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REDUCTION BY A MODEL OF NAD(P)H. CONSTRUCTION OF ELECTRON BRIDGES

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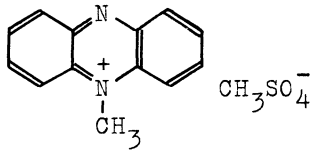
Attempts have been made to construct electron bridges starting from N-benzyl-1,4-dihydronicotinamide, a model of NAD(P)H. It has been found that N-methylphenazinium methosulfate and pyocyanine are effective catalysts to reduce some substrates.

Pyridine nucleotides, NADH and NADPH, are coenzymes frequently required by oxidoreductases in biochemical reactions. These nucleotides or their model compounds, however, can reduce substrates of quite limited variety in non-enzymic reactions.[1,2] Since information obtained from model reactions with limited substrates is not sufficiently reliable to be deduced to enzymic reactions, it is desirable to extend the scope of model reactions as wide as possible. Extension of the scope of reactions with model coenzymes will contribute not only to understanding mechanisms of enzymic reactions but also to organic synthetic chemistry, because the model reaction will suggest a possibility to undergo organic reactions under mild conditions.

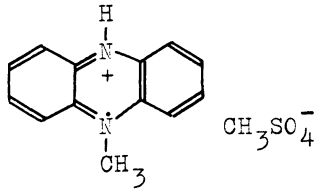
N-benzyl-1,4-dihydronicotinamide (BNAH), a model of NAD(P)H, reduces thiobenzophenone into diphenylmethanethiol,[3] but benzophenone and other alkyl or aryl ketones and aldehydes are insensitive to the reduction by BNAH. The reactivity of thiobenzophenone has been attributed to its facile electron-acceptability.[4] In our recent paper,[5] it has been proposed that the reaction proceeds with the three-step "electron-proton-electron transfer" process rather than the one-step "hydride transfer". Extending the above concepts, we have searched for catalysts that promote reductions of non-enzymically inactive substrates. In

this communication will be reported the preliminary results on the construction of electron bridges.

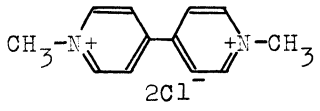
A degassed ethanol solution of BNAH and N-methylphenazinium methosulfate (PMS) exhibits ESR signals due to PMSH.[6] The spectrum, however, disappeared immediately when an ethanol solution of methyl viologen (MV) was added to this



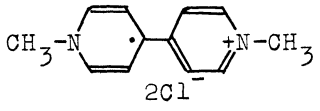
PMS



PMSH·

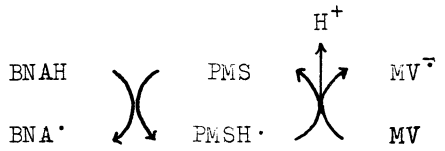


MV



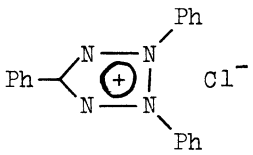
$MV^{\cdot}$

system at room temperature in a dark, and a new spectrum[7] due to $MV^{\cdot}$ was observed. MV was not reduced by BNAH without PMS under the same conditions. This fact suggests that PMS has played a role of a catalyst for an electron-transfer reaction, or has constructed an electron bridge (eq. 1).

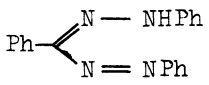


(1)

2,3,5-Triphenyltetrazolium chloride (TTC) can be substituted for MV. Catalytic activity of PMS was measured for this reaction by observing the intensity



TTC

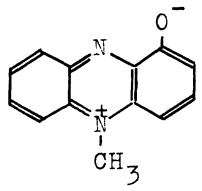


TPF

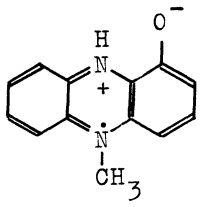
of characteristic absorption of formed triphenylformazane (TPF) at 480 nm. It was found, in a typical run (9.04×10^{-6} mol BNAH, 9.80×10^{-10} mol PMS, and 1.29×10^{-5} mol TTC in 3.0 ml of 33% aq-ethanol at 30°C after 84 hr), that PMS turned the cycle about 900 times, i.e., 9.05×10^{-7} mol of TTC was reduced into TPF.

Thus, PMS ($E_o' = 0.08$ volt)[8] constitutes an effective bridge for reductions of MV and TTC, but it is not sufficiently effective, in general, for reductions

of biologically important aldehydes, ketones, and quinones. Pyocyanine (PC) (E_o' = -0.034 volt)[8] is, however, more effective catalyst than PMS for this purpose: a mixture of BNAH and PC in ethanol gave ESR signals assignable to



PC



PCH·

PCH·. However, since this species is unstable under the condition, the ESR signal disappeared completely within the recording time. On the other hand, an ethanol solution of BNAH and anthraquinone or acenaphthenequinone gave very faint and broad ESR signal barely observable with modulation width of 5 gauss and increased amplitude. When an aqueous solution of PC was added to this solution, strong ESR signals sue to semiquinone radical of anthraquinone[9] or that of acenaphthenequinone[10] were observed, respectively. Integration under the area of signals revealed that the concentration of semiquinone radicals was enriched by PC about 30 or 15 times higher than that in the solution without PC for anthraquinone or acenaphthenequinone, respectively.

So far, PMS and PC have been regarded as catalysts for the electron transfer, or a sort of synzymes[11]. From another viewpoint, the electron bridge can be regarded as a model of respiratory chain. The research is in progress for both directions.

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