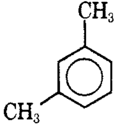
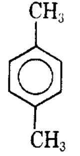
ACETYLATION OF *o*-, *m*-, AND *p*-XYLENES. EVALUATION OF REACTION TECHNIQUES

Run	Reagent added[a]	Moles: $Me_2C_6H_4$	Moles: Ac_2O	Moles: AcCl	Moles: $AlCl_3$	Solvent (ml)	Addn time, hr	Reflux time, hr	Yield, %[b]	% composition: 	% composition: 	% composition: 
1	Ac_2O	*o*- 2.0	2.2		5.4	CS_2 (1150)	2.25	2.5	81[c]	52	48	
2	Ac_2O	*o*- 0.125	0.1		0.28	CS_2 (50)	0.5	1.0	96	88	12	
3	*o*-$Me_2C_6H_4$	*o*- 0.125	0.1		0.28	CS_2 (50)	0.5	1.0	89	98	2	
4	$AlCl_3$	*o*- 0.125	0.1		0.28	CS_2 (50)	0.5	1.0	71	99	1	
5	AcCl	*o*- 0.125		0.1	0.12	CS_2 (50)	0.5	1.0	99	94	6	
6	*o*-$Me_2C_6H_4$	*o*- 0.125		0.1	0.12	CS_2 (50)	0.5	1.0	94	100		
7	AcCl–$AlCl_3$[d]	*o*- 1.0		1.0	1.0	EC[e] (750)	3.0		94[c]	100		
8	*o*-$Me_2C_6H_4$	*o*- 0.125		0.1	0.1	EC[e] (100)	0.5		99	100		
9	Ac_2O	*p*- 0.125	0.1		0.28	CS_2 (50)	0.5	1.0	99		31	69
10	*p*-$Me_2C_6H_4$	*p*- 0.125	0.1		0.28	CS_2 (50)	0.5	1.0	91			100
11	Ac_2O	*m*- 0.125	0.1		0.28	CS_2 (50)	0.5	1.0	86		100	
12	*m*-$Me_2C_6H_4$	*m*- 0.125	0.1		0.28	CS_2 (50)	0.5	1.0	90		100	
13	Ac_2O	Tech.[f] 0.125	0.1		0.28	CS_2 (50)	0.5	1.0	96	16	76	8
14	Ac_2O	Tech.[f] 2.0	2.2		5.4	CS_2 (1150)	4.0	2.0	82[c]	9	91	

[a] Added to a stirred mixture of the other reagents. [b] Glpc yield as determined by internal standard technique (4-methylacetophenone). [c] Isolated yield. [d] Homogeneous solution of complex in 500 ml of ethylene chloride. [e] EC = ethylene chloride. [f] Technical xylene (52%, *m*-; 38%, *o*-; 10%, *p*-).

TABLE II

ALUMINUM CHLORIDE-CATALYZED ISOMERIZATION OF THE XYLENES IN CARBON DISULFIDE[a,b]

$Me_2C_6H_4$	% composition[c]: 	% composition[c]: 	% composition[c]: 
ortho	77	23	
meta		98	2
para		27	73

[a] Reaction conditions were 0.125 mol of xylene, 0.28 mol of $AlCl_3$, and one drop of Ac_2O as a cocatalyst in 50 ml of CS_2 at reflux for 1.5 hr. [b] Reaction mixture is heterogeneous. [c] Glpc analyzed on 10 ft × 1/8 in. 5% Morflex 530-5% Bentone 34 on Chromosorb W 60–80.

phenone was formed from *o*- or *p*-xylene when the acetylation with acetic anhydride was carried out by addition of the hydrocarbon or aluminum chloride to the reaction mixture.

Prior isomerization of the xylene is time dependent. Thus, *o*-xylene is isomerized to the extent of 48% when the addition time of acetic anhydride was 2.25 hr (Table I, run 1, 2.0-mol scale) but only to 12% when the addition time was 0.5 hr (run 2, 0.1-mol scale).

The results are even more surprising since it has been shown that *o*-xylene is acetylated more rapidly than *m*-xylene (2.6 times faster in nitromethane).[11] The formation of a mixture of ketones is best explained by the occurrence of two competitive processes: (1) direct acetylation of unrearranged xylene to give the desired product and (2) isomerization to give the more stable *m*-xylene which is then acetylated.

This was dramatically demonstrated in the acetic anhydride acetylation of commercial xylene. All three dimethylacetophenones were produced when the addition time was only 0.5 hr (Table I, run 13); however, when the addition time was 4 hr (run 14), essentially only 2,4-dimethylacetophenone was formed.

From the standpoint of laboratory convenience acetyl chloride is preferred over acetic anhydride since less aluminum chloride is required and the work-up is somewhat simpler. Isomerically pure dimethylacetophenones are only obtained when (1) acetyl chloride (or anhydride)–aluminum chloride mixture (soluble in ethylene chloride) is added to the xylene in ethylene chloride, (2) aluminum chloride is added to a mixture of acetyl chloride (or anhydride) and xylene in carbon dioxide or ethylene chloride, or (3) when there is an addition of the xylene to a mixture of aluminum chloride and acetyl chloride (or anhydride) in carbon disulfide.

