^{1}H-NMR. (in D_2O): a) at 2.85 ppm (*m*, 6H), b) at 4.2 ppm (broad *d*, 6H), c) at 4.75 ppm (*m*, 3.3H), and d) at 5.22 ppm (*s*).

$C_9H_{18}Cl_3O_4P$ (327.6) Calc. C 32.99 H 5.54 Cl 32.47% Found C 32.85 H 5.62 Cl 32.32%

3. $[(\overset{a}{CH_3}\overset{c}{CHOH}\overset{e}{CH_2})_3\overset{b}{P}\overset{d}{CH_2}\overset{e}{OH}]^+Cl^-$ (*III*). From 190.5 g (1 mole) of $(HOCH_2)_4PCl$ in 150 ml H_2O, 53 g KOH in 150 ml H_2O, pH 8, and 191 g (3.3 moles) propylene oxide as in 1, 247 g (90.1%) of III, a colorless, viscous oil, is obtained. ^{31}P-chem. shift (in H_2O) –28.6 ppm. ^{1}H-NMR. (in D_2O): a) at 1.85 ppm (two *t*, J_{HH} 7, J_{PCCCH} 2.5 Hz, 9H), b) at 3.1 (*m*, 5.95 H), c) at 4.75 ppm (*m*, 3.05 H), d) at 5.10 ppm (*d*, J_{PCH} 1.8 Hz, 2.2 H), and e) at 5.25 ppm (*s*).

$C_{10}H_{24}ClO_4P$ (274.7) Calc. C 43.72 H 8.80 Cl 12.91% Found C 43.64 H 8.76 Cl 12.92%

4. $(\overset{a}{CH_3}\overset{c}{CHOH}\overset{d}{CH_2})_3\overset{b}{P}{=}O$ (*IV*). From 11.1 g (0.0404 mole) III, 50 ml H_2O, 6.3 g (0.089 mole) chlorine, pH kept at 4–7; procedure and isolation as in 2 gives 8.5 g (93.6%) of IV, a colorless viscous liquid, ^{31}P-chem. shift (in H_2O) –51.0 ppm: ^{1}H-NMR. (in D_2O): a) at 1.8 ppm (J_{HH} 6, J_{PCH} 1.4 Hz, 9H), b) at 2.65 ppm (*m*, 6H), c) 4.55 ppm (*m*, 3.4 H) ,and d) at 5.27 ppm (*s*).

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148. Microcalorimetric Measurements with the Valinomycin - Potassium Iodide Complex[1])

Preliminary Communication[2])

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(18. V. 71)

Zusammenfassung. Die Mikrokalorimetrie wurde erstmals zur Bestimmung von Assoziationskonstante, Reaktionsenthalpie, freier Reaktionsenergie und Reaktionsentropie der Komplexbildung zwischen Kaliumjodid und Valinomycin in Äthanol verwendet. Eine konstante Konzentration von Valinomycin (10^{-4} M) wurde mit verschiedenen Konzentrationen von Kaliumjodid (10^{-5} bis 10^{-3} M) versetzt. Die Enthalpieänderung (Grössenordnung 0,5 bis 5,0 mcal) wurde als Titrationsparameter benützt. Die Auswertung der Sättigungskurve nach *Klopfenstein* [3] ergab

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[1]) Part of the thesis of *H. M.*; discussed at the 11th European Peptide Symposium, Vienna, April 29, 1971.

[2]) A full paper will be submitted to Helv.

eine Stöchiometrie von 1:1 und eine gemittelte Assoziationskonstante von $1{,}2 \pm 0{,}5 \cdot 10^6$ l pro Mol. Diese Werte stimmen mit den von *Shemyakin et al.* [4] publizierten gut überein. Zusätzlich konnten Reaktionsenthalpie ΔH° (−8,9 kcal/Mol) und Reaktionsentropie ΔS (2,16 e.u.) bestimmt werden. Die Empfindlichkeit ist mindestens so gut wie bei der Leitfähigkeitsmethode.

