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Nanostructed Organic-inorganic Composite for Application in Fuel Cells and Solar Collectors

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The paper describes the synthesis of nanostructed organic-inorganic composites using sol-gel technique. The presence of sulfocontaining monomer (3-sulfopropyl acrylate potassium salt) in obtained comonomer provides its proton conductive properties. Proton conductivity depending on temperature was determined by means of impedance spectrometry. Nanostructed organic-inorganic composites have been applied for obtaining thermoabsorbing coatings for solar collectors.

Keywords: Nanostructed organic-inorganic composite, Sol-gel process, Photoinitiated polymerization, Impedance spectrometry, Solar collector, Thermoabsorbing coating

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1. INTRODUCTION

Nanostructed organic-inorganic composites have attracted great attention for their unique properties due to combining inorganic and organic constituents. In particular, they may be used as membranes in fuel cells and as thermoabsorbing coatings in solar collectors [1-6].

Solid polymer electrolytes must have high thermal, mechanical, chemical stability as well as water absorption characteristics to get high proton conductivity. One of the limitation of the current proton conductive membranes in fuel cells operating at high temperatures is that the presence of CO in hydrogen feed gas leads to poisoning of Pt catalyst. It demands increasing an operating temperature, that in turn decreases proton conductivity of membrane. Solution of this problem seems to be modification of the properties of commonly used membranes Nafion or creation of new membranes with high water retention.

Sol-gel technique is suitable for incorporation of hydrophilic oxides into nanostructed organic-inorganic material. It allows also to fabricate thin films.

Organic-inorganic materials can be applicated for obtaining thermoabsorbing coatings in solar collectors. Sol-gel process shows the effectiveness for formation nanostructure of composite materials, used for these purpose.

2. EXPERIMENTAL

Synthesis of nanocomposite organic-inorganic thin films was conducted via radical photoinitiated polymerization of acrylamide, acrylonitrile and 3-sulphopropylacrylate potassium salt. The reaction was carried out using UV irradiation. The intensity of irradiation was 14 W/m^2. Photoinitiator used was 2,2-dimethoxy-1,2-diphenylethane-1-on (IRGACURE 651). Content of comonomer containing sulphogroups (3-sulphopropylacrylate potassium salt) was varied in the range 5-20 % w. of the total comonomer mixture. Cross-linker *N,N'*- methylenebisacrylamide was used to form cross-linked structure of copolymer. The obtained films were washed from unreacted products of reaction in sufficient amount of distilled water.

Hybrid organic-inorganic composites were obtained using sol-gel method of synthesis. Sol-gel system (tetraethoxysilane-ethanol-water in appropriate proportions) was added to the mixture of comonomers. The content of sol-gel system in compositions was 5-20 % w. The process of photoinitiated copolymerization was carried out similarly.

Proton conductivity of synthesized films were measured by impedance spectrometry using impedance spectrometer "AUTOLAB" (Ecochem, Holland) with FRA program. The investigated samples were gripped between two Pt electrodes by a diameter of 1 cm. The thickness of the samples was 1 mm.

Impedance hodographs in the range of frequencies 10-10^5 Hz (Fig. 1, 2) were analysed. Specific proton conductivity was found to be ~ 10^{-4} Sm/cm. Addition of sol-gel system into copolymer does not change proton conductivity significantly. Increasing of temperature causes the enhancement in proton conductivity.

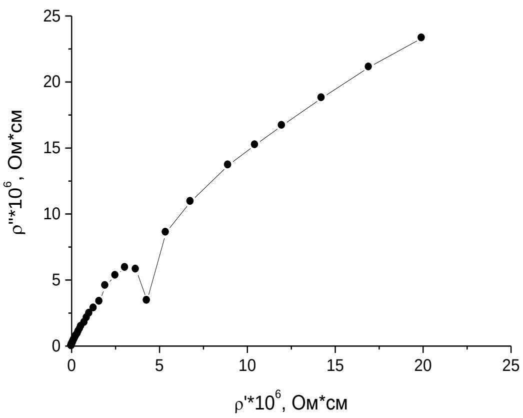

Fig. 1 – Niquist diagram for copolymer film at 23 °C

Activation energy of the process of proton conduction was determined to be 0,19 eV.

Some types of spectral-selective composite coatings for solar collectors were synthesized using sol-

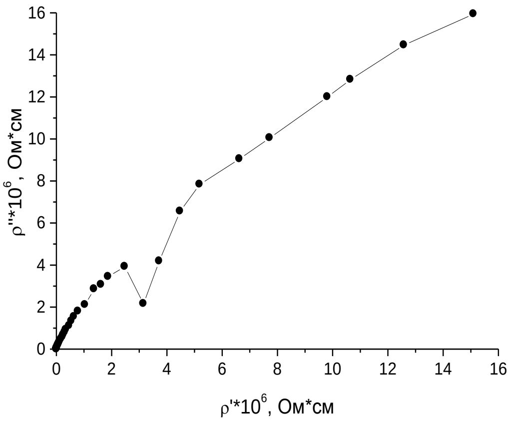

Fig. 2 – Niquist diagram for organic-inorganic film at 23 °C

gel method. The coatings contain carbon nanoparticles dispersed in dielectric SiO_2 or NiO matrices. The compositions were applied on Al and Cu plates (40 × 40 mm) by spin-coating or by dipping of the plates with following drying at different temperatures. For evaluation of the effectiveness of the synthesized materials maximal temperature of heating of the plates with investigated coatings applied on them were determined at irradiation by natural solar irradiation as well as at irradiation by the imitator of solar spectrum.

Fig. 3 – Optic and thermometric parts of measuring apparatus

Comparative investigations of the synthesized coatings with the sample from SunSelect (Germany) were conducted. Above mentioned coating is widely used for production of solar collectors. However, it is prepared by expensive technology – vacuum evaporation.

Experimental results of measurements of investigated samples temperature at irradiating them with intensity of 1000 W/m^2 are presented in Table 1.

Table 1 – Results of comparative measurements of absorbing ability of investigated coatings

Investigated sample	No 1 (S1)	No 2 (S1)	No 3 (S2)	No 4	No 5	No 6
T, °C	54,2	56,3	46,8	51,6	47,7	63,4
Investigated sample	No 7	No 8	No 9	No 10	No 11	
T, °C	48,4	42,2	67,5	55,8	47,3	

As one can see, equilibrium temperature of the sample No 6 practically coincides with the result for the sample No 9 (SunSelect). The obtained results indicated that synthesized coatings are of the same effectiveness of solar energy absorption as the known analogue and can be used as selective coatings for solar collectors. The composition and the method of preparing of the sample No 6 may be regarded as prospective for further improvement.

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