

INVESTIGATION OF THE EFFECTS OF POLYMER-FERROCENE COMPOSITES

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The article describes the effects observed in polymer-ferrocene composites. It is shown that in photo composites based on polymer (HDPE, PVDF) and di- π -cyclopentadienyl iron (π -C₅H₅)₂Fe, ferrocene), the effect of photo quenching of electrical conductivity under the action of light is observed. The photoelectret effect in PVDF-ferrocene composites is investigated.

Keywords: ferrocene, high density polyethylene, polyvinylideneflorid, electrical photo quenching, photoelectret

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1. INTRODUCTION

A negative internal photoelectric effect was observed in the polymer-ferrocene composite. The essence of the negative internal photoelectric effect is a decrease in the electrical conductivity of a photosensitive material or a composite with a photosensitive component under the influence of electromagnetic or corpuscular rays. This effect is less noticeable than the usual internal photoelectric effect, which is an increase in the electrical conductivity of a substance under the influence of light [1-4]. The development of new light-sensitive polymer composites and the synthesis of their individual components (for example, metal compounds, various transition metal complexes) is a very important task. That is, the ability of these components to form composites with polymers with different properties has led to the emergence of new active materials with optical and electrical properties. Of particular importance is the proposed polymer-ferrocene composite (a metal compound of the di- π -cyclopentadienyl (π -C₅H₅)₂Fe type) with negative photoelectric properties. Also, in composites based on PVDF (polyvinylidene fluoride) and ferrocene, the photoelectric properties of the sample are determined by measuring the difference in electret potentials after polarization and determining the relaxation time of the electret load.

2. METHOD OF EXPERIMENT

The resulting composites were obtained as follows: powders of polymer and ferrocene (diameter \leq 50 μ m) were mechanically mixed, an approximately homogeneous system was obtained (mixing was carried out at room temperature); the volume of components in the mixture varies depending on the issue being addressed; samples from a homogeneous mixture (413-483) K in the temperature range, at a pressure of 15 MPa with a size of 20 x 10 x 0.07 mm were obtained by hot pressing. The magnitude of the photocurrent, photoresist and photovoltaic loads were measured with

an electrometric voltmeter (V7-30, U5-11). The light intensity varied in the range (200-400) mW / cm². The value applied to the component was taken equal to 100 V. An electrode system of two designs was used: 1) the distance between the electrodes of the concentric circle was 5 mm; 2) placed between two glasses with translucent metal electrodes on a composite sample.

Ferrocene and its oxygen derivatives can be used as additives to ensure the thermal stability of the polymer. The ionization potential of the ferrocene molecule is 6.72 eV. Analysis of the results obtained by various researchers shows that the ionization potential determined for ferrocene varies by up to 0.5 eV. It is also used as an inhibitor for the purposeful regulation of the oxidation of the polymer phase of thermic and photo-decomposition reactions of polymer matrix composites [5, 6]. Effective light-sensitive composite materials based on ferrocene have been obtained. If we take into account that ferrocene and its compounds are sensitive to the effects of light in the field of vision, then under certain conditions, the rotating photo may be subject to fragmentation.

In high-density polyethylene-ferrocene composites, the surface of which is exposed to light intensity of 400 mW / cm², the resistance of the composite increases 10 to 108 times when the volume fraction of ferrocene varies from 10% to 50%. That is, the permeability of the photo material decreases by the same amount (Figure 1.1, curve 2). Similar studies were performed for PVDF-ferrocene composites (Figure 1.1, curve 1). Given the stability of the applied voltage (U = 100V) and the intensity of the incident light (400 mW / cm²), the ratio of R_f / R₀ in PVDF matrix composites increased 6-67 times, while the volume fraction of the ferrocene phase in the composite varied from 10% to 50%. The results show very accurately that the effect of light extinction is more pronounced in non-polar matrix composites. It should be noted that the effect of photoconductivity extinction also depends on the intensity of the incident light. This effect is of great practical importance. For this purpose, the dependence of HDPE (80% volume fraction) - ferrocene (20% volume fraction) composites on the

intensity of incident light was studied. This dependence is shown in Figure 1.2. Here

$$tg \alpha = \frac{\Delta R_f}{\Delta E} = 18,85 \times 10^5 \frac{Om \cdot m^2}{W}$$

is the ratio of the change in the intensity of the incident light to the resistance of the composite under the influence of factor light. Figure 1.2 shows that the specific volume of the composite we are studying depends significantly on the intensity of the light falling on the resistor, and the value of the resistance increases nonlinearly with the intensity of the light.

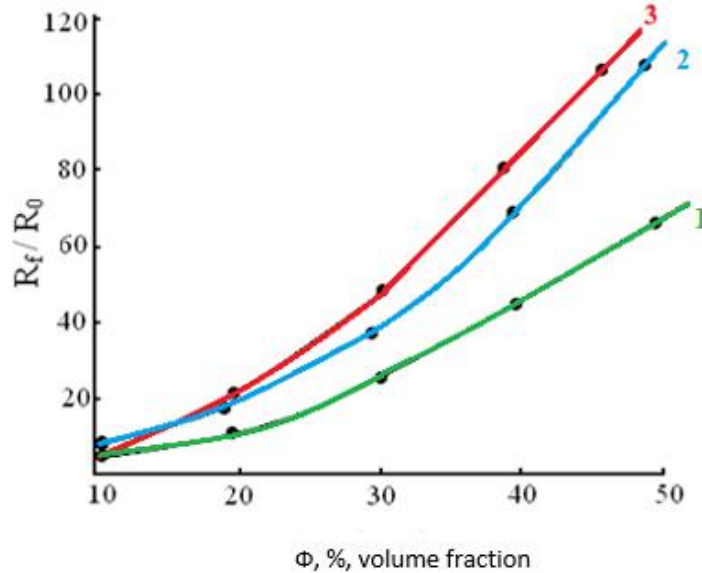


Fig. 1.1. Dependence of the ratio R_f / R_0 on the volume fraction of the composite ferrocene Φ , % phase 1. PVDF – ferrocene; 2. HDPE - ferrocene; 3. PVDF - ferrocene - 20% volume share CdS; $U = 100V$; $E_i = 400 \text{ mWt} / \text{cm}^2$.