Experimental Section

Infrared and nmr spectra were obtained on a Beckman IR8 spectrophotometer and a Varian A-60 spectrometer, respectively. All chemical shifts are reported in parts per million (ppm) on the δ scale relative to an internal standard of tetramethylsilane. Gas chromatographic data were obtained on a Varian-Aerograph Hy-Fi III Model 1200 using a 15 ft × 1/8 in. 5% silicone grease on Chromosorb G 60–80 column. The relative retention times of the acetophenones under conditions of column temperature (150°), injection temperature (230°), detector temperature (270°) and nitrogen (15 psi tank pressure), and hydrogen (5 psi tank pressure) pressure were as follows: 4-methylacetophenone (20.0 min), 1.00; 2,5-dimethylacetophenone, 1.24; 2,4-dimethylacetophenone, 1.32; and 3,4-dimethylacetophenone, 1.77.

Procedure.—The procedure followed for the carbon disulfide runs was basically that described in "Organic Syntheses."[2] The addend (see Table I) was added dropwise at such a rate that caused gentle refluxing of the carbon disulfide. The mixtures were analyzed by glpc with 4-methylacetophenone as an internal standard.

The components from run 1 (Table I) were separated by preparative glpc (6 ft × 0.25 in. 15% Apiezon L 5% Bentone 34 on Chromosorb P 60–80) and by fractional distillation (18-in. spinning-band column) to give 2,4-dimethylacetophenone, bp 92° (5.5 mm) [lit.[7b] 92–94° (5 mm)], and 3,4-dimethylacetophenone, bp 103° (5.5 mm) [lit.[7b] 95–97° (4 mm)]. The spectral data on these components agreed with that reported below. The identity of 2,4-dimethylacetophenone was further confirmed by oxidation[12] to 2,4-dimethylbenzoic acid, mp 124–126° (lit.[13] 126–127°); the amide derivation[14] had mp 179–180° (lit.[13] 179–181°).

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(11) G. A. Olah, M. E. Moffatt, S. J. Kuhn, and B. H. Hardie, *J. Amer. Chem. Soc.*, **86**, 2198 (1964). These relative rates may not be applicable to reactions in carbon disulfide.

(12) *Cf.* M. S. Newman and H. L. Holmes, "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1943, p 428.

(13) "Dictionary of Organic Compounds," Vol. II, I. Heilbron, Ed., Oxford University Press, New York, N. Y., 1965, p 1149.

(14) *Cf.* R. L. Shriner, R. C. Fuson, and D. Y. Curtin, "The Systematic Identification of Organic Compounds," 5th ed, John Wiley and Sons, Inc., New York, N. Y., 1964, p 235.

For the ethylene chloride run[8,9] a 1:1 complex of aluminum chloride (133 g, 1.0 mol) and acetyl chloride (78.5 g, 1.0 mol) was prepared in 500 ml of ethylene chloride. This solution was added dropwise over 3 hr to a mechanically stirred solution of *o*-xylene (106 g, 1.0 mol) and 750 ml of ethylene chloride in a 3-l., three-necked flask. The reaction mixture was hydrolyzed by pouring it onto a slurry of ice-concentrated hydrochloric acid. The layers were separated. The organic layer was washed with water, 5% sodium bicarbonate solution, and water before being dried over calcium chloride. Rotary evaporation left 140 g (94%) of 3,4-dimethylacetophenone (essentially 100% pure by glpc), bp 100° (5 mm) and n^{20}_{D} 1.5385 [lit.[7b] bp 95-97° (4 mm), n^{20}_{D} 1.5381].

Ir and nmr analyses were run on the crude reaction products from the runs where glpc showed the presence of only one component. In this manner the products from runs 6, 10, and 11 (Table I) were positively identified as 3,4-dimethylacetophenone, 2,5-dimethylacetophenone, and 2,4-dimethylacetophenone, respectively. The nmr of 3,4-dimethylacetophenone showed a singlet at δ 2.28 (6 H), aromatic methyls; a singlet at 2.44 (3 H), acetyl methyl; a doublet at 7.10 (J = 7.5 cps, 1 H), aromatic hydrogen in the 5 position; a doublet at 7.61 (J = 7.5 cps); and an overlapping singlet at 7.64 (2 H) assigned to the aromatic hydrogen in the 6 position and the aromatic hydrogen in the 2 position, respectively. The nmr of 2,5-dimethylacetophenone showed a singlet at δ 2.22 (3 H), aromatic methyl in the 5 position; a broadened singlet at 2.38 (6 H), aromatic methyl in the 2 position and acetyl methyl; a singlet at 6.99 (2 H), aromatic hydrogens in the 3 and 4 positions; and a singlet at 7.37 (1 H), aromatic hydrogen in the 6 position. The nmr of 2.4-dimethylacetophenone showed a singlet at δ 2.25 (3 H), aromatic methyl in the 4 position, a singlet at 2.40 (3 H), aromatic methyl in the 2 position; a singlet at 2.46 (3 H), acetyl methyl; a broad band at 6.98 (2 H), aromatic hydrogens in the 3 and 5 positions, and a doublet at 7.57 (J = 7.5 cps, 1 H), aromatic hydrogen in the 6 position.

