the C_2H_6N radical becomes the most abundant of the higher mass species to desorb from the catalyst. A satisfactory explanation which is, in our opinion, supported by other data with the palladium catalyst, is that perhaps there are two kinds of "active" hydrogen atoms to be considered here. One type is simply a single hydrogen atom which is capable of an independent existence when formed in the gas phase or which dissociates into a proton and electron when diffusing through the palladium metal. But there may be another type, a more complex form of "active" hydrogen, which can be stabilized only on the surface of palladium. This form is better thought of as an H_3 molecule capable of adding in one step to the triple bond of methyl cyanide to account for the peculiar mass-44 species we observe. If this interpretation is correct, this will be the first piece of chemical evidence for the existence of the H_3 molecule. Additional support for our H_3 hypothesis is the fact that when we try to observe what species desorb when pure molecular hydrogen diffuses through our palladium catalyst, no positive mass-1 species are detectable below the ionization potential of H_2. This result indicates at least that single hydrogen atoms do not leave the catalytic surface; it may also suggest that single hydrogen atoms as such are not present on the palladium surface. However, above the ionization potential of H_2, we do obtain large yields of both masses 2 and 3. Thus far we have failed in all our attempts to distinguish between the two possible reactions,

$$H_3 + e^- \rightarrow H_3^+ + 2e^- \qquad (3)$$

$$H_2^+ + H_2 \rightarrow H_3^+ + H \qquad (4)$$

which could account for the mass-3 species observed under these conditions. If H_3 exists long enough to desorb and be ionized by the electron beam according to reaction 3, then our inability to prove that this reaction takes place must be because the ionization potential of H_3 is slightly greater than that of H_2.

Although much more work must be done to establish the validity of our hypothesis for the existence of the H_3 molecule, we have no doubt that the palladium catalyst technique reported here is applicable to a wide range of other surface chemical problems.

T. W. MARTIN
R. E. RUMMEL
Department of Chemistry, Vanderbilt University, Nashville, Tennessee

References and Notes

1. G. C. Eltenton, *J. Chem. Phys.* **15**, 455 (1947); *J. Phys. Chem.* **52**, 463 (1948).
2. A. J. B. Robertson, *Proc. Roy. Soc. London, Ser. A* **199**, 394 (1949).
3. C. E. Melton, *J. Chem. Phys.* **35**, 1751 (1961); *ibid.* **33**, 647 (1960).
4. A. G. Harrison, in *Mass Spectrometry of Organic Ions*, F. W. McLafferty, Ed. (Academic Press, New York, 1963), pp. 221–224.
5. Claud S. Gordon Co.
6. T. W. Martin, R. E. Rummel, C. E. Melton, *Science*, **138**, 77 (1962).
7. T. W. Martin and C. E. Melton, *J. Chem. Phys.* **32**, 700 (1960).
8. We gratefully acknowledge the support of this work under U.S. Atomic Energy Commission contract AT-(40-1)-2825.

16 October 1963

Precaution in the Use of Iodine-125 as a Radioactive Tracer

Abstract. *The absorption of the low-energy radiation from iodine-125 under certain circumstances may be a serious disadvantage in its use as a radioisotopic tracer.*

The advantages of iodine-125 over iodine-131 as a radioactive tracer isotope of iodine have been reviewed recently by Daniel *et al.* (*1*). A limitation in the use of I^{125} has been observed, however, in that a high proportion of the gamma radiation derived from this isotope is absorbed by solutions of certain electrolytes, for example, cesium chloride and potassium iodide. Although this absorptive effect could have been predicted from theoretical considerations, and is obvious to the physical scientist, other biologists may overlook this point, as we did, in changing from the use of I^{131} to I^{125}.

