approximately 6 cycles on the high field side from benzene. The spin–spin splitting is about 24 cycles. The fluorine resonance spectrum consists of two broad bands arising from spin–spin coupling of the fluorine nuclei with the proton. The high field member of this doublet was measured at 2100 cycles on the low field side of trifluoroacetonitrile.

The vapor pressure of difluoroamine was measured and can be expressed by a Clausius–Clapeyron equation

$$\log P(\text{mm.}) = -1298/T + 8.072$$

The boiling point of difluoroamine is −23° and the heat of vaporization is estimated to be 5940 cal./mole. The melting point is approximately −131° and its critical temperature measured by the Cagniard de la Tour tube method is 130°. From an extrapolation of the vapor pressure data a critical pressure of 93 atmospheres was calculated.

A material thought to be difluoroamine has been reported previously by Ruff and Staub[3] and Staub.[4] They found it to be a product of the electrolysis of ammonium bifluoride and reported a boiling point "ostensibly about −100°,"[4] an approximate b.p. −65°, and m.p. −125°.[3] These figures are somewhat different from those reported herein, b.p. −23° and m.p. −131°. We have failed in many attempts to obtain difluoroamine by the electrolysis of ammonium bifluoride. Burg[5] has pointed out the uncertainty of the identification of difluoroamine by Ruff.

Caution should be used in working with difluoroamine. We have had occasional explosions with both solid and liquid difluoroamine. Difluoroamine has been stored at room temperature in glass vessels for long periods of time with no apparent decomposition.

The authors wish to express their appreciation to Dr. Keith S. McCallum for the n.m.r. and infrared spectra of difluoroamine.

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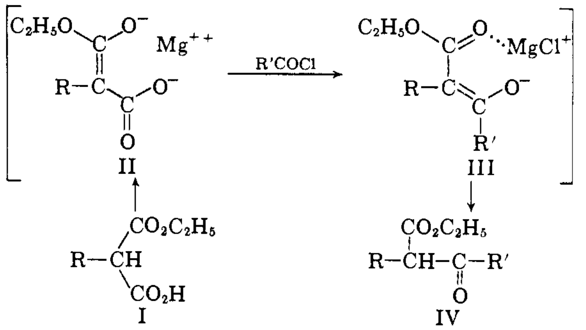
A NEW SYNTHETIC METHOD FOR THE PREPARATION OF α-SUBSTITUTED β-KETOESTERS

Sir:

During the course of a synthetic program directed toward polycyclic terpenes, we had need of substantial quantities of the β-ketoester, ethyl 5-(*o*-methoxyphenyl)-3-keto-2-methylvalerate (IV, R = CH_3, R′ = *o*-$CH_3OC_6H_4CH_2CH_2$). One approach (methylation of the pyrrolidine enamine of the unsubstituted β-ketoester, obtained *via* partial hydrolysis[1] of the corresponding malonate) led to the desired product in only 31% yield from *o*-methoxyhydrocinnamic acid. In an effort to find a more rewarding synthesis we turned to the acylation of the magnesium salt of ethyl hydrogen methylmalonate and have been able to develop this method into a very convenient one-step synthesis of α-substituted β-ketoesters.

By treatment of ethyl hydrogen methylmalonate[2] (I, R = CH_3) with two equivalents of magnesium ethoxide, then removal of the ethanol formed,[3] or, better, with two equivalents of isopropylmagnesium bromide in tetrahydrofuran, the half-ester was converted to the tetrahydrofuran-soluble magnesium chelate (II, R = CH_3).[4] Addition of acetyl chloride to this solution at 0° led to the rapid evolution of carbon dioxide and the formation of the new magnesium chelate (III, R = CH_3, R′ = CH_3). Removal of most of the solvent, and hydrolysis of the residue with dilute aqueous ammonium chloride afforded a 62% yield of ethyl α-methylacetoacetate (IV, R = CH_3, R′ = CH_3), b.p. 70° (13 mm.).[5] Similarly we have prepared ethyl 3-keto-2-methylcaproate (IV, R = CH_3, R′ = C_3H_7), b.p. 86–89° (10 mm.),[6] in 69% yield from butyryl chloride; ethyl α-methylbenzoylacetate (IV, R = CH_3, R′ = C_6H_5), b.p. 90–94° (0.2 mm.),[7] in 52% yield from benzoyl chloride; and diethyl 3-keto-2-methyladipate (IV, R = CH_3, R′ = $CH_2CH_2CO_2C_2H_5$), b.p. 80–82° (0.08 mm.) (C, 57.45; H, 7.66), in 71% yield from β-carbethoxypropionyl chloride. Application of this method to the formation of the desired β-ketoester (IV, R = CH_3, R′ = *o*-$CH_3OC_6H_4CH_2CH_2$), b.p. 117° (0.1 mm.) (C, 68.04; H, 7.53) led to a 63% yield from *o*-methoxycinnamic acid without isolation of the acid chloride.



