

two or three moles of potassium hydroxide, several crystalline stable hydrides  $[\text{IrH}_y\text{Cl}_{3-y}(\text{PEt}_2\text{Ph})_3]$ , whose stereo-chemistry was discussed.

A number of other similar iridium complexes were also reported. In the "reversed carbonylation" reaction, a ruthenium(II) complex  $[\text{Ru}_2\text{Cl}_3(\text{PEt}_2\text{Ph})_6]\text{Cl}$  gave under similar treatment with potassium hydroxide in ethanol, methane and the hydrocarbonyl complex  $[\text{RuHCl}(\text{CO})(\text{PEt}_2\text{Ph})_3]$ .

A. D. Allen and C. D. Cook, of the University of Toronto, reported kinetic and equilibrium measurement for the displacement of some aryl acetylenes by others in platinum complexes  $[\text{Pt}(\text{PPh}_3)_2\text{L}]$  (L = aryl acetylene).

F. Zingales, University of Milan, gave a paper on the reactions of palladium (II) chloride with phenyl-ethyl-acetylene (L) from which he obtained three products, 1,2,4-triphenyl-3,5,6-trimethyl-benzene, and two

complex palladium compounds. These were crystalline, diamagnetic, non-electrolytic solids of formulation  $\text{PdClL}_4$  and  $\text{Pd}_2\text{Cl}_2\text{L}_4$ . By reduction of either of the latter two compounds with sodium borohydride, a cyclooctatetraene derivative was obtained. The first of the two palladium complexes could be converted by thiocyanate or iodide ion to  $\text{Pd}(\text{SCN})\text{L}_4$  and  $\text{PdIL}_4$  respectively.

W. D. Jacobs, J. T. Pyle and R. B. Wilson, of the University of Georgia, described a large number of substituted dithio-oxamides, some symmetric, some unsymmetric, and investigated these as reagents for palladium, platinum, osmium, rhodium and ruthenium. The complexes are formed in very strong hydrochloric acid solutions. With some, maximum colour is developed almost instantaneously at room temperature, while for others considerable time is required and heating is sometimes necessary.

## Production of Hydrogen from Coal

### PALLADIUM CATALYSTS IN DEHYDROGENATION OF VITRAIN

The possibility of the economic production of molecular hydrogen by the catalytic dehydrogenation of coal is suggested by the results of work reported recently by R. Raymond, I. Wender and L. Reggel, of the Pittsburgh Coal Research Center, U.S. Bureau of Mines (*Science*, 1962, **137**, (August 31st), 681-682). Surprisingly large yields of hydrogen were obtained in attempts to determine the hydroaromaticity of coal by the dehydrogenation of vitrains and other related materials with the use of polycyclic aromatic solvents and supported palladium catalysts.

In the laboratory-scale process, 0.5 g finely-divided coal (—200 mesh), the solvent and 0.55 g palladium-on-calcium carbonate catalyst were refluxed together for five hours in a helium atmosphere. Generally the major part of the gases, consisting of hydrogen with small amounts of carbon monoxide, carbon dioxide and methane, was evolved in the first hour. With phenanthridine as solvent and a 30 per cent palladium-on-calcium carbonate catalyst, 30 per cent of the hydrogen

contained in Pittsburgh vitrain was evolved. Other coals, under the same conditions, gave lower but appreciable yields of hydrogen, depending on their rank. About 50 per cent of the total hydrogen content of Pittsburgh vitrain was evolved when 2-azafluoranthene was used as solvent, but it is thought that some of this hydrogen was due to side reactions.

Yields of about 30 per cent of the total hydrogen in Pittsburgh vitrain were also obtained when other platinum metal catalysts were used with phenanthridine as solvent. Such catalysts included 1 and 5 per cent palladium-on-calcium carbonate, 5 per cent palladium-on-alumina, 5 per cent ruthenium-on-alumina, and 5 per cent rhodium-on-alumina. A commercial chromia-on-alumina catalyst was totally ineffective in these conditions.

This catalytic dehydrogenation process, demonstrated so far only on a small scale, has indicated a possible new use for certain coals as a source of hydrogen gas.

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