zyme mole ratio 10/1), yielding lysine, and to a lesser extent leucine, methionine, glutamic and aspartic acids, threonine, serine and glycine.

Denaturation was effected by 48 hours of exposure to HCl, *p*H 1, at 0°, followed by 24 hours of dialysis against HCl, *p*H 3.

The present results are compatible with the suggestion that activation of trypsinogen is accompanied by the splitting of a peptide from the amino end of the polypeptide chain[5] but it remains to be seen whether in analogy with the activation of chymotrypsinogen to α-chymotrypsin,[2] a peptide is split from the carboxyl end of the chain as well. Further quantitative studies of these phenomena are in progress and will be published at a later time.

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RECEIVED NOVEMBER 24, 1952

IONIZATION OF ORGANOMETALLIC HALIDES

Sir:

Although trimethyltin iodide[1] and the triethyllead halides[2] have long been known to be soluble in water and to undergo metathetic reactions in aqueous solution, the rapid and complete hydrolysis of organosilicon halides[3] precludes such reactions. The similar alcoholysis[4] of organosilicon halides, and their related reaction with ammonia[5] and amines[6] prevent the use of these polar liquids as ionizing solvents.

For much the same reasons, the electrochemistry of organometallic compounds has been concerned chiefly with the electrolytic behavior of organomercury compounds in water,[7] the conductivity of trimethyltin iodide in acetone, alcohols, and pyridine,[8] and of Grignard reagents[9] in ether and related solvents. The organosilicon halides exhibit no conductivity in ether.

We now find that a considerable number of methyl-, ethyl-, dodecyl-, octadecyl- and phenyl chlorosilanes are soluble in anhydrous dimethylformamide, and that such solutions are highly conducting. For example, dimethyldichlorosilane exhibits an equivalent conductance of 18 $ohms^{-1}$ at a concentration of 0.004 equivalent per liter, and 0.5 ohm^{-1} at one equivalent per liter, both at 30°. The conductances of eleven organochlorosilanes are being studied, and from these and the colligative properties of the solutions the degrees of ionic dissociation are being sought. Preliminary results indicate that the dissociation constants are relatively small, in the range 10^{-2} to 10^{-4}.

The chemical significance of these results lies in the fact that the concentrations of organosilicon ions of the types R_3Si^+, R_2Si^{++}, and RSi^{+++} are amply sufficient to permit ionic oxidation-reduction and metathetic reactions in dimethylformamide. Thus dichromate ion is reduced by dimethyldichlorosilane in this solvent to several lower oxidation states of chromium; ammonium thiocyanate undergoes metathetic reaction with the same chlorosilane to precipitate ammonium chloride; boric acid reacts to form a silicone polymer of the "bouncing putty" variety; phosphotungstic acid precipitates a dimethylsilyl phosphotungstate; *para*nitrobenzoic acid dissolves in a solution of dimethyldichlorosilane in dimethylformamide, but not in the amide itself nor in a mixture of the amide with hydrogen chloride.

In similar vein, we have found that some organogermanium halides form conducting solutions in dimethylformamide and undergo ionic metatheses. While it may prove possible to employ concentrated hydrochloric acid as a dissociating solvent for organogermanium compounds because of an observable reversibility,[10] the preparative utility of such a solvent is more limited. However, we have found that dimethyltin dichloride may readily be handled in acidic aqueous solution; it hydrolyzes in pure water only to the extent of 10.5% in 0.064 molal concentration at 25°. Cryoscopic measurements in water give a van't Hoff *i* factor of 2.60 at 0.1693 molal concentration, 2.69 at 0.1041 molal, and 2.86 at 0.0639 molal. The $(CH_3)_2Sn^{++}$ ions may be retained on a cation exchange resin and eluted with various acids. By elution and by metathesis we have prepared dimethyltin tungstate, molybdate, sulfide, oxalate, succinate, naphthionate, salicylate, phthalate, benzoate, ferricyanide, ferrocyanide, iodate, arsenate, vanadate, cyanate and antimonate. A report on the preparation, purification, and properties of these compounds is being prepared.

The financial assistance of the Mallinckrodt Fund and the Office of Naval Research is greatly appreciated.

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RECEIVED OCTOBER 27, 1952

ISOTOPE EFFECTS IN THE IONIZATION OF ALKYL CHLOROSULFITES

Sir:

Examples occur frequently in the literature of marked changes in the rate of reactions which break bonds to hydrogen, when deuterium or tritium is substituted for this hydrogen. No appreciable effects have heretofore been observed when the reactant and product have all bonds to hydrogen intact. Such studies have in fact become a standard tool for the detection of bond-breaking in the rate determining steps of reactions.[1,2] In an experiment designed to study by this technique the mechanism of the elimination reaction which ac-

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companies the displacement of the chlorosulfite group by chloride in the decomposition of secondary alkyl chlorosulfites,[3] we have studied the kinetics and products from the decomposition of an extensively deuterated 2-pentyl chlorosulfite in dioxane. Table I shows the results of these experiments both on the undeuterated compound and on a sample of chlorosulfite made from 2-pentanol in which 86% of the hydrogens on the 1- and 3-positions were replaced by deuterium by exchange of the corresponding ketone.

