Chapter 21
Effect of Water on Activity and Protective Properties of Catalysts Used in Respiratory Protective Equipment

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ABSTRACT

This chapter presents the results of the study on the water effect on the activity and protective properties of supported metal-complexes catalysts (SMCC) and manganese oxides intended for equipping personal respiratory protection equipment (PRPE) against toxic carbon monoxide and ozone. The problem is that many catalysts reduce or completely lose activity in conditions of high air humidity and do not ensure stable air purification from gaseous toxic substances to maximum permissible concentrations for the working area. The factors determining the effect of water are the water vapor adsorption, adsorbed water molecules protolysis, and dehydration of the carrier surface. The quantitative model is evaluated by the generalized thermodynamic parameter GTP, with which aid it is possible to predict the mechanism of formation and the catalytic-active complexes composition. The natural tripoli and acidic-modified clinoptilolite-based catalysts demonstrate steady CO protecting properties under the air-gas flow high humidity and are used for equipment PRPE.

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INTRODUCTION

The greatest danger to the environment, including humans, is represented by toxic gaseous compounds of the following two groups: i) HF, SiF_4, SO_2, H_2S, P_2O_5, P_4, NO_x; ii) CO, PH_3, O_3. These compounds differ significantly in their physicochemical properties, which leads to the use of chemisorption (i) and catalytic (ii) methods of their neutralization. In real production conditions compounds of the first and second groups can be present in the exhaust gases in different proportions as well as aerodispersed particles, the content of which often exceeds the maximum permissible concentration in the air of the working area. In this regard, there is a need for workers to use complex respiratory protection means, in which air purification is carried out according to a multistage scheme.

This paper presents the results of the study on the water effect on the activity and protective properties of supported metal-complexes catalysts (SMCC) and manganese oxides intended for equipping personal respiratory protection equipment (PRPE) against toxic carbon monoxide and ozone. The problem is that many catalysts reduce or completely lose activity in conditions of high air humidity and, therefore, the main requirement for functional materials is not met – to ensure stable air purification from gaseous toxic substances to their maximum permissible concentrations for the working area. The factors determining the effect of water are the water vapor adsorption, adsorbed water molecules protolysis, and dehydration of the carrier surface.

The aim of the work is to study the mechanism of the effect of water on the activity and protective properties of deposited metal complex catalysts and transition metal oxides intended for personal respiratory protective equipment from toxic carbon monoxide and ozone; to substantiate quantitatively the effect of the nature of the carrier on the thermodynamic activity of adsorbed water, the activity of hydrogen ions and the mechanisms of formation of surface metal complexes and functional groups on oxide surfaces.

BACKGROUND

In many cases, due to the unfavorable sanitary and chemical situation at various enterprises, there is a need for workers to use complex respiratory protection means, in which air purification is carried out according to a multistage scheme: capturing aerodispersed particles; chemisorption of compounds of the first group of acidic nature; catalytic oxidation of CO, PH_3 (possibly SO_2) and decomposition of O_3 (Rakitskaya et al., 2005; 2020b; 2019a; Rakitskaya & Ennan, 2012). At the same time, the greatest difficulties arise in the development of low-temperature oxidation catalysts of carbon monoxide, phosphine, and ozone decomposition. A catalyst for low-temperature oxidation of phosphine micro concentrations based on palladium(II) and copper(II) salts deposited on activated carbon fiber materials (ACF) is used in the "Snezhok GP-E" respirator (Rakitskaya & Ennan, 2012). A catalyst containing copper chloride on ACF is used in the "Snezhok GP Ozone" respirator to protect the respiratory organs of workers in the welding industry from ozone (Rakitskaya et al., 2020b).

One of the special requirements for catalysts intended for respiratory personal protective equipment (RPPE) is to ensure stable air purification from gaseous toxic substances below the maximum permissible concentration (MPC) at high air humidity and ambient temperature (Rakitskaya & Ennan, 2012; Rakitskaya et al., 2020a). For this reason, despite a large number of patents and scientific publications on catalysts for low-temperature oxidation of carbon monoxide (KNO-CO) (Rakitskaya et al., 2005;