IV. Conjectures on the Structure of the Catalysts

As was stated at the end of section I, it turned out, in contrast with the original assumption, that the catalysts with the best efficiency also exhibit the simplest section pictures. This means that no other crystals or other substances, such as glass, or almost none were formed beside the mass of the magnetitic base crystals. This crystalline groundmass is optically moderately to weakly anisotropic. There are no peculiarities in the majority of these catalysts. In individual sections segregations of an unknown nature are discernable in the interior of the crystal. In other sections new formations with quite differnet optical properties occur individually or in small groups. Essentially, however, the optical behavior of the groundmass is very simple for the most part.

The X-ray examination of the structure of a number of typical representatives of various groups for all practical purposes only gave the interference of magnetite, Fe_3O_4, with the normal lattice constant, alpha = 8.04. Only in individual catalysts, which showed particularly marked deviations, was it possible to determine weak interferences of a deviating nature. These, however, admitted of no simple determination.

We are of the impression that no insights worth mentioning are possible by the use of X-rays. Optical methods appear to be sharper and more trustworthy by far with r espect to variations in compostion.

According to these experiences and the result of the conversions, the specific requirements for the composition can be formulated more ~~mf~~ or less in the following shape.

The magnetitic component, Fe_3O_4, should consist of 38 parts in the unreduced catalyst, or 36 parts if copper has been added. To this should be added 10 parts of "acid components, the best of which is considered to be $FeO.ZrO_2$. Earth alkalis and potassium should be added as ferrites in a proportion of 1 each. Similarly, copper should be added as cupric ferrite in a proportion of 2.

From this we can visualize the situation in a magnetite which is to a certain extent contaminated. It consists of 72 - 76 parts of ~~x~~ pure Fe_3O_4 to which has been incorporated ferrous zirconate (20 parts) in a manner similar to ilmenite in titanium magnetite. The other in themselves negligeable components appear to be uniformly dispersed in this lattice, indeed for their part effect a homogenization.

The comparison of the "simplified numerical ratios" or the mol % of the table, particularly the mean values derived from it, shows that the sum total of the compounds assumed to be ferrites stands in a simple integral ratio of 4:1 to the "acid" components, especially to the zirconate. If we base our conception with the formula for titanium magnetite, $FeO.Fe_2O_3 . FeOTiO_2$, which was mentioned at the beginning of the previous section, then the following formula can be constructed as the desired ideal formula for this type of iron catalyst: $4\ MeO . Fe_2O_3 - 1\ FeO . ZrO_2$. For MeO, FeO with 36-38 mol %, earth alkali (CaO), with 1, K_2O with 1 plus CuO with 2 mol % is used. It is assumed that iron can be replaced by CaO or CuO plus K_2O within certain limits.

The "acid component", principally the $FeO.ZrO_2$ in this instance, is incorporated in between symmetrically according to the model of the titanium magnetite. This rather bold hypothesis is derived from the fact that it is especially the good catalysts that correspond to the mixture as well as the analysis according to this formula. These catalysts all exhibit little optical anomaly which is an indication of only a slight disturbance of the lattice. We undoubtedly have here a quite uniform, homogenous, and primarily regular dispersion. This regualr dispersion gives regular disturbance spots which are doubtless the "active spots" of the catalyst. The increase in catalytic efficiency with the rising atomic and molar weight of the acid components is presumably connected with the drop in atomic volume and the simultaneously better adjustment to the lattice. A completer and more uniform incorporation and also the formation of numerous and regularly dispersed active spots is also effected.

The catalysts, however, are not employed in their oxidic form, but rather after previous reduction with hydrogen. It was not possible to determine heretofore to what extent reduction proceeds individually. Optcal examination with sections revealed nothing, solely bare metallic areas with no characteristic details whatever. Comparison experiments with congruent oxide mixtures having the same empiric compositoin as the fused catalysts yielded similar products but, at best, only 1/5 of the amount was obtained which was produced by fused catalysts. The probable significance of this is that similar effects can be produced by mixing but that a completely homogeneous and also primarily regular dispersion has a far superior efficiency. Sections of the reduced catalyst, in the case of glass-containing catalysts, i.e. those possessing "binders", in no instance revealed even traces of the binder. It appears that during the lengthy thermal treatment of the catalyst in reduction either absorption into the metallic spongy mass or perhaps even diffusion occurs. This could have resulted in effects similar to those occurring with the alkalised sintered catalysts proposed by Dr. Michael. However, it appears to me to be more favorable if a thoroughly uniform structure is attained by fusion, consisting, as was described, of a quite uniform dispersion throughout the entire mass of the catalyst also in the reduced catalyst. At least such catalysts are easier to "handle".