fifth hour after the injection is independent of the administration route. We registered 450 counts-per-minute per μc of injected P^{32} with a standard deviation of ± 33%. The "build up" curves can therefore be normalized by equalizing to 1000 the mean value of the countingrate at the fifth hour. Figure 2 shows examples of the normalized curves.

The observation of these curves permits us to affirm that the geometrical and biological variabilities do not prevent the study of other variables introduced at will: one may study particularly the administration route (as we have done), the room temperature, the effects of the pharmacological substances administrated.

The discussion of the significance of our measurements is out of the scope of the present note. However, from the analysis (to be published) of these curves, and considering the results of our other researches, we can say that what is measured is the activity of the extracellular and cellular spaces, while the blood activity is not significantly measured.

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Riassunto

Gli autori descrivono una tecnica che consente di attuare determinazioni esterne di radioattività β su tessuti superficiali nel topo, mantenendo costante il rendimento di misura per una durata di alcune ore. Vengono presentati e brevemente commentati alcuni esempi di curve ottenute con questa tecnica in seguito ad iniezioni di P^{32} per via endovenosa, endoperitoneale e sottocutanea.

Informations - Informationen - Informazioni - Notes

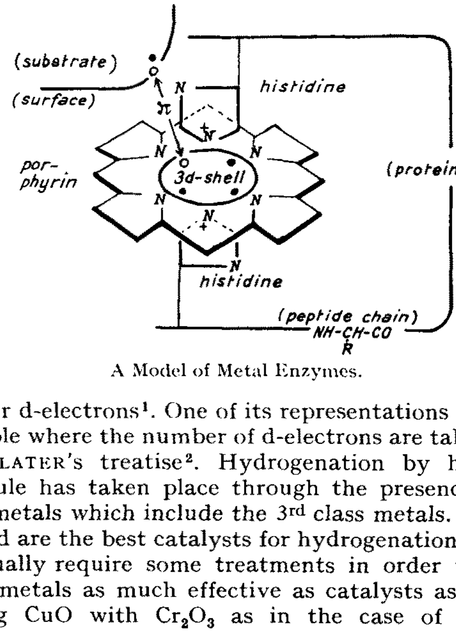
THEORIA

An Electronic Theory of Transition Metal Enzymes and Catalysts

It is well-known that the transition metal is a good catalyst for oxidation and reduction. We have as industrial catalysts: platinum black, Raney's nickel, cobalt for hydrocarbon synthesis, and iron for ammonia synthesis; and as biocatalysts: heme-protein (cytochrome, cytochrome-oxidase, peroxidase, catalase, hemoglobin), and copper-protein (phenol- and ascorbic-acid-oxidase, hemocyanin).

In the heme-protein, an iron porphyrin and two histidines of protein sometimes form the d^2sp^3 octahedral six covalent iron complex salt[1]. As the 3d-orbitals of iron atom in the complex are saturated by the electrons of ligands, the 3d-electrons can be assumed to form a closed shell similar to the 3d-electrons of metal copper. It has been found that a bond radius of iron in the complex is about 1·23 Å[2], and an atomic radius of metal copper is about 1·27 Å[3]. The π-electrons of conjugated double bond in the iron porphyrin will be able to move freely among atoms just as do the 4s-electrons of metal copper. By taking it for granted that each of six nitrogen atoms of porphyrin and two histidines has the same relation to the central iron atoms and forms a symmetrical structure to the latter, an analogy to the metallic model that is, a polyhedron of metal copper calculated quantum-mechanically by WIGNER-SEITZ's method may exist as an isolated form in the prosthetic group of heme-protein. The copper-protein acts in the same way as does the heme-protein. Since the 3d-orbitals of copper atom are almost filled, the copper-protein will have no need to make a complex salt with the aid of porphyrin. The state containing 9 electrons in d-orbitals will be called hereafter "platinum-like state", since Pt is the most powerful catalyst for oxidation-reduction. One electron coming in and out of the platinum-like state may play a decisive role in the oxidation-reduction process for the metal enzymes, as shown in the Figure[4].

Transition metal atoms are ordinarily arranged according to the well-known order of the periodic table by their physical and chemical properties. However, it has been found to be convenient for a survey of catalytic activities to rearrange them according to the number of their d-electrons[1]. One of its representations is shown in Table where the number of d-electrons are taken from the SLATER's treatise[2]. Hydrogenation by hydrogen molecule has taken place through the presence of 2nd class metals which include the 3rd class metals. Both Pt and Pd are the best catalysts for hydrogenation. Cu and Ni usually require some treatments in order to make these metals as much effective as catalysts as Pt, e.g. mixing CuO with Cr_2O_3 as in the case of ADKINS' catalyst, or dissolving out Al by alkali from Al-Ni alloy to leave porous Ni as in the RANEY's catalyst. In the d-electron deficient state, the metals will accept electrons from substrates and form at their surface some intermediate complex compounds with substrates which will later be decomposed and reduced, like Co in the FISCHER's synthesis and Fe in the HABER's synthesis.



A Model of Metal Enzymes.

