

PRODUCTION OF ORGANOMETALLIC COMPOUND BY THE EXPLOSION OF A COPPER WIRE IN XYLENE, WATER AND THEIR MIXTURE

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Products gained by the explosion of a thin Cu wire in different environments have been investigated. Infrared absorption spectra of the reaction products are given using chemically active liquids as well as air and argon. IR spectra show that complex organometallic compound were produced having a central Cu atom and ligands based on carboxylic acids.

ОБРАЗОВАНИЕ ОРГАНО-МЕТАЛЛИЧЕСКИХ СОЕДИНЕНИЙ ПРИ ПОМОЩИ ВЗРЫВА МЕДНОЙ ПРОВОЛОКИ В КСИЛОДЕ, ВОДЕ И ИХ СМЕСЯХ

В работе исследованы продукты реакций, полученные при помощи взрыва тонкой медной проволоки в различных средах. Приводятся инфракрасные спектры поглощения продуктов реакций для химически активных жидкостей, а также воздуха и аргона. Инфракрасные спектры показывают, что полученные органо-металлические комплексные соединения имеют центральный атом меди и лиганд, основанные на карбоновых кислотах.

I. INTRODUCTION

In order to obtain organometallic compounds it is necessary to get the metallic atom into the organic molecule. Necessary conditions for producing such compounds are created by the explosion of a thin wire in organic liquids.

Organometallic compounds containing the so-called transition metals have characteristic properties. Copper is one of the less investigated transition metals. Coordination compounds of Cu especially with H₂O appear to be of great importance for their oxidation catalytic effects [1].

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II. EXPERIMENTAL

The experimental apparatus is shown in Fig. 1. A high voltage supply (HVS) charged the condenser battery (CB) of 50 μF to a voltage of up to 6 kV. The high voltage circuit was switched by a three pole spark gap (SG) filled with argon. A Cu wire of a diameter 0.4 mm was used. The length of the wire was 6 cm. The closed chamber for the explosion of the wire has a volume of about 0.8 l.

Further details about the experimental apparatus and spectroscopical measurements of temperature and plasma concentration gained by the explosion of some wire have been presented in a previous paper [2].

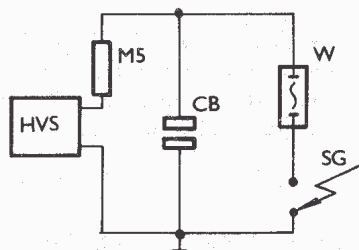


Fig. 1. Scheme of the electrical circuit (HVA — high voltage source, CB — condenser battery, SG — spark gap, W — wire chamber).

The samples were obtained by the explosion of a Cu wire in the following environments: argon (0.6 MPa), air, xylene, water and a mixture of xylene and water (the ratio of the components was 2:5).

In cases of gas environments the powders gained at the explosion of some wire were directly suitable for further analysis. In cases of liquid environments powders scattered in a liquid were obtained. Powders suitable for analysis were obtained by sedimentation and drying. All the powders were to a great extent hygroscopic and had a fine granicity. The size of the grains was less than 5 μm .

Samples were analysed by infrared absorption spectrometry using the KBr tableting technique. The Perkin Elmer absorption spectrometer was used operating with 5 gratings with a wave number range from 4000 cm^{-1} to 180 cm^{-1} .

III. RESULTS AND DISCUSSION

IR absorption spectra of the samples gained by explosion of a Cu wire in various surroundings are presented in Figs. 2—6. Refs. [3—6] served for the analysis of IR spectra.

The sample gained by the explosion of a Cu wire in argon at a pressure of 0.6 MPa (sample A — Fig. 2) consists of a mixture of copper oxides, first rate Cu_2O , in

a lesser degree CuO (IR absorption bonds at wave numbers 630, 530, 470 cm^{-1}) and coordination reaction products generated by reactions of impurities in Ar with Cu. The IR absorption bonds $\nu\text{OH} - 3450 \text{ cm}^{-1}$, $\nu\text{CH}_2 - 2930$ and 2860 cm^{-1} , $\nu\text{C}=\text{O} - 1740 \text{ cm}^{-1}$, $\nu_{\text{as}}\text{COO}^- - 1600 \text{ cm}^{-1}$, $\nu_{\text{s}}\text{COO}^- - 1460 \text{ cm}^{-1}$, $\nu\text{C}-\text{O} - 1050 \text{ cm}^{-1}$ show that the groups CH_2 , COOR or COOH are the primary types of ligands of the coordination compounds. The ratio of the coordination compounds to the oxides is small.