To determine the role of ferrocene in the composite in the photoresist, the dependence of the photocurrent on the wavelength of incident light in different volumes of ferrocene is given. Studies show that the minimum value of the photocurrent, regardless of the volume fraction of ferrocene, corresponds to a value of 600 nm of light wavelength (Figure 1.3).

In polyolefins and halogen-containing polymers dispersed with ferrocene $(C_5H_5)_2Fe$, the photo quenching effect of light conductivity was observed.

Note that, this effect (photo-splitting) depends on the chemical and physical structures of the polymer phase we use in composites.

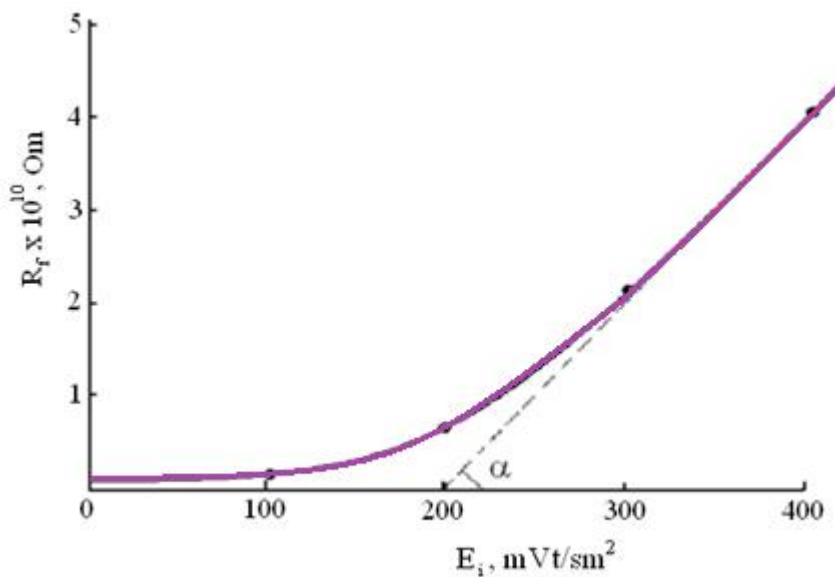


Fig. 1.2. The dependence of the photoresistance of HDPE-ferrocene composite on the intensity of incident light in the visible region of light. $U = 100V$, the volume share of ferrocene is 20%, the volume share of HDPE is 80%.

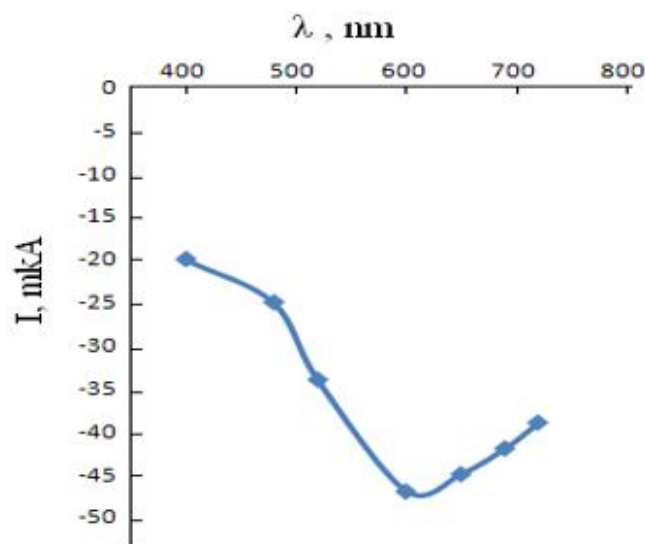


Fig. 1.3. Typical dependence of photocurrent on the wavelength of incident light for ferrocene-HDPE composites. Ferrosen - 40% volume fraction, $U = 100V$; $E_i = 400mVt / cm^2$.

If we analyze the nature of the applications of ferrocene, we can conclude that under the influence of light, many properties of ferrocene phase composites (thermal, mechanical, electromechanical), as well as the photoelectret effect, which is the main goal of our work, can be purposefully varied [7-9].

The electret properties of the investigated composite sample are determined by measuring the difference in electret potentials after polarization and determining the relaxation time of the electret load. It is assumed that the relaxation time of a photovoltaic cell based on a polymer-ferrocene composite is such that the difference between the electret load or the electret potential decreases to e [7].

3. CONCLUSION

Thus, in composites based on di- π -cyclopentadienyl iron ($(\pi - C_5H_5)_2 Fe$, ferrocene), the effect of photo quenching of electrical conductivity under the action of light was observed. The main reason for the formation of the effect of photo quenching of rotational conductivity in polyolefin-ferrocene composites is the formation of a local electric field in the direction opposite to the external field, as a result of the formation of multiply charged centers and a dipole moment in the ferrocene phase under the action of light. The photoelectret effect in PVDF-ferrocene composites is investigated.

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