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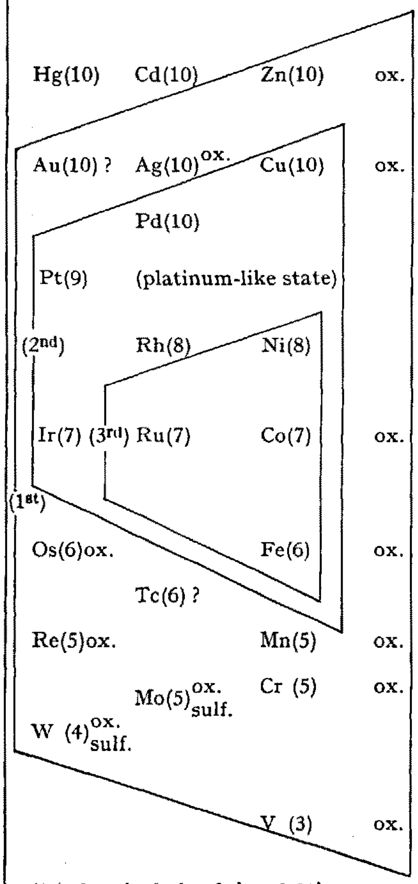
Table.–The Classification of Transition Metal Catalysts



No. of d-electrons	Transition metal catalyst: 6 period	5 period	4 period		Types of oxidation-reduction: addition reaction using 3^{rd} class	hydrogenation by H_2 using 2^{nd} class	hydrogenation by H_2: substrate	oxidation by O_2 using 1^{st} class
10	Hg(10)	Cd(10)	Zn(10)	ox.				
10	Au(10) ?	Ag(10)$^{ox.}$	Cu(10)	ox.	(copper-protein)	methanol syn. (hp.) Adkins' cat. (hp.)	C=O	formalin syn. copper-protein
9	Pt(9)	Pd(10) (platinum-like state)				Pd, Pt are the best cat.	$>C=C<$	NH_3 oxidation sulfuric acid syn.
8	(2^{nd})	Rh(8)	Ni(8)		Reppe's reaction	Raney's Ni cat. fat hardening		use of natural gas
7	Ir(7)	(3^{rd}) Ru(7)	Co(7)	ox.	Oxo-process (hp.) Co-complex salt	Fischer's syn.	C=O decomp.	drier of oil fatty acid syn.
6	(1^{st}) Os(6)ox.	Tc(6) ?	Fe(6)	ox.	heme-protein	Haber's NH_3 syn. (hp.) Bergius method (hp.)	N≡N decomp. dest.	NH_3 oxidation heme-protein
5	Re(5)ox.		Mn(5)	ox.				
4	W (4)$^{ox.}_{sulf.}$	Mo(5)$^{ox.}_{sulf.}$	Cr (5)	ox.				dehydrogenation
3			V (3)	ox.				phthalic acid syn. sulfuric acid syn.
	(1^{st} class includes 2^{nd} and 3^{rd} classes, and 2^{nd} class includes 3^{rd} class)				(Abbreviations: ox.: oxide; sulf.: sulfide; syn.: synthesis; cat.: catalyst; hp.: high pressure; decomp.: decomposition; dest.: destructive hydrogenation).			

Oxidation by oxygen molecule can be carried out in the presence of the 1st class metal oxides or sulfides which include the 2nd and the 3rd classes. The interesting reaction is the CO-addition where organic compounds having one more carbon atoms are synthetized. This reaction can be carried out by only the 3rd class metals, particularly, Ni, Co and their carbonyls, the example being one of Reppe's reaction and Oxo-process[1].

The substrates reduced by H_2 are mostly diatomic molecules like C=O, N≡N, O=O, furthermore, $>C=C<$, —C≡C—, —N=N—, C≡N, N—O, which consist of the 2nd period atoms and would be able to assume the triplet state of O_2. The oxidation-reduction of substrates would be carried out through the triplet state. S, Se, Te situated in the same column of the periodic table with O, as well as P, As with N, are strong inhibitors for the transition metal catalyst. The fact may be explained by assuming that they will behave in the same manner as O or N and compete with the substrates[1].

Consequently, it may be concluded that the oxidation-reduction process be most easily carried out by the closed shell structures having the large orbital angular momentum like the d-closed shell in atoms or the π-closed shell in molecules. In the well-known Lewis octet theory, he noticed the stability of the p-closed shell in atoms and the σ-closed shell in molecules. The present idea might be considered to be an extension of the Lewis' theory to the d- and π-closed shells.

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Research Institute of Science and Industry, Kyushu University, Fukuoka, Japan, September 29, 1953.

Zusammenfassung

Zur Deutung der katalytischen Wirkung von Übergangsmetallen und Enzymen werden dieselben gemäss ihrem Elektronenaufbau der Aussenschalen klassifiziert, und es wird festgestellt, dass Oxydations-Reduktions-Prozesse über abgeschlossene *d*-Schalen in Atomen und abgeschlossene π-Schalen in Molekülen leicht stattfinden.

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