Registry No.—*o*-Xylene, 95-47-6; *n*-xylene, 108-38-3; *p*-xylene, 106-42-3; 3,4-dimethylacetophenone (1), 3637-01-2; 2,4-dimethylacetophenone (2), 89-74-7; 2,5-dimethylacetophenone, 2142-73-6.

A Facile and Economic Synthesis of Ethanol-OD[1]

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The use of large quantities of deuterium-labeled solvents is often precluded due to economic considerations. In some of our studies we required large quantities of ethanol-OD of high isotopic purity and thus were forced to find a low-cost procedure for its preparation. Previously, the most attractive procedure employed the acid-catalyzed deuterolysis of tetraethylorthocarbonate.[3] The current prohibitively high cost of tetraethylorthocarbonate, and the fact that only 2 moles of product are produced per mole of starting material, precluded the use of this material. Triethylorthocarbonate[4] and diethyl oxalate[5] have been used as starting materials; however, the costs are somewhat greater, and the utilization of starting material is poorer. Aluminum ethoxide[6] has also been employed as a starting material giving excellent yields of product. Aluminum ethoxide is quite expensive; however, it can be synthesized separately.[7] Several exchange procedures have been reported but none are suitable for the preparation of high isotopic purity ethanol-OD.

We have found that the uncatalyzed deuterolysis of tetraethylorthosilicate, followed by distillation of the ethanol-OD from the residual silicon dioxide under reduced pressure, produces 90% yields (based on the availability of all four ethoxyl groups) of ethanol-OD of very high isotopic (no O–H detectable by nmr) and chemical purity (>99.7%). The reaction may be carried out on a multiple mole basis. The cost of the ethanol-OD prepared by this procedure is roughly five cents per gram (based on the cost of the chemicals used) and is *considerably* cheaper than presently commercially available ethanol-OD of lower isotopic purity.

Although we have not extended this procedure to other alkanols-OD, a number of tetraalkylorthosilicates are available thus potentially providing sources of alkanols-OD considerably below current commercial prices.

Experimental Section

Preparation of Ethanol-OD.—The following procedure is typical although the quantities may be increased or decreased. A mixture of 104.2 g (0.5 mole) of tetraethylorthosilicate (Aldrich Chemical Co.) and 40 g (2 moles) of deuterium oxide (99.8%, Diaprep Inc.) is stirred in a stoppered distillation flask at room temperature until a viscous, miscible mixture is obtained (approximately 24 hr). The distillation flask is attached to a distillation head and condenser and subjected to distillation at 2 mm, collecting the product in a flask immersed in a Dry Ice–acetone bath, until no further product is produced. The ethanol-OD (90% average yield) displayed practically no O–H absorption in the infrared spectrum and no detectable OH in the nmr (<0.5%). The gas-liquid partition chromatogram indicated the presence of 0.2% D_2O, the remainder being C_2H_5OD.

Registry No.—Ethanol-OD, 925-93-9.

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[1] Supported by the Petroleum Research Fund of the American Chemical Society, Grant 1225-Al, 3.

[2] Alfred P. Sloan Research Fellow, 1967–1969.

[3] J. D. Roberts, C. M. Regan, and Inka Allen, *J. Amer. Chem. Soc.*, **74**, 3679 (1952); D. S. Tarbell and W. E. Lovett, *ibid.*, **78**, 2259 (1956).

[4] V. J. Shiner, Jr., and M. L. Smith, *ibid.*, **83**, 593 (1961).

[5] C. Párkányi and F. Šorm, *Collect. Czech. Chem. Commun.*, **28**, 2491 (1963).

[6] W. R. Vaughan, M. V. Andersen, Jr., H. S. Blanchard, D. I. McCane, and W. L. Meyer, *J. Org. Chem.*, **20**, 819 (1955).

[7] "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, Inc., New York, N.Y., 1943, p 599.

The Preparation of Fluorodinitroacetonitrile and Fluorodinitroacetamide[1]

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Received July 17, 1967

Chlorination of the dinitroacetonitrile anion was found to produce the chloro derivative $ClC(NO_2)_2CN$ in moderate yield.[2] Therefore, it was of interest to determine the course of reaction upon fluorination in aqueous media since it has been suggested that fluorina-

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[1] This work was carried out under the sponsorship of the U. S. Army Missile Command, Redstone Arsenal, Alabama under Contract DA-021 ORD-11878 (Z) Mod. No. 7.

[2] C. O. Parker, *et al.*, *Tetrahedron*, **17**, 89 (1962).