obtained by Bernay, who designated it "limonin," we suggest that this name be retained.

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Mechanism of Nuclear Isomer Separation Process

By G. T. Seaborg, G. Friedlaender and J. W. Kennedy

It has been shown that the energy released during the radioactive transition from an upper to a lower isomeric state of an atomic nucleus can be used to effect a chemical separation of two genetically related nuclear isomers and this discovery has provided a powerful method for the study of nuclear isomerism.[1,2,3,4] These so-called *isomeric transitions* have been the source of activation energy for many interesting chemical reactions and offer a unique method for a study of chemical activation.[1–6] We wish to report briefly some experiments which we have performed for the purpose of elucidating the mechanism of the chemical separation process.

The small amount of recoil energy, about 5.6 kcal. per mole,[7] acquired in the majority of the cases by the Br^{80} atom as the result of the emission of an internal conversion electron during an isomeric transition in a Br^{80} nucleus, seemed to be too small to account for the bond rupture and activation experiments (sometimes 100% efficient[1]) observed with bromine compounds. We have performed experiments with the isomeric transitions[3] in radioactive Te^{127} and Te^{129}, where the recoil energies are again very small. Internal conversion electrons are emitted in these cases and the recoil energies[3] of the tellurium atoms are 9.2 and 6.6 kcal. per mole for Te^{127} and Te^{129} respectively. We made a quantitative study of the change of telluric acid to tellurous acid which occurs when the radioactive Te^{127} or Te^{129} nucleus in the telluric acid undergoes a transition from its upper to its lower isomeric state. The experiments show, for both Te^{127} and Te^{129}, that the isomeric transitions effect reduction of telluric to tellurous acid with approximately 100% yield in aqueous solution at room temperature or even when frozen to the temperature of liquid air.

These experiments suggest, in view of the very small recoil energies involved, that the bond rupture and activation occurs, not as a result of the recoil energy, but as a consequence of the high state of electronic excitation which results from the vacancy in the K- or L-shell created by the emission of the internal conversion electron. A direct test of this view could be obtained by determining whether or not bond rupture could be initiated by an isomeric transition in which the transition gamma-ray undergoes very little internal conversion. Just such a case[8] is radioactive Zn^{69}, where the transition gamma-rays are largely *unconverted* and are of such an energy as to impart 40 kcal. of energy to the recoiling zinc atoms. We compared the effectiveness of the Zn^{69} transition in producing bond rupture with that of Te^{127} and Te^{129} under comparable conditions, namely, with the zinc and tellurium in the form of their gaseous diethyl compounds at 110°. The separation of the radioactivity corresponding to the lower isomeric state, as shown by its presence on the walls of the containing vessel (where fragments of the ruptured molecules collected), made it evident that again the isomeric transitions in Te^{127} and Te^{129} had been effective in producing an isomer separation process, while in the case of the zinc diethyl no separation was observed. The tellurium isomers were separated either in the presence or absence of electrically charged plates while the zinc isomers were not separable in any case. It is difficult to see how the isomer separations observed in tellurium compounds can be attributed to the recoil energy involved, since the recoil energy in the case of zinc is roughly five times greater and yet produces no separation in a similar molecule with similar bond energies.

These results lead to the not unexpected[6] conclusion that the state of high electronic excitation which exists after the loss of an internal conversion electron is responsible for the accompanying isomer separation process. For example, the tellurium atom is excited after K-shell conversion to the extent of 32 Kev. (740,000 kcal. per mole) or after L-shell conversion to 4.9 Kev. (110,000 kcal. per mole). During the electronic rearrangement which follows, the molecule should have ample opportunity to dissociate by reaching

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(1) E. Segrè, R. S. Halford and G. T. Seaborg, *Phys. Rev.*, **55**, 321 (1939).

(2) D. C. DeVault and W. F. Libby, *ibid.*, **55**, 322 (1939).

(3) G. T. Seaborg, J. J. Livingood and J. W. Kennedy, *ibid.*, **57**, 363 (1940).

(4) A. Langsdorf, Jr., and E. Segrè, *ibid.*, **57**, 105 (1940).

(5) L. J. LeRoux, C. S. Lu and S. Sugden, *Nature*, **143**, 517 (1939).