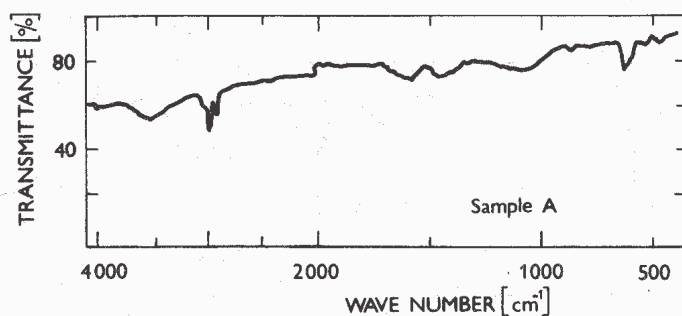


Fig. 2. IR absorption spectrum of a sample gained by the explosion of a wire in argon at a pressure of 0.6 MPa.

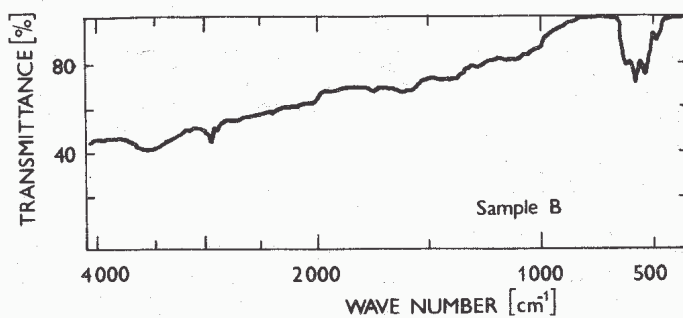


Fig. 3. IR absorption spectrum of a sample gained by the explosion of a wire in air at atmospheric pressure.

The sample gained by the explosion of a wire in air (sample B) consists of a mixture of Cu oxides, above all CuO, next Cu_2O (bonds 630, 585, 530, 470 cm^{-1}) and coordination compounds. The latter compounds were produced by the reaction of Cu with CO_2 , O_2 , H_2O (IR bonds $\nu\text{OH} - 3450 \text{ cm}^{-1}$, $\nu\text{CH}_2 - 2930$, 2860 cm^{-1} , $\nu\text{C}=\text{O} - 1740 \text{ cm}^{-1}$, $\nu_{\text{as}}\text{COO}^- - 1600 \text{ cm}^{-1}$, $\nu_{\text{s}}\text{COO}^- - 1460 \text{ cm}^{-1}$, $\nu\text{C}-\text{O} - 1050 \text{ cm}^{-1}$). Ligands are based on the CH_2 , COOR or COOH groups. The ratio of the coordination compounds to the Cu oxides is small, but greater than it is in case of the sample A.

IR absorption bonds of the sample gained by the explosion of a Cu wire in xylene (sample C): νCH — 2980 cm^{-1} , $\nu\text{C—C ring}$ — $1620, 1600\text{ cm}^{-1}$ and $\nu\text{C—C ring}$ — 1410 cm^{-1} , in-plane bending vibrations of CH — $1160, 1110, 1080, 1060\text{ cm}^{-1}$, out-of-plane bending vibrations of the ring — $910, 870, 830, 790, 760, 730, 700\text{ cm}^{-1}$, ν_{as} ring-metal-ring— 470 cm^{-1} show that the sample consists of mixtures of organometallic compounds with Cu atoms and ligands based on the benzene ring. There are various substitutions on the benzene ring, namely CH_2 , (νCH_2 — $2940\text{ cm}^{-1}, 2860\text{ cm}^{-1}, 1390\text{ cm}^{-1}$), OH (νOH — 3450 cm^{-1} , OH subst.

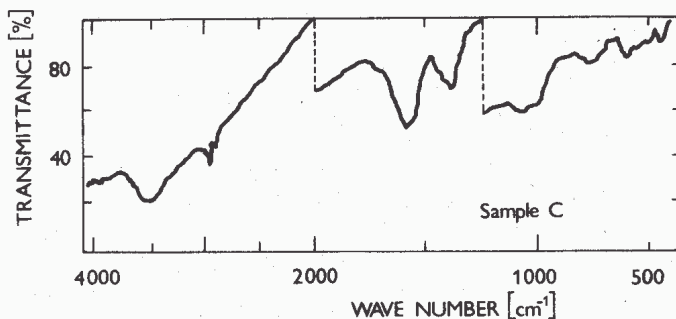


Fig. 4. IR absorption spectrum of a sample gained by the explosion of a wire in xylene.