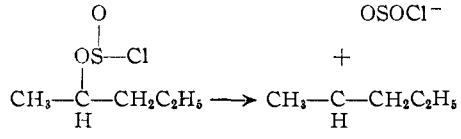
TABLE I

FIRST ORDER RATE CONSTANTS AND PRODUCT YIELDS IN THE DECOMPOSITION OF 2-PENTYL CHLOROSULFITE IN DIOXANE

	Protium comp.	Deuterium comp.
$k \times 10^4$ sec.$^{-1}$ at 61.5°	2.2 ± 0.1	1.6 ± 0.2
$k \times 10^4$ sec.$^{-1}$ at 77.5°	9.8 ± .1	6.2 ± .2
$C_5H_{11}Cl$ yield, 61.5°	51 ± 1%	51 ± 1%
$C_5H_{11}Cl$ yield, 77.5°	45.0 ± 1%	45.6 ± 1%

We also found that the yield of hydrogen chloride was not markedly altered by the introduction of deuterium, but the data were not well reproducible, due to analytical difficulties; however, it is clear that alkyl chloride, olefin, hydrogen chloride and sulfur dioxide account for substantially all of the chlorosulfite. Combustion of 2-pentene isolated from the runs at 62.5° showed that 85% of the hydrogen at the 1- and 3-positions was substituted by deuterium, within experimental error the same as the starting alcohol.

Since the product ratios are not significantly altered, it is apparent that the rate of chloride production is appreciably reduced, although all bonds to hydrogen in the chlorosulfite are intact in the product. The mechanism of this reaction (neglecting solvent effects) appears to be a rate-determining ionization to an undissociated ion pair,[4] which can for simplicity be written



The chloride then results in attack of chloride ion at the 2-position and the olefin from attack of some base on the hydrogens at the 3-position. The source of this unusual isotope effect appears to be the weakening of the bonds to the hydrogen in the 1- and 3-positions in the carbonium ion and the transition state due to hyperconjugation structures with no bond to hydrogen. The change in the force constants of these bonds then produces a different change in the zero-point energies of vibration of the protium and deuterium compounds during the reaction, and the usual rate difference results. The failure to observe significant isotope fractionation in olefin formation can also be attributed to the great weakness of these bonds at the stage when the olefin is formed.

We believe that this type of isotope effect can be used to detect hyperconjugation in the transition state and hence may be used as a measure of the extent of electron deficiency on carbon in the transition state of a displacement reaction. This has so far been determined only by very indirect and dubiously reliable methods.

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(5) Ethyl Corporation Fellow, 1952–53.

ISOLATION OF 4-AMINO-5-IMIDAZOLECARBOXAMIDE RIBOSIDE FROM THE CULTURE MEDIUM OF SULFONAMIDE-INHIBITED *ESCHERICHIA COLI*

Sirs:

4-Amino-5-imidazolecarboxamide which has been isolated from sulfonamide-inhibited cultures of *Escherichia coli*[1,2] has been considered as a possible intermediate compound in purine biosynthesis,[2,3,4] but several lines of evidence have suggested that instead its riboside or ribotide is an intermediate.[5,6,7,8] If it is considered that ring closure of the carboxamide occurs at the ribotide level,[5,7] then it might be expected that in the presence of sulfonamide[8] the carboxamide ribotide as well as the riboside and free base could accumulate. 4-Amino-5-imidazolecarboxamide riboside is shown by the present studies to be the major carboxamide component in young cultures of sulfadiazine-inhibited *E. coli*.

A procedure for isolation of the riboside on a small scale is given. *E. coli*, strain B from a nutrient agar slant, is inoculated into a 24 × 200 mm. tube containing 10 ml. of glucose, salts and NH_4Cl medium.[9] After 16 hr. of incubation at 37° the culture is inoculated into a 1-liter erlenmeyer flask containing 250 ml. of the same medium plus 2.8 mg. of sulfadiazine and 7.5 mg. of glycine. A stationary incubation is carried out for 11 hr. at 37°. The cells are removed by centrifugation in the cold. Extracts of the boiled cells contain little carboxamide. Approximately 100 μM. of diazotizable, non-acetylatable amine[3] is formed per liter of culture medium. The medium is lyophilized to dryness, taken up in a minimum of water, and the sirupy mixture is deposited in a continuous narrow line on 5 sheets of 18.5 × 22.5″ Whatman No. 1 filter paper for chromatography. These are chromatographed with 80% *n*-propanol in H_2O (v./v.). Several components can be visualized with the ultraviolet lamp (Mineralite). Some of these can be detected as diazotizable amines.[3] More than 90% of the diazotizable non-acetylatable amine re-

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