differ slightly in hydrogen-ion concentration. However, since the difference in potential between the hydrogen and quinhydrone electrodes in the same solution is not a function of the hydrogen-ion concentration but of the total electrolyte present, little difference between the values in the two series would be expected. This proved to be the case. The mean values at 25 ± 0.01° were: for (a) 0.69903 ± 0.00002 volt, for (b) 0.69898 ± 0.00002 volt. When the quinhydrone electrode is part of a cell involving liquid junction 0.6990 volt should be used for both (a) and (b). Due to its reproducibility and constancy we are convinced that in all around qualifications this standard quinhydrone electrode excels either the 0.1 N or saturated calomel electrode.

The above potentials differ appreciably from the ideal value for the cell Pt/H_2, electrolyte, quinhydrone/Au because of the salt error. This will be considered in a later report.

MORLEY CHEMICAL LABORATORY
WESTERN RESERVE UNIVERSITY
CLEVELAND, OHIO
FRANK HOVORKA
WM. C. DEARING

RECEIVED NOVEMBER 17, 1933

ADDITION OF HYDROGEN BROMIDE TO 4,4-DIMETHYLPENTENE-1

Sir:

The addition of halogen acids to substituted ethylenes has been under investigation in our laboratory for some time, particularly as regards the effects of peroxides and antioxidants on the direction of addition. For certain theoretical reasons these studies included the addition of halogen acids to 4,4-dimethylpentene-1.

In view of the recent publication of Whitmore and Homeyer [THIS JOURNAL, **55,** 4555 (1933)] it appears desirable to publish some of our pertinent findings.

Our results indicate that the direction of addition of hydrogen bromide to 4,4-dimethylpentene-1 is governed by the peroxide content of the material or reagents. From that standpoint the compound 1-bromo-4,4-dimethylpentane, the product first isolated by Whitmore and Homeyer, is what we define the "abnormal" product of the reaction. This product is formed whenever the addition of halogen acid is carried out in air, or when the mixture contains peroxides. On the other hand, if the addition of hydrogen bromide is carried out *in vacuo* in the presence of good antioxidants, the isomeric 2-bromo-4,4-dimethylpentane is obtained. It is this last product that we consider the "normal" product of the reaction.

In conformity with what we have just stated, we find that if the addition of hydrogen bromide to 4,4-dimethylpentene-1 is carried out *in vacuo* (instead of in air) 50% of the 2-bromo-4,4-dimethylpentane is obtained. The physical constants of the hitherto unknown 2-bromo-4,4-dimethylpentane are: b. p. 59.4° at 34 mm.; n^{20}_{D} 1.4463; while those of the 1-bromo-4,4-dimethylpentane under the same experimental conditions are: 68.8° and 1.4485. The table summarizes some of our results. The yields were excellent in all cases.

No.	Mole of olefin	Mole HBr	Reagent added, in mole
1	0.046	0.075	Ascaridole, 0.0012
2	.046	.075	None
3	.045	.079	Acetic acid, 0.075
4	.048	.077	*p*-Thiocresol, 0.0024
5	.049	.088	Diphenylamine, 0.0030

No.	Gas in bombs	n^{20}_{D}	2-Isomer, % ± 10%
1	Air (R. T.)	1.4483	0
2	Vac. (0°)	1.4474	50
3	Vac. (0°)	1.4479	27
4	Vac. (R. T.)	1.4469	73
5	Vac. (R. T.)	1.4463	100

JONES CHEMICAL LABORATORY
UNIVERSITY OF CHICAGO
CHICAGO, ILLINOIS
M. S. KHARASCH
CHESTER HANNUM
M. GLADSTONE

RECEIVED NOVEMBER 20, 1933

THE RULE OF SHIFT (VERSCHIEBUNGSGESETZ)

Sir:

Efforts to discover an indirect method for the correlation of the configurations of structurally similar substances have led to the enunciation of several rules all of which may be classed under the general heading of the "Rules of Shift." The earliest of these is perhaps that of Tschugaeff[1] stating that in homologous series the rotations of individual members increase asymptotically to a maximum value. To the same group belong the "Lactone Rule" of Hudson,[2] the "Phenylhydrazide Rule" of Levene,[3] etc. In its most comprehensive form (presented by K. Freudenberg[4]) the rule states that in similar, configurationally-related substances an identical substitution on identical groups produces a shift of rotation in the

[1] Tschugaeff, *Ber.*, **31**, 360 (1898); *Chem. Zentr.*, I, 93 (1905); *Trans. Faraday Soc.*, **10**, 70 (1914).

[2] Hudson, THIS JOURNAL, **40**, 813 (1918); **40**, 1141 (1919).

[3] Levene, *J. Biol. Chem.*, **23**, 145 (1915).

