

tain extent with other simple meteorological factors such as temperature, wind velocity, humidity and rainfall. The present is a record of the observations kept for four years, 1940-43.

The following table contains the averages of some meteorological factors and the number of dusty days for the period 1940-43:—

Month	Rainfall in inches	Humidity%	Temp. °F.	Wind Velocity in miles per hour	No. of Dusty Days
January	1.0	78	49	5.9	..
February	0.9	65	55	7.2	..
March	0.1	43	68	8.5	4
April	0.3	30	80	8.7	9
May	0.3	29	89	10.2	19
June	1.7	49	89	9.4	12
July	6.2	73	87	10.2	5
August	8.2	83	83	9.5	..
September	3.1	73	80	7.7	..
October	..	57	74	5.8	..
November	..	47	62	4.5	..
December	0.3	67	51	5.4	..

It appears that it is in the month of May the driest of the year, that the largest number of dust storms occur. This has also been found in Oklahoma by Langham and others.¹⁰ Kellogg¹¹ recorded similar observations.

It can be concluded that the number of dusty days in any summer month varies directly as the wind speed and the temperature and inversely as the humidity and rainfall.

From various considerations this is not altogether unexpected. Thus occurrence of dust in the air is intimately connected with meteorological conditions. Driest and warmest years are expected to have dustiest summers and this is probably true for all localities situated in arid and semi-arid regions.

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A RELATION BETWEEN THE SHEAR CONSTANT c_{44} , MELTING POINT AND INTERATOMIC DISTANCE OF METALS

It is usual, in the study of the solid state of matter, to correlate the various physical properties of solids to their lattice constants and

obtain the latter independently from them. A similar study reveals that the shear constant c_{44} of all metals crystallising in the cubic system is intimately related to their melting-points and the interatomic distances. It is found that the following relation holds good:

$$\frac{(c_{44})_0 r^3}{T_m} = 9.0 \times 10^{-15}$$

$(c_{44})_0$ is the shear constant of single crystals at the absolute zero, r is the interatomic distance and T is the melting-point in degrees Kelvin. The interatomic distance calculated from the above formula on substituting the known values of c_{44} and T_m are given in the table. With the exception of α Fe, c_{44} for all the metals have been taken from our earlier paper¹ where their values at the absolute zero were estimated. The room temperature values have been used for W, Pb and α Fe. On account of the small coefficient of expansion of tungsten, we do not expect a large difference between the room temperature and the absolute zero values of c_{44} in that case, but in the other two cases the difference may be of the order of 10 per cent. The errors of measurement of c_{44} are, however, generally larger. It will be seen that the difference between the calculated and experimental values of r is never more than 5 per cent., which is of the order expected from the uncertainty of about 15 per cent. in the values of $(c_{44})_0$.

It is interesting that a change from the face-centered to the body-centered structures does not effect the validity of the formula.

Structure	Metal	$r \times 10^8$ calculated	$r \times 10^8$ experimental
Face-centered ..	Al	2.96	2.86
	Ag	2.82	2.86
	Au	2.89	2.87
	Cu	2.46	2.55
	Pb	3.35	3.49
Body-centered ..	W	2.78	2.73
	α Fe	2.41	2.47
	Li	3.14	3.04
	Na	3.78	3.72
	K	8.87	4.62

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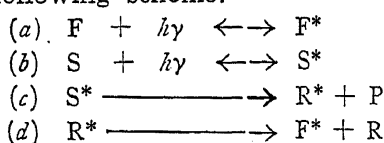
A NEW HYPOTHESIS FOR THE MECHANISM OF ACTIVATION OF SUBSTRATE MOLECULES BY ENZYMES

ACTIVATION of molecules in chemical processes is very generally accepted to be due to collision between reactant molecules with sufficient violence, resulting in transformation of kinetic energy of translation into vibrational energy

within the molecule. Enzymes, however, are peculiar in bringing about reactions at much lower temperatures and hence must be assumed to have acted according to one or other of the two following mechanisms:

(i) By making the reaction follow some different path, which entails much less energy consumption; an intermediate complex of enzyme substrate is formed which can then break into the reaction products liberating the enzyme again.