Introduction. – The saturation curve of a given, reversible association reaction, $A + nB \rightleftharpoons \{A, B_n\}$, can be determined by using the change in enthalpy, ΔH_{exp}, as titration parameter. For example. a number of calorimetric experiments are carried out in which the analytical concentration, c_A^0, of one of the ligands, A, is kept constant, and that, c_B^0, of the other, B, is varied within an appropriate range, covering as much of the mean saturation fraction, $\bar{s}$, as is needed for sufficient information [1]. Depending on the strength of the complex, a variety of methods may be used for obtaining from the saturation curve, the reaction enthalpy, ΔH, and the stoichiometry, n, of the process.

Form ΔH and ΔH_{exp} follow $\bar{s}$ and the concentrations of the "free" ligands, c_A and c_B, as well as the concentration of the complex, c_{AB}. These data allow for the computation of the association constant, K_{ass}, the reaction energy, ΔG, and the reaction entropy, ΔS.

In view of our work with synthetic peptides capable of complexing alkali cations (especially potassium) [2], we have chosen the better known system potassium iodide-valinomycin for testing the usefulness of microcalorimetry in this field.

Materials and Methods. – The measurements were carried out at 25° with a batch microcalorimeter LKB 10700 (*LKB-Produkter AB*, Bromma, Sweden) combined with a *Keithley* 150 B Microvolt Ammeter and a *Sargent Welch* Recorder, Model SRG. A-grade valinomycin was a product of *Calbiochem* (Lucerne); *purissimum* grades of potassium iodide and ethanol (99.5%) were purchased from *Fluka Ltd.* (Buchs).

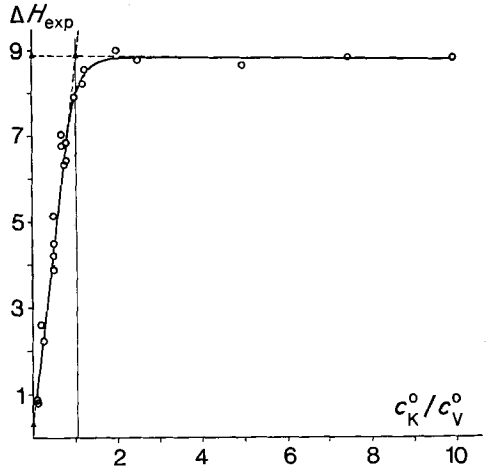
Valinomycin (V) and potassium iodide were separately dissolved in ethanol and the solutions introduced into the half-cells of the measuring cell and the reference cell, respectively. – *Measuring cell:* a) 2 ml of valinomycin ($c_V^0 = 2 \cdot 10^{-4}$ M); b) 4 ml of a solution of potassium iodide in ethanol ($c_K^0 = c_V^0 \cdot 10^{-1 \text{ to } 1}$). – *Reference cell:* a) 2 ml of ethanol; b) 4 ml of KJ solution (c_K^0). After each measurement, the calorimeter was calibrated electrically. The absolute values of ΔH_{exp} were found to lie between 0.5 and 5.0 mcal. The enthalpy of dilution of the valinomycin solution (from 2 to 6 ml) determined in a seperate experiment, using 4 ml of ethanol in the half cell b, was found to be -0.18 kcal · mole^{-1}. All measured values of ΔH_{exp} were corrected for this change (because of the reference system chosen, there was no need to correct for the enthalpy of dilution of the potassium iodide solutions).

All solutions were stored in the dark and thermostatted at 25° before use.

Calculations and Results. – The *reaction enthalpy*, ΔH, per mole of complex was obtained from the experimental saturation curve, ΔH_{exp} *vs.* c_K^0/c_V^0 (figure) by linear regression analysis of all values of ΔH_{exp} for ratios $c_K^0/c_V^0 \geqslant 2.0$ ($\bar{s} \simeq 1$), and extrapolation to the intersection with the extrapolated linear regression of ΔH_{exp} for ratios $c_K^0/c_V^0 \leqslant 1.0$. The y coordinate of the intersection was used as a reasonable value for ΔH; its x coordinate is indicative of the stoichiometry (n) of the reaction. The values found were: $\Delta H_{298} = -8.87$ kcal · mole^{-1} and n = 1.05 (figure, table).