(6) J. E. Willard, This Journal, **62**, 256 (1940).

(7) G. E. Valley and R. L. McCreary, *Phys. Rev.*, **56**, 863 (1939).

(8) J. W. Kennedy, G. T. Seaborg and E. Segrè, *ibid.*, **56**, 1095 (1939).

either a repulsive state or an attractive state with sufficient vibrational energy (due to the operation of the Franck–Condon principle).

In some cases activation of a chemical reaction by an isomeric transition may follow from the formation of an undissociated molecular residue which, either before or after it regains an electron, is itself in a sufficiently reactive state. The irradiation of solutions by X-rays, wherein the same type of molecular excitation is produced, has also led to the observation of chemical decomposition and activation processes.[9]

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(9) See H. Fricke, E. J. Hart and H. P. Smith, *J. Chem. Phys.*, **6**, 229 (1938), for bibliography.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA
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Reaction of Sulfur with Mercuric Acetate in Glacial Acetic Acid

BY RICHARD E. VOLLRATH

When sulfur is heated with mercuric acetate in glacial acetic acid, no mercuric sulfide is formed but instead mercurous acetate. Quantitative experiments in which the reduction product was estimated as mercurous chloride and the oxidation product as barium sulfate indicate that the chief process taking place corresponds to

$$6Hg(C_2H_3O_2)_2 + S \longrightarrow 6HgC_2H_3O_2 + 6HC_2H_3O_2 + H_2SO_4$$

By carrying on the reaction in a sealed tube at 135°, over 90% of the mercury can be recovered as mercurous acetate. No more than a trace of mercuric sulfide was obtained after prolonged heating.

Prolonged heating of the mixture gives some mercurated acetic acid or related compound, as indicated by the fact that addition of sodium iodide no longer gives a precipitate of red mercuric iodide but instead a pale yellow iodide having the characteristics of an organic mercury compound. Further work is being done on this phase of the problem.

DEPARTMENT OF PHYSICS
UNIVERSITY OF SOUTHERN CALIFORNIA
LOS ANGELES, CALIFORNIA
RECEIVED JANUARY 27, 1940

NEW BOOKS

Statistical Method from the Viewpoint of Quality Control. By WALTER A. SHEWHART, Ph.D., Member of the Technical Staff, Bell Telephone Laboratories, New York, with the editorial assistance of W. EDWARDS DEMING, Ph.D., Senior Mathematician, The Department of Agriculture, Washington. The Graduate School, The Department of Agriculture, Washington, 1939. ix + 155 pp. Illustrated. 16.5 × 24.5 cm.

Based on four lectures delivered in March, 1938, this book is a critique of statistical quality control, for readers who already have some acquaintance with the elements of statistical theory, and are more interested in applying than in developing it. Chemists and physicists will be interested in the analysis of the data on basic physical and chemical constants, in the light of which the incompatibilities pointed out by R. T. Birge may be evidence that statistical sins, even in high places, do not go forever unpunished. "When a scientist makes a mistake in the use of statistical theory, it becomes a part of 'scientific law'; but when an industrial statistician makes such a mistake, woe unto him for he is sure to be found out and get into trouble." The discussion of the specification of accuracy and precision will be a disappointment to readers who are looking for easy answers, "...neither the physical nor the numerical aspect of an operation by itself can be taken as a complete description of the operation." The table of contents by sections goes far toward atoning for the lack of an index, and the typography reflects credit on the Lancaster Press.

ELLIOT Q. ADAMS

Theoretical Qualitative Analysis. By J. H. REEDY, Associate Professor of Analytical Chemistry, University of Illinois. McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y., 1938. ix + 451 pp. 34 figs. 14.5 × 21 cm. Price, $3.00.

Most present-day Qualitative Analysis texts consist of companion sections on the theory of the processes of precipitation and separation, and on the characteristic reactions of the various ions, with the detailed analytical procedures. The author has followed this plan, presenting first some 150 pages of theory dealing with solutions, colloids, mechanics of precipitation, analytical operations, equilibrium, mass law, ionization and its applications, sulfide behavior, amphoterism, complex ions, hydrolysis, cell potentials, and the handling and balancing of equations. This list is a comprehensive and ambitious one for the space allotted; the treatment of each item is matter-