(ii) By supplying energy¹ to the system of reacting molecules necessary for their activation; Medwedew¹ has rejected the intermediate complex mechanism and proposed one in which the molecules of the enzyme can activate the substrate molecules according to the following scheme:—



F (enzyme molecules) become activated (F^*) by taking a quantum from the energy liberated in decomposition. F^* collides with the substrate S and activates them to S^* . R and P are products of decomposition.

The following facts are, however, clear from both the theories:—

(i) The outstanding property of enzymes, viz., their specificity has not been adequately explained. Theory of active groups and centres when reviewed critically degenerates into something like arguing in a circle (cf. Bayliss²).

(ii) The enzymes are known not to contain any other group than the ordinary proteins; why not then all the proteins are catalytically active?

(iii) Even in any given reaction the view that substrate molecules have some definite active groups appears to be opposed by the observations of Munch and Kuhn³ on sucrose inhibition.

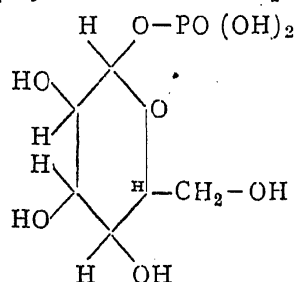
The following mechanism for the activation of substrate molecules by the enzyme, is, therefore, proposed as a preliminary hypothesis. The enzyme molecules are unstable bodies at the ordinary temperature; due to this fact the enzyme molecules can give off energy, the transference of energy from the enzyme to the substrate molecules occurs by virtue of the (i) resonance between some group or atomic vibration in the substrate and some characteristic frequency in the enzyme molecule (primary activation). (This must occur prior to any enzyme-substrate complex formation, if any such compound formation occurs). A similar mechanism of resonance has been postulated to explain the high efficiency of exciting the lower vibrational states of ethylene by hydrogen.⁴

(ii) From this excited group or atom of the substrate molecule distribution of energy among the various other bonds may occur under the influence of the enzyme, so that energy may finally be stored in the bond which will be the seat of chemical reaction (secondary activation). Such redistribution of energy to other parts of the molecule from

one particular bond which primarily receives energy is known to occur in the photo-chemical decomposition of ketene⁵ and also in some prototropic changes.⁵

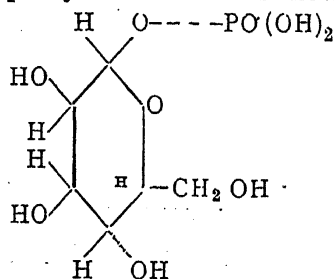
It has, however, been shown that activation by absorption of infra-red radiation is hardly possible; however great the energy density, the fundamental frequencies cannot decompose the molecule because the energy of the quantum is not large enough, and a harmonic having sufficiently high frequency is not absorbed.⁶ It appears possible, however, that the energy required for the reaction may be absorbed not in a single quantum of certain frequency but in terms of several quanta at a correspondingly lower frequency.⁷ A further possibility may be presented in a stepwise absorption of vibrational energy, the next step of absorption occurring only after excitation has died down by distribution of energy among other bonds.

The case in point may best be illustrated by one arbitrary example, e.g., glucose-1-phosphate \rightarrow polysaccharide with phosphorylases.



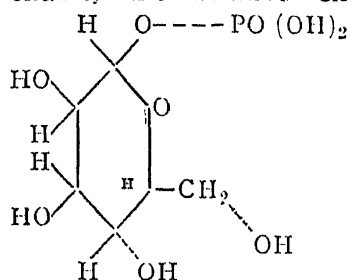
(i) The etheric oxygen atom is set into resonance vibration by the enzyme, (ii) part of the excess energy goes over to the upper part of the molecule and is located in O—P bond while the rest flows down the lower part, one fraction exciting the C_6 —OH bond while the other is located in the C_4 —OH bond. For steric reasons the C_2 —OH bond cannot become chemically reactive by absorption of energy.