The *mean saturation fraction* is $\bar{s} = \Delta H_{exp}/\Delta H'$, where $\Delta H'$ is the theoretical reaction enthalpy for a given ratio of c_K^0/c_V^0 assuming an infinitely high association constant. $\Delta H'$ was calculated for every experiment, on the basis of $\Delta H' = \Delta H$ for $c_K^0/c_V^0 =$

1.0 [3]. On the other hand, $\bar{s} = c_{AB}/c_A^0$, and $c_A = c_A^0 - c_{AB}$; $c_B = c_B^0 - c_{AB}$; $K_{ass} = c_{AB}/c_A \cdot c_B$; $\Delta G = R \cdot T \cdot \ln K_{ass}$; $\Delta S = (\Delta H - \Delta G)/T$. Results are compiled in the table.



Saturation Curve for the Valinomycin-Potassium Iodide Complex in Ethanol at 25°
ΔH_{exp} versus c_K^0/c_V^0 (see text)

Thermodynamic Parameters of the Valinomycin-Potassium Ion Complex at 25°

Method	Conductivity	Membrane Potential	Microcalorimetry (this paper)
Solvent	Ethanol	Methanol	Ethanol
Anion	Cl^-	I^-	I^-
K_{ass} (l/mole)	$2.0 \cdot 10^6$ [4] $5.2 \cdot 10^3$ [5] $6.8 \cdot 10^5$ [6]	$> 8 \cdot 10^3$ [7]	$1.2 \cdot 10^6$
$\Delta H°$ (kcal/mole)	–	–	–8.9
$\Delta G°$ (kcal/mole)	–	–	–8.2
$\Delta S°$ (e.u.)	–	–	–2.16

Discussion. – The data obtained show that microcalorimetry is well suited for the determination of association constants and other thermodynamic parameters of complexes between alkali ions and organic ligands whose stability is comparable to that of the valinomycin-potassium iodide complex. The method applied for deriving these parameters from the saturation curve permits the direct determination of K_{ass} for every single calorimetric experiment, and errors in the results are immediately apparent.

The sensitivity of the method would, in our case, allow for a further reduction of the minimal concentrations (c_V^0: 10^{-4}; c_K^0: 10^{-5}). Weaker complexes with less pronounced saturation curves would, however, probably require other methods of calculation [1].

The mean association constant of the valinomycin-potassium iodide complex in ethanol obtained by microcalorimetry ($1.2 \pm 0.5 \cdot 10^6$ l/mole) agrees well with the revised value of the Moscow Group [4]; the values published earlier (conductivity [5] [6], membrane potentials [7]) are 10 to 10^3 times lower (table).

A great advantage of the calorimetric method is the direct determination of ΔH^0 and ΔS^0 (table). For the system examined, the main contribution to complex stability seems to be due to energy changes rather than entropy change.

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149. Catalytic Aminomethylation of Alkenoic Compounds: I. Reaction of Monoolefins with Secondary Amines, Carbon Monoxide, and Water in the Presence of Rhodium and Iron Catalysts

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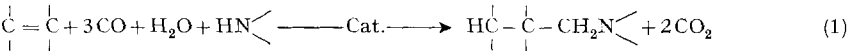
(5. V. 71)

Summary. Reactions, in the presence of rhodium oxide and/or iron pentacarbonyl, of cyclic or acyclic higher olefins with carbon monoxide, water, and secondary amines to give the corresponding aminomethyl-cycloalkanes or -alkanes (equ. 1) are described. As catalyst rhodium oxide is by far superior to iron carbonyl; however, optimum results are obtained with combinations of the two. The method can be applied to synthesis of long-chain alkylamines, which are valuable as intermediates for synthetic detergents.

Introduction. – Aliphatic amines have found widespread application in industry. The most frequently employed commercial methods of preparation involve reduction of nitriles or carboxamides, or alkylation of ammonia or amines by aldehydes, alcohols, or alkyl halides. The increasing availability of cheap olefinic raw material stimulated our interest in olefins as alkylating agents for amines. This paper deals with the one-step, catalytic, reductive alkylation of secondary amines by mono-olefins, carbon monoxide and water according to equation 1, referred to as 'amino-methylation' of olefins.



$$\dot{C}=\dot{C} + 3CO + H_2O + HN\!\!\diagup\!\!\diagdown \xrightarrow{\text{Cat.}} H\dot{C}-\dot{C}-CH_2N\!\!\diagup\!\!\diagdown + 2CO_2 \qquad (1)$$

The reaction, discovered by *Reppe* [1], required large quantities of toxic iron carbonyl or its derivatives as catalyst. The value of the process was however limited by the considerable consumption of the catalyst involved (due to loss of carbon