During a study of the possible incorporation of 5-iodo-2′-deoxyuridine-I^{125} into viral DNA (*2*), it was observed that an aqueous solution of radioactive DNA, labeled with 5-iododeoxyuridylic acid-I^{125}, appeared to "lose" as much as 80 percent of its radioactivity, as measured by a gamma-scintillation counter, when recovered from a cesium-chloride density gradient. Investigations were therefore made on the effect of solutions of cesium chloride, rubidium chloride, potassium hydroxide, and potassium iodide on the efficiency of counting the gamma radiation from either I^{125} or I^{131} (Fig. 1). The effect of substances of various densities on the transmission of gamma radiation was determined by means of a pair of concentric tubes, with the isotope in the inner tube and the absorbing material in the outer annular space (Table 1).

Samples of constant volume were counted in a well-type scintillation detector, with a NaI (Tl) crystal and a pulse-height analyser and scaler; in order to maintain a low statistical error, at least 3000 counts were registered.

The results show that, in all conditions studied, the absorption by the electrolyte or solvent of the gamma radiation from I^{125} ($E = 0.035$ Mev) was much greater than that from I^{131} ($E = 0.36$ Mev) and is affected more by the atomic numbers of the constituents of the absorber than by its density. The absorption of gamma radiation by matter is a summation of several specific absorption modes, and for radiation of low energy, that is, <0.1 Mev, the predominant mode is dependent on the fifth power of the atomic number of the absorber. Thus the variation of absorption with atomic number is not linear but soon approaches a limiting asymptotic value. This is seen here with the chlorides of rubidium (atomic number 37) and cesium (atomic number 55), where an increase of 18 in the atomic number has no effect on the magnitude of the absorption, but a decrease of 18, that is, potassium (atomic number 19), practically abolishes the absorption. The higher energy radiation from I^{131}, however, is almost totally unaffected by the same absorbers. The radioactivity "lost" by I^{125}-labeled DNA in such an absorbing solution may be "recovered" by separation of the DNA-polymer from the absorbing electrolytes by any one of a number of procedures, such as dialy-

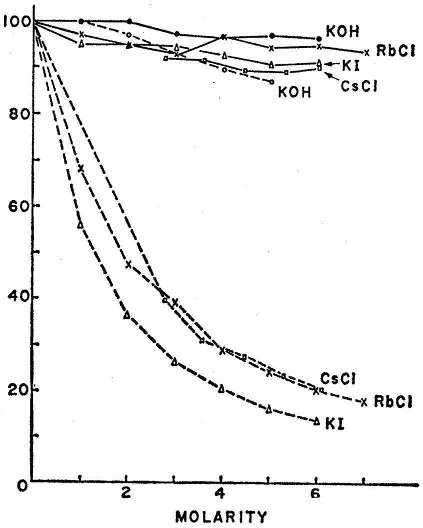

Fig. 1. The effect of various compounds on the transmission (percent) of gamma radiation derived from I^{131} (solid lines) and I^{125} (dotted lines).

Table 1. The effect of various substances on the absorption of gamma radiation from I^{125} by the concentric tubes technique. The thickness of the annular space was 2.0 mm.

Substance	Density (g/ml)	Transmission (%)
Air (control)		100
Water	1.00	94
Potassium tartrate	1.40	64
Chloroform	1.47	34
Carbon tetrachloride	1.60	30
Cesium chloride	1.60	12

sis, alcohol-precipitation, or chromatography.

Although corrections for this absorption may be applied, or the use of salts with nuclei of high atomic number avoided, an awareness of this absorption phenomenon may be of value in the choice of the radioactive isotope to be employed.

Y. S. BAKHLE
WM. H. PRUSOFF
J. F. McCREA
Departments of Pharmacology and *Microbiology, Yale University, New Haven, Connecticut*

References and Notes

1. P. M. Daniel, M. M. Gale, D. E. Pratt, *Nature* **196**, 1065 (1962).
2. W. H. Prusoff, Y. S. Bakhle, J. F. McCrea, *ibid* **199**, 1310 (1963).
3. Supported by research grants CY-5262 and E-2213-C3 from the U.S. Public Health Service and GP-0397 from the National Science Foundation. One of us (Y.S.B.) was supported by the James Hudson Brown Memorial Fund (1962–63) and by the Anna Fuller Fund (1963–64).