Depending on the nature of the phosphorylases, a relative distribution of energy between the C_6 —OH bond and C_4 —OH bond occurs, in the case of plant phosphorylases the former is very little excited, practically the whole share going to the latter, while an almost equitable partition of energy between the two bonds occur in the case of animal phosphorylases. The result can be shown thus: (i) For plant phosphorylases: If this now condenses



with itself with elimination of phosphoric acid, starch will result (i.e., glucose 1:4 glucoside chains) and for the second case: (ii) for animal phosphorylases: Condensation of this with itself will give rise to branched chain carbohydrates in which some are glucose—1;4-

glucoside chains and others are glucose—1:6-glucoside chains, the relative excitation of



C_6-OH and C_1-OH bonds determine unit chain length, i.e., whether glycogen or amylopectin will be formed. Hence animal and plant phosphorylases would appear to differ only in degree and not fundamentally in their mode of action. Since monomolecular decomposition occurs by virtue of a "time-lag" between activation and decomposition due to redistribution of energy among the various degrees of freedom, such a system as above will be expected to decompose unimolecularly.

Let us now review some of the enzymic properties in the light of the above hypothesis.

Specificity.—Specificity of enzymes is determined by the fact that approximate coincidence or 'matching' between the characteristic frequency of the enzyme and that of some group, etc., of the substrate molecule must occur. Since it is known that frequency of a group may remain more or less unchanged or unaffected by other parts of the molecule, it is no wonder that compounds with similar structure should be the substrate for the same enzyme.

Inhibition.—(i) Competitive type: this occurs when the primary activation, viz., resonance of the inhibitor molecule with the enzyme molecule can occur but the second step, viz., distribution and localisation of energy in some suitable part of the inhibitor molecule, which may react chemically is not possible. Hence this type of inhibition occurs only with molecules which are chemically related to the substrate.

(ii) Non-competitive type: When the inhibitor molecule may react with the substrate molecule or enzyme molecules so that they become "out of tune", activation is inhibited and the reaction retarded.

Energy of activation.—It is generally found that the heat of activation is smaller for the enzymic decomposition of any chemical compound than the non-catalysed process. It is evident that in thermal activation, all parts of the molecule must be raised to a high level so that a particular bond which is to break may have a definite amount of vibrational energy; but in the enzymic process the enzyme can by its influence cause the energy to be specifically located in the said bond and thus can dispense with the extra amount of energy which goes to other parts of the molecule. It follows from our present scheme that when the primary absorption of energy occurs at a bond which is also the seat of chemical reaction, the heat of activation will be expected to be a minimum; but when this is not the case, i.e., when the second phase of activation, viz., localisation of energy in some other bond is required

naturally the heat of activation will be expected to be greater.

Effect of a slight change in substrate or enzyme.—A slight change in substrate may serve to make it in better harmony with the enzyme, e.g., native egg albumin is slowly hydrolysed by trypsin, but slight heating of the solution makes it very susceptible to attack by the enzyme. For the similar case of trypsin on keratin it is known that the appearance of $-SH$ groups is not responsible for the observed phenomenon. Activators of enzymes may also be effective in the same way.

In this connection a closer study of (i) coupled reactions such as xanthine oxidase + xanthine + catalase + ethyl alcohol; (ii) action of mixture of two enzymes on the same substrate, e.g., Haworth's 'Q' factor and Hanes' potato phosphorylase on glucose-1-phosphate; (iii) change of the nature of reaction with the same enzyme under different experimental conditions, e.g., muscle phosphorylase *in vitro* and *in vivo*; (iv) reactions in which one enzyme catalyses the direct side and another (and a quite different one) catalyses the reverse, will be of interest. According to our present conception, specificity being determined by some frequency in the enzyme molecule, may be susceptible to change under different experimental conditions and is not rigid depending upon some unchangeable active groups.

The real test of a hypothesis lies, however, in its quantitative aspect; but since the infrared and Raman data on complex molecules are meagre and since the interaction of the various energy states in the complex molecule is difficult to anticipate, a full mathematical treatment is not easy.

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CUPRIC-AMMINO-SULPHATES

A. K. DEY and A. K. Bhattacharya¹ have reported evidence from the electrical conductivity measurements of the existence of cupric-amino-sulphates having 2, 4, 5 and 6 molecules of ammonia for a molecule of copper sulphate. In another publication² these authors report that they have succeeded in isolating a blue amino-copper sulphate having five molecules of ammonia for one molecule of copper sulphate. The existence of the aforesaid amino-compounds and of others having intermediate composition has been concluded by previous workers from a systematic study of some physical properties of copper sulphate and ammonium hydroxide system. Bhattacharya and