[4] Freudenberg, *Ber.*, **66**, 177 (1933).

same direction. Thus, in configurationally-related carboxylic acids or esters, identical substitution on the carboxyl groups should produce a shift of rotation in the same direction. Many of these rules were found very useful and results obtained by these methods were substantiated subsequently by direct chemical methods. On the other hand, there have accumulated in our laboratory a number of observations in which these rules, if used as the basis for establishing configurations, would have led to erroneous conclusions.

In order to show the possible error to which a "Rule of Shift" may lead, we present in the table the rotations of five acids and their esters. All the acids are configurationally related.

TABLE I

MAXIMUM MOLECULAR ROTATIONS OF CONFIGURATIONALLY RELATED ACIDS AND THEIR ETHYL AND (*p*-) NITROPHENYL ESTERS ($[M]_D^{25}$ (HOMOGENEOUS))

	Free acid	Ethyl ester	*p*-Nitrophenyl ester
Acetic Acid Series			
(1) $C_2H_5—CH(CH_3)—COOH$	−18.0	−22.9	−52.5
(2) $C_4H_9—CH(CH_3)—COOH$	−24.3	−30.7	−65.7
Propionic Acid Series			
(3) $C_2H_5—CH(CH_3)—CH_2—COOH$	−10.4	−11.5	−20.0
(4) $C_3H_7—CH(CH_3)—CH_2—COOH$	+ 3.6	+ 0.7	+ 5.0
(5) $C_5H_{11}—CH(CH_3)—CH_2—COOH$	+ 8.1	+ 4.2	+11.2

In the first three acids the substitution of the ethyl group by a *p*-nitrophenyl leads to a shift of the rotation to the left, and in the fourth and fifth, to the right.

In the first two acids, the contribution of the carboxyl is levorotatory and the increase of the rotation due to substitution of the ethyl group by a *p*-nitrophenyl is as expected. However, in the third, fourth and fifth, the contributions of the carboxyl groups are dextrorotatory and yet the fourth and fifth behave differently from the third on an identical substitution.

Thus, another case is presented in which the "Rule of Shift" fails.

THE ROCKEFELLER INSTITUTE
FOR MEDICAL RESEARCH,
NEW YORK, N. Y.

P. A. LEVENE
G. M. MEYER

RECEIVED DECEMBER 11, 1933

THE ALCOHOLIC FERMENTATION OF *d*-GLUCOSE IN DEUTERIUM WATER

Sir:

The production of 100% deuterium water (D_2O) in this Laboratory has made it possible to study a natural process, the alcoholic fermentation of *d*-glucose by yeast, in this medium. Measurements of the rate of fermentation were made by determining the amount of carbon dioxide formed during the enzymatic reaction in a fermentation saccharimeter after various intervals of time. One half cc. of 100% deuterium water (d_4^{20} 1.105) containing 40 mg. of *d*-glucose and 18 mg. of yeast was employed in the first experiment. The changes in height of the glycerol column in the calibrated tube of the apparatus indicated the volumes (V_1) of carbon dioxide. A control experiment was run simultaneously with ordinary distilled water; in this case V indicates the volume of carbon dioxide evolved in the process. In a second experiment 0.4 cc. of D_2O containing 32 mg. of *d*-glucose and 18 mg. of yeast was used. This experiment, too, was at the same time duplicated with ordinary distilled water. No special care was exercised to keep the temperature constant; it varied between 21 and 25.5°, affecting the corresponding experiments with heavy and ordinary water equally. The results obtained are shown in Table I.

TABLE I

Expt.	Time, hours	V, vol. of CO_2 in cc. with H_2O	V_1, vol. of CO_2 in cc. with D_2O	V/V_1
1	..	..	..	...
	2	0.80	0.10	8.0
	12	4.40	.45	9.8
	15	5.50	.60	9.1
	18	6.50	.73	9.0
	21	7.25	.85	8.6
	24	7.65	1.00	7.6
	45	..	1.70	...
	85	..	2.63	...
	205	..	8.50	...
2	..	..	..	...
	2	0.90	0.10	9.0
	8	3.65	.40	9.1
	12	5.00	.50	10.0
	24	6.30	.70	9.0
	48	..	1.20	...
	73	..	1.80	...
	96	..	2.35	...

The values of the factor V/V_1 clearly indicate that the alcoholic fermentation of glucose in 100% deuterium water is about 9 times slower than in ordinary distilled water. In another set of experiments with 60% heavy water the values for V/V_1 were found to be about 1.6. When the fermenting sugar solution with D_2O, in the second experiment, became four days old, it was diluted with 0.5 cc. of ordinary distilled water. Subsequently, no significant increase in the daily rate of carbon dioxide formation was experienced.