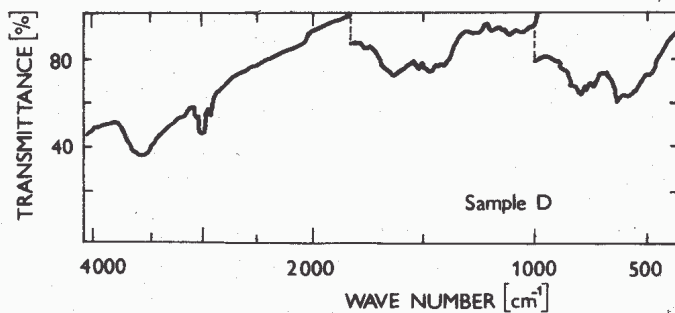


Fig. 5. IR absorption spectrum of a sample gained by a explosion of a wire in a mixture of xylene and water.

on ring— 630 cm^{-1}), COOH ($\nu_{as}\text{COO}^-$ — 1600 cm^{-1} , $\nu_s\text{COO}^-$ — 1410 cm^{-1} , — COOH subst. on ring 530 cm^{-1}), COOR (COOR subst. on ring— $610, 590\text{ cm}^{-1}$). In most such cases a connection of the benzene rings was realized partly via the Cu atoms or their substituents, partly via a condensation of the benzene rings (IR absorption bonds $\nu\text{C}=\text{C}$ conjugation — 1600 cm^{-1} , position of out-of-plane bending vibrations of the benzene ring — 910 — 700 cm^{-1}). On that account the compound has a polymer character.

Sample D, gained by the explosion of a Cu wire in a mixture of xylene and water (ratio of the components 2:5) consists of mixtures of organometallic compounds with central Cu atoms and ligands based on the benzene ring with various substitutions, namely OH, CH₂, CO, COOH, COOR (IR bonds analogous with the IR bonds of the sample C). The presence of water in the reaction mixture causes that the condensation of the benzene rings does not arise (a decrease of the $\nu\text{C}=\text{C}$ conjugation bond on the wave number 1600 cm^{-1} in relation to the sample C) and substitutions of a carboxylic acid type and metallic chelates of β diketons of carboxylic acids prevail on the benzene ring. The compound has a polymer character.

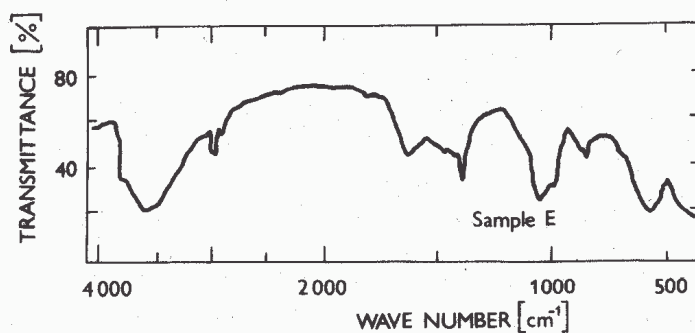


Fig. 6. IR absorption spectrum of a sample gained by the explosion of a wire in water.

Sample E, gained by the explosion of a Cu wire in water consists of the compounds of Cu with a directly coordinated OH group (νOH monomer — 3700 cm^{-1} , bridge deformation of OH — 1055 cm^{-1} , deformation of Cu—OH — $1055, 955\text{ cm}^{-1}$), for

example, $\text{Cu} \begin{array}{c} \text{H} \\ \diagup \quad \diagdown \\ \text{O} \\ \diagdown \quad \diagup \\ \text{O} \\ \diagup \quad \diagdown \\ \text{H} \end{array} \text{Cu}$, and coordination compounds of Cu and a ligand of the cyclic dimer of

carboxylic acid (IR bonds νOH — 3450 cm^{-1} , $\nu\text{C}=\text{O}$ — 790 cm^{-1} , $\nu_{\text{as}}\text{COO}^-$ — 1620 cm^{-1} , $\nu_{\text{s}}\text{COO}^-$ — 1465 cm^{-1} , out of plane bending vibration OH of the cyclic dimer of carboxylic acid — $870, 850\text{ cm}^{-1}$). The metal in the coordination compound is connected above all through oxygen or carbon (Cu—O — $570, 420\text{ cm}^{-1}$, Cu—C — 570 cm^{-1}). Compounds with OH and COOH ligands may be of various types.

IV. CONCLUSION

The analysis carried out by IR absorption spectrometry has confirmed that organometallic compounds were produced by the explosion of a Cu wire in xylene,

water and their mixture as the main products. Coordination organic compounds were produced by the explosion of a wire both in air and in argon, but their ratio to the copper oxide was low.

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