When ethyl hydrogen phenylmalonate[8] was employed, acetylation of the resulting magnesium chelate (II, R = C_6H_5) afforded a 60% yield of ethyl α-phenylacetoacetate (IV, R = C_6H_5, R′ = C_6H_5), b.p. 128–134° (8 mm.)[9] Diethyl 3-keto-2-phenyladipate (IV, R = C_6H_5, R′ = $CH_2CH_2CO_2C_2H_5$), b.p. 137–138° (0.25 mm.) (C,

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65.81; H, 6.85) was obtained in a 41% yield by treatment of the salt (II, R = C_6H_5) with β-carbethoxypropionyl chloride.

Benzoylation of the magnesium chelate formed from ethyl hydrogen malonate[10] and magnesium ethoxide led to the introduction of two benzoyl residues and the formation of ethyl dibenzoylacetate.[11]

The authors wish to acknowledge many helpful and stimulating discussions with Drs. R. M. Stiles and H. L. Finkbeiner.

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(12) Public Health Service Research of the National Heart Institute.

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THE "FLORY (θ) TEMPERATURE" OF ATACTIC AND ISOTACTIC POLYPROPYLENE

Sir:

Identical intrinsic viscosity–molecular weight relationships for atactic and isotactic polystyrene *in thermodynamically good solvents* have been confirmed but real differences in the second virial coefficients were detected.[1,2,3]

According to theory, the second virial coefficient depends on (1) the unperturbed dimensions of the polymer chain, (2) the enthalpy and entropy parameters κ_1 and ψ_1 and (3) the partial specific volume of the polymer. Krigbaum, *et al.*, found (3) contributes only a minor effect and proposed the main effect arose through differences in (1).

The thermodynamic interaction parameters can be evaluated through phase equilibria studies in the liquid–liquid region where the critical temperature (T_c) is related to the thermodynamic parameters by the relationship[4]

$$1/T_c = 1/\theta[1 + (1/\psi_1)(1/x^{1/2} - 1/2x)] \qquad (1)$$

where

$$\theta = \kappa_1 T/\psi_1; \; x = \bar{M}_n \bar{v}_2/V_1$$

V_1 = molar volume of the solvent, $\bar{v}_2$ = specific volume of the polymer.

Phase diagrams of carefully characterized fractions[5] of atactic and isotactic polypropylene have been determined and binodials characteristic of *liquid–liquid* separations for both isomers obtain in phenyl ether at temperatures near the melting point of the isotactic polymer.

Reciprocals of the critical temperatures determined from the phase diagrams were plotted against the function $(1/x^{1/2} - 1/2x)$ according to equation (1) and the parameters ψ_1 and θ evaluated. Curves for atactic and isotactic polypropylene differ considerably in both slope and intercept and yield values for the parameters as shown in Table I.

TABLE I
THERMODYNAMIC INTERACTION PARAMETERS IN PHENYL ETHER

	θ, °K.	ψ_1
Isotactic	418.4	1.414
Atactic	426.5	0.986
Difference	8.1	0.426

Under these conditions the atactic polymer is less soluble than its isotactic counterpart, supporting the proposition that the atactic form is the more flexible.[3]

The data predict a reversal in precipitation order above the unique condition (intersection of the two curves) where the term $\psi_1 (1 - \theta/T)$ for the two isomers is identical. The point of intersection depends on the solvent, the molecular weight and the temperature. A similar intersection appears in the data of Danusso and Moraglio[2] on the second virial coefficients of atactic and isotactic polystyrene and the unfortunate choice of a polymer near the critical molecular weight may have prevented Krigbaum, *et al.*,[3] from detecting differences in the unperturbed dimensions of polystyrene chains by viscosity ratios; however, their conjecture that the θ temperatures for the two isomers may differ is confirmed.

We finally conclude that both θ and ψ_1 as determined by phase studies may ultimately be used to reflect the degree of stereoregularity within polymer chains. As suggested by theory[6,7] intrinsic viscosity–molecular weight relationships may not be identical for conformational isomers in poor solvents where segment–segment interactions are magnified.

In a future paper we plan to reveal the unperturbed dimensions of the two isomers at their respective θ temperatures and will discuss the significance of these data in terms of structure and dilute solution behavior of polymeric stereoisomers.

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ON THE NATURE OF PROTEIN-BOUND LIPOIC ACID

Sir:

Previous work[1] indicated that lipoic acid, in its functional form in bacterial pyruvate dehydrogenation complexes, is bound to protein in covalent linkage through its carboxyl group. This communication presents evidence that lipoic acid is bound to the epsilon amino group of a lysine residue.

When *Escherichia coli* is grown aerobically in the presence of lipoic acid-S_2^{35}, radioactive lipoic acid is incorporated into the pyruvate dehydrogenation complex. A highly purified preparation[2] (176 mg.; sp. act. 678; 1.47 μg. radioactive lipoic acid per mg. protein) was treated with performic

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