29 November 1963

Condensation Model Producing Crystalline or Amorphous Tetrahedral Networks

Abstract. *Wire models of tetrahedral networks have been built up by a process representing condensation from a fluid, which yields amorphous structures unless a nucleus of crystalline structure is present initially. A random tetrahedral network of 300 units has been constructed for direct measurement of coordinates; the construction process is uniquely defined so that it may be possible to synthesize larger networks by use of a computer.*

In constructing experimental networks of tetrahedra linked at all vertices (to serve as models of tetrahedrally coordinated atomic arrangements in substances such as SiO_2 and H_2O), an attempt was made to codify the construction procedures so that ultimately the construction of the network may be done by a computer. The object of the work is to realize at last the "random network" that has been discussed as a rather vague abstraction ever since Zachariasen (*1*) and Warren (*2*) first introduced the idea.

The random network is conceived as a structure in which the relation between adjacent units is defined rather rigidly by the coordination and any limitations on bending or rotation of bonds, but the relations between more distant units are variable, depending on the variations of bending and rotation within permitted limits. Because a specific model was not available, Warren (*2*) approximated the distribution of distances for nearest and second nearest tetrahedra by analytically defined distribution functions that ignore any influence of the remainder of the network on the orientation of these units. More detailed random network models may yield closer correlations with experimental data and thereby permit more critical examination of the postulates on which the models are based.

Regular structures (*3, 4*) have also been postulated which embody the same principles of bonding as the random network. Experience with the present models suggests that these regular structures are rare, although they may be important in special nucleation processes. The geometrical and topological statistics of the regular models are easily calculated, but serve only as rather unsatisfactory approximations to those of the random network. A specific random network model must be large, however, in order that its statistics may represent an adequate sample of an infinite population.

The wire tetrapod units devised by Tilton (*3*) are used, primarily because the great emptiness of the resulting model makes it possible to determine the coordinates of each unit, but also because the units are so conveniently joined (Fig. 1).

The ends of the four 5-cm legs of each tetrapod, made of wire 1.5 mm in diameter, correspond to the vertices of the coordination tetrahedron; their junction corresponds to its center. Joining two tetrapods by a length of suitable elastomer tubing forms a bond that tends to remain straight but permits free rotation of each tetrapod about the bonded leg. The addition of new tetrapods and new bonds between previous ones can be continued, with the permitted rotations and only moderate bending of bonds, to produce amorphous structures or any regular network based on tetrahedral coordination.

Adding a unit to the model involves three stages of decisions: the site at which the new unit is attached, the positions to which its other three legs are rotated, and the formation of any bonds to these other three legs. The following set of rules was found sufficient to generate an amorphous network of 300 tetrahedra with no unshared vertices except those normally present at the surface, and with no apparent limit to further additions.

1) The new tetrapod is attached to the most highly bonded of the earlier ones that are still incompletely bonded.

2) Tetrapods are numbered serially in the order of addition to the model. If the choice of a site under rule 1 is not unique, preference is given to the tetrapod of lowest serial number.

3) The legs of each new tetrapod (and their projecting ends, hereafter called the vertices) are numbered 1–4, with 1–3 forming a right-handed vector system. The first bond to the model uses leg number 1. If the choice of a site under rule 2 is not unique, preference is given to the leg of lowest number.

4) When a new tetrapod is attached, the bond is initially straight, and the tetrapod is oriented by rotation about its bonded leg to the position that brings its lowest-numbered unbonded vertex closest to an unbonded vertex of another tetrapod.

5) After the attachment of each new tetrapod, one or more additional bonds may be possible without excessive deformation of the model (that is, bending any existing bond more than about 20 deg.). These additional bonds are formed one at a time, the preference being given in each case to the pairs of vertices closest together.

6) In the course of bonding under rules 4 and 5 it sometimes happens that two possible sequences of bonding are approximately equally acceptable, one of which leads to the inclusion of an unbonded vertex within a cage in the model. The choice is made to avoid including the unbonded interior vertex. This choice has always been found reasonable with tetrahedral networks, but other types of networks may quite possibly lead inescapably to the inclusion of unbonded vertices within the model.

Rules 1 to 3 are purely topological,