TABLE I

POLYMERIZATION OF BUTADIENE BY RHODIUM SALTS

Conditions: 1 g. of rhodium salt, 100 g. of butadiene, 200 ml. of solvent in capped bottles

Rhodium salt	Solvent	Emuls.,[a] g.	Reaction temp., °C.	Yield, g./hr.	$[\eta]$ Tetralin 135°	% Cryst.[b]	Ratio[c] of——— trans	vinyl	cis
Rhodium chloride·3H$_2$O	Water	5	5	0.02	0.5	43	99	0.2	<1
Rhodium chloride·3H$_2$O	Water	5	50	2.4	0.4	37	99	0.3	<1
Rhodium chloride·3H$_2$O	Water	5	80	21	0.1	37	>98	0.2	1.2
Rhodium nitrate·2H$_2$O	Water	None	50	0.1	0.1	37	>96	<2	<2
Rhodium nitrate·2H$_2$O	Water	5	50	0.4	0.1	60	98	1	<1
Rodium nitrate·2H$_2$O	Ethanol	None	Room	0.1	0.1	41	98	0.5	<2
Rhodium nitrate·2H$_2$O	Ethanol	None	80	7.0	0.1	21	>90	<8	2.7
Rhodium nitrate·2H$_2$O	Dimethyl-formamide	None	Room	0.1	0.1	32	98	0.7	<2
Ammonium chlororhodate·1.5H$_2$O	Water	5	50	1.3	0.3	36	99	0.2	<1
Sodium chlororhodate·18H$_2$O	Water	5	50	1.5	0.3	49	>98	<1	<1

[a] Sodium dodecylbenzene sulfonate. [b] Estimated by X-ray diffraction.[1] [c] Determined by the infrared absorption in KBr discs by a method similar to that described by Hampton.[2] The ratios are normalized to 100% total unsaturation.

nitrate in the filtration step. This procedure of filtration and addition of butadiene to produce more *trans*-polybutadiene was repeated several times each week for several weeks. The catalyst was still active, although after repeated filtrations the concentration was so low that polymer was forming at a greatly reduced rate.

We believe that rhodium salt catalysis represents a novel method of vinyl polymerization, one which will give stereospecific polymer in water and other polar solvents, with or without emulsifier.

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ROBERT E. RINEHART
UNITED STATES RUBBER COMPANY   HOMER P. SMITH
RESEARCH CENTER   HARRY S. WITT
WAYNE, NEW JERSEY   HENDRIK ROMEYN, JR.

THE EFFECT OF UREA ON HYDROPHOBIC BONDS: THE CRITICAL MICELLE CONCENTRATION OF *n*-DODECYLTRIMETHYLAMMONIUM BROMIDE IN AQUEOUS SOLUTIONS OF UREA[1]

Sir:

In recent years the concept of denaturation has been profoundly modified. Oversimplified, but useful, arguments, suitable for discussion of the breakdown of a hydrogen-bonded structure in a vapor phase, have given way to more sophisticated treatment accounting for the existence of secondary structure through the manifold interactions possible in aqueous solutions.[2,3,4,5,6] Naturally,

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this re-examination of the thermodynamic effects responsible for stability has led to doubts concerning the effects responsible for instability, *i.e.*, the roles of specific denaturing agents in disrupting the secondary structure also have been re-examined. For example, the efficacy of urea as a denaturant always has been ascribed to the breaking of protein–protein hydrogen bonds and preferential formation of protein–urea hydrogen bonds. Recently, however, this has been called into question, and the hypothesis that urea breaks hydrophobic bonds, and owes at least some of its denaturing capacity to this property, has received some experimental support.[7,8,9] In this preliminary report, we describe experiments in which the effect of urea on hydrophobic bonds was tested by measuring (conductivity) critical micelle concentrations of a cationic detergent in aqueous solutions containing varying concentrations of urea. This work complements studies of the solubility of organic substances in aqueous urea.[7,8,10]

Preparation of *n*-Dodecyltrimethylammonium Bromide.—*n*-Dodecyl bromide was prepared from the corresponding alcohol.[11] The compound was distilled over the range 128–132.5° at 6.3 mm. pressure. The bromide was added slowly to a cold solution of excess trimethylamine in absolute ethanol and the mixture stirred at 0° for one hour. The solution was heated to reflux under a brine condenser, cooled, and the solvent evaporated in a Rinco apparatus. The salt was collected by vacuum filtration, dried, and recrystallized once from benzene–ether and once from acetone–ether. The product decomposed at 207° and contained 25.90% bromide (theoretical, 25.95%).

Conductivity Measurements.—Conductivities of solutions made up by weight were measured to four significant figures, using a Kohlrausch-type

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bridge, at 25°. The cell constant was determined using 0.001000 M KCl. The equivalent conductance (Λ) of each detergent solution containing urea was multiplied by the ratio of the viscosity of the urea solution to that of water. When this correction is made, the equivalent conductance of the detergent at infinite dilution is essentially independent of urea concentration in the range we employed.

