MECHANISM OF THE STABILIZATION OF ETHER BY COPPER.

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The value of copper in preventing the formation of peroxides in anæsthetic ether has previously been reported from this Laboratory.[1]

It has been shown that a tin container, coated on the inside with copper, is the most effective of all types of containers investigated for the preservation of anæsthetic ether in its original state of purity. This investigation included containers of various types used by domestic and foreign manufacturers of ether, such as ordinary tin cans, and bottles made of glass of various types and degrees of transparency to light, wrapped and sealed with various materials designed to protect the ether from deterioration. It was found that peroxide-free anæsthetic ether packaged in containers of this type almost invariably developed peroxides after varying storage periods, but that the same ether packaged in copper-lined tin cans, even though kept at elevated temperatures over long periods of time, remained free from peroxides or other decomposition products for an indefinite period.

Originally it was assumed that this protective action of copper was inhibitive in nature and that the copper exerted a negative catalytic effect upon the reaction by which peroxides are normally produced in ether, thus preventing their formation. However, additional research work has shown that metallic copper removes the agents causing oxidation, thus preserving ether in its original pure state, and that this reaction forms cuprous oxide, which in turn is capable of decomposing and removing peroxides from ether which may contain them. It was further shown that the formation of ether peroxides represents an oxidation reaction between ether and atmospheric oxygen and that this oxidation reaction appears to proceed in at least two distinct steps, one the combination of atmospheric oxygen with ether to produce a compound which is not disclosed by the U. S. P. peroxide test, and the other, an oxidation of this intermediate substance, either through further reaction with atmospheric oxygen or by auto-oxidation, to the final product, the ether peroxide.

The existence of the intermediate oxidation product is supported by the following experimental facts. It is possible to remove atmospheric oxygen from ether by distillation of ether. Ether peroxides, by which are meant the final oxidation products, are not volatile at the temperature at which ether distils. If anæsthetic ether is distilled in the absence of oxygen so as to remove all oxygen present therein with the first portion of the distillate, and if a further portion of the distillate is then collected under anæric conditions and this ether packaged in the absence of air in either glass or ordinary tin containers, peroxides will develop after a certain storage period. Theoretically, all the oxygen has been removed and the ether has been collected and stored under conditions which prevent recontamination, and any traces of ether peroxides which may have been originally present in quantities not detectible are left in the residue. The packaged ether should therefore contain no peroxides or oxygen which might cause development of peroxides, and should be completely stable upon storage. The only apparent explanation for the instability of this ether is the assumption of the existence of an intermediate

[1] Nitardy and Tapley, JOUR. A. PH. A., 17 (1928), 966–968.

oxidation product which is not detectible by the U. S. P. test, being not a true peroxide, and although being sufficiently volatile to distil off with the ether, is not volatile enough to be removed with the first distillate containing oxygen.

It has also been shown that pure metallic copper reacts more readily with atmospheric oxygen than does ether. If a strip of copper is cleaned chemically until by suitable test it is found free from cuprous oxide, and then exposed to air for only a few seconds, a film of cuprous oxide sufficient to be detectible by chemical test will be formed on its surface, demonstrating the speed with which metallic copper can be oxidized by atmospheric oxygen. We have further found that ether peroxides and apparently also the substance which has been termed the intermediate compound, are unstable in the presence of cuprous oxide and that the latter will remove these compounds from ether. If the ether originally contains a small amount of peroxides, their decomposition by cuprous oxide results in the formation of an organic acid, probably acetic acid, which increases the acidity of the ether. If the original ether, however, is entirely peroxide-free, the ether is preserved entirely free of impurities for an indefinite period of time when packaged in contact with copper.

It, therefore, appears that the mechanism by which copper preserves and protects peroxide-free anæsthetic ether consists of a reaction between any atmospheric oxygen which may be present in the sealed can, and the copper surface, forming a coating of cuprous oxide. The elimination of this oxidizing agent in this manner prevents the oxidation of the ether to peroxides and other oxidation impurities, so that ether stored in contact with copper remains entirely free from impurities as long as the can is sealed so that a further supply of atmospheric oxygen is not available.

CONCLUSIONS.

1. Ether peroxides are formed by oxidation of the ether by atmospheric oxygen, resulting first in an intermediate compound which is then further oxidized to the true ether peroxide, either by further reaction with atmospheric oxygen or by auto-oxidation.

2. This intermediate oxidation product, which has not been identified, appears to distil with ether, but does not appear to be a true peroxide as it does not respond to the U. S. P. test.

3. Contact of ether containing atmospheric oxygen or intermediate oxidation products with a copper surface in sealed containers results in the removal of these substances from the ether.

4. Ether, originally containing a small amount of ether peroxide, when stored in any sealed container, will eventually become free from peroxides and simultaneously traces of acids develop, probably acetic acid, due to decomposition of peroxides. If stored in a copper container this change is accelerated.

5. Ether, originally free from peroxides, when stored in contact with copper is not subject to oxidation and is maintained in its original state of purity for an indefinite period. Any oxygen that may be dissolved in the ether or present in the can disappears during storage, being removed by combination with the copper.

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