Critical micelle concentrations (c.m.c.) were determined by plotting $\Lambda\eta_\mu/\eta_{H_2O}$ vs. the square root of detergent concentration, the c.m.c. being obtained from the break in the curve. Results for four solutions are presented in Table I. The

TABLE I

Urea concn., moles/l.	0.0	0.5	2.0	6.0
C.m.c. moles/l.	0.0142	0.0156	0.0204	0.0454

results in pure water agree with those of other investigators,[12,13] and the data show a clear increase in c.m.c. with increasing urea concentration. Thus, urea does break hydrophobic bonds in aqueous solution. The effect of urea is modest, however, as was shown by measurements made with aqueous solutions of detergent in 6.6 M acetone. The latter experiments showed no evidence of micelles even at detergent concentrations as high as 0.12 M.

The mechanism by which urea may act as a breaker of hydrophobic bonds is by no means clear. However, since the average dielectric constant of the medium is not the determining factor (urea and acetone having opposite effects on the dielectric constant), we are led to hypothesize that the urea acts to stabilize the molecularly dispersed system, perhaps indirectly, by some favorable interaction with the "iceberg" regions that presumably form about the exposed hydrocarbon tails of the detergent,[14,15] or by formation of structures similar to urea–hydrocarbon clathrates.[7] Spelling out the details of the interaction will have to await further elucidation of the effect of urea on the structure of water.

Direct application of these results to protein, deoxyribonucleic acid, or polypeptide denaturation is not possible in view of the absence of definitive equilibrium data on the denaturing effect of organic molecules, such as acetone, at concentrations comparable to those used in studies of urea action. If its effect on hydrophobic bonds is responsible for the denaturing action of urea, then acetone, at comparable concentrations, should be a more effective denaturant. If acetone is not more effective, then urea must be capable of destroying other sources of stabilization (e.g., hydrogen bonds) in addition to hydrophobic bonds.[16]

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DEPARTMENT OF CHEMISTRY
WASHINGTON UNIVERSITY   WALTER BRUNING
ST. LOUIS 30, MISSOURI   ALFRED HOLTZER

A CASE OF INTRAMOLECULAR ASSISTANCE OF AMIDE HYDROLYSIS BY A NEIGHBORING AMIDE GROUP[1]

Sir:

We have obtained evidence for an amide hydrolysis which is strongly assisted by a *neighboring amide function*. In the course of our work[2] on intramolecular hydrogen transfer during diazonium ion decomposition, we observed hydrolysis of o-benzamido-N,N-dicyclohexylbenzamide (I) under (acidic) conditions which had failed to cause hydrolysis of much less sterically hindered amides. Furthermore, the basic and acidic hydrolyses of this compound gave different products. Whereas the basic cleavage in aqueous ethanol occurred, as expected, at the benzoyl group, the acidic hydrolysis in acetic acid took place at the more sterically hindered *tert.* amide linkage to yield N-benzoylanthranilic acid (IV) and dicyclohexylamine.

In acetic acid which was 6.9 M in water and 0.89 M in sulfuric acid, I hydrolyzed to the extent of 87% in five hours at 80°. On the other hand, N,N-dicyclohexylbenzamide (II) yielded no detectable benzoic acid when subjected to the same reaction conditions for one week. Assuming that as little as one half per cent. yield of benzoic acid would have been detected, the rate of hydrolysis of I is *at least* 10^4 times greater than that of the much less sterically compressed model compound II.

In an attempt to obtain a finite rate difference between I and II, the reactions were run in the same solvent at reflux (112°). At that temperature, I hydrolyzed to the extent of 89% in one half hour whereas II yielded N-cyclohexylbenzamide (53%) and benzoic acid (47%) after one week. Since in the latter case, the basic fraction contained no appreciable dicyclohexylamine,[3] it appears likely that the benzoic acid arose from partial hydrolysis of N-cyclohexylbenzamide which presumably was formed by acid catalyzed solvolysis of II.[4] No attempt was made to isolate the other likely products, cyclohexanol, cyclohexylacetate, and cyclohexene. The data are summarized in Table I.
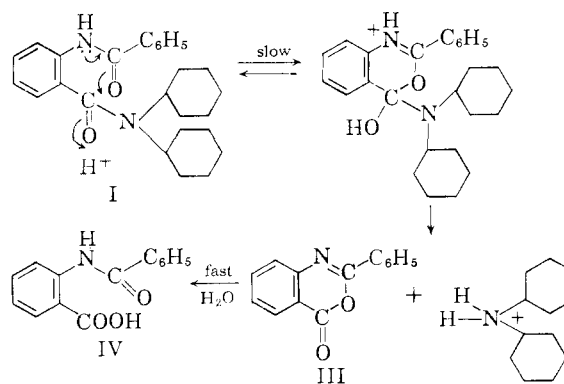

Fig. 1.