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Properties and structure formation of cadmium sulfide nanocomposites with polypropylene

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The photoluminescent properties of CdS nanoparticles based on polypropylene (PP) in wavelength interval λ= 300-750 nm have been studied. The atomic-force microscope (AFM) scanning revealed that various dose γ-radiation treatment of polymeric powder in the air influences the nanoparticles concentration in polymer matrix and increase the intensity of photoluminescence peak of nanocomposite. It is owing to formation of oxidative centers in polymers, which play the role of nucleation centers for CdS.

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1. Introduction

The research of photoluminescent polymeric nanocomposites (PNC) is a question of great scientific and practical importance for understanding of energy transfer mechanism, transport carriers in multiphase polymeric systems. Luminescent screens, transducers, sensors and other facilities with improved physical-chemical characteristics and broadened intervals of phosphorescence in visible region of spectra are created on PNC basis. Development and preparation of new photoactive nanocomposites is closely connected with understanding of interrelation "structure-technology-properties-application" of these materials. The creation of polymeric nanocomposites, composed of two or more phases, challenge the studies of physical and chemical processes of modification structures and properties of new active elements [1-4]. Polymer matrix provides the high physical-mechanical properties of PNC (flexibility, machinability) and active fillers – the high sensitivity and sufficient photoluminescent properties. It should be noted that by variation of components properties it is possible to change the properties of nanocomposites, to study the interface effects, to research intermolecular transfer processes and migration of electron excitation in polymeric medium, the influence of interface interactions on photoluminescent properties of filler [5-7]. The research of polymeric nanocomposites structures with inorganic semi-conductors (sulfides, transition metals oxides) is of interest in terms of inherent to them new electrochemical and photochemical characteristics [8-10]. Structure and properties of these composites associate to each other. The data of structure (size and character of distribution of the particles of dispersed phase in the matrix of polymer) allows forecasting the properties of this system and vice versa the investigation of the properties allows forecasting the structure of nanocomposites.

2. The experimental method

In this work have been studied photoluminescent properties of nanocomposites on the basis of polypropylene (PP) and filler CdS treated in wavelength interval λ= 300-1000 nm. The polymeric powder (size of particles 0.5-1.0 μm) of PP was used as matrix. The various doses of polymeric powder (size of particles 0.5-1.0 μm) was treated by γ-radiation with aim to increase the reactivity and create the trapping site towards the transition metal ions Cd^{2+}. The structure of PP after γ-radiation was investigated by AFM. The nanocomposite - polymer + CdS was prepared by treatment of samples of powder of PP in 0,1 M solution of $CdCl_2$. The definite proportion of treated polymeric powders of PP first was mixing by magnetic mixer with 0,1 M solution of $CdCl_2$ during 30 minutes. Then filtered powder, containing Cd^{2+} ions was cleansed by water in order to remove the weakly bounded Cd^{2+} ions, and then was treated by 0,1 M solution of Na_2S. After that, the powder was getting dry in 24 hours. Further from that were prepared the samples of nanocomposites PP + CdS by hot-pressing method at the melting point of PP. Photoluminescent spectra was studied on spectrofluorimeter Cary Eclipse in wavelength interval 200-1000 nm.

3. Results of experiments and discussion

The spectra, presented in Pic.1 are IR spectra of PP and nanocomposite PP + CdS samples, treated by γ-radiation in the air (up to 10 Mrad). It is clear from Fig.1 that there is strong change in IR spectra especially in wavelength region 2846 cm^{-1}, 1456-1186 cm^{-1}.

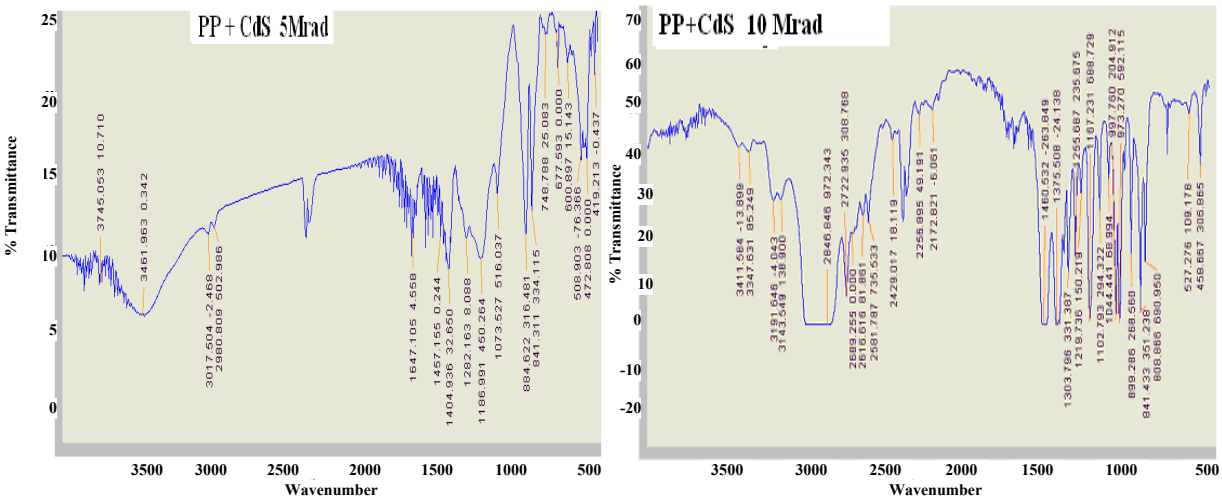

Fig. 1. IR spectra of PP and nanocomposite samples, treated by γ-radiation (5-10 Mrad).

Depending on radiation dose, was observed the increasing of absorption band strength in wavelength region 2950 cm^{-1} and 2839 cm^{-1}, to result from the activation of CH valence vibrations in spectra of polypropylene. It is also shown in IR spectra of nanocomposite PP + CdS samples, treated by γ-radiation, the activation of absorption band strength of CH valence, deformation vibrations and vibrations mutual influence of CH and CH_2 groups were observed.

There was scanned by the atomic-force microscope (AFM) the relief of nanocomposites PP + CdS samples, obtained from PP powder, treated by γ-radiation (10 Mrad) (Fig. 2). AFM investigation the relief of nanocomposites PP + CdS samples testify the increasing of numbers of CdS nanoparticles on surface. It is seen (Pic.2) that treated samples relief becomes rough. It is known that treatment of polyolefines by γ-radiation in the air leads to density increasing and stability of electrets charges, resulting from linking redox reactions. These reactions lead to formation different oxygen containing and trans-vinyl groups and deep trapping sites (up to 1.2 electron volt), dielectrical cavities and free quasi-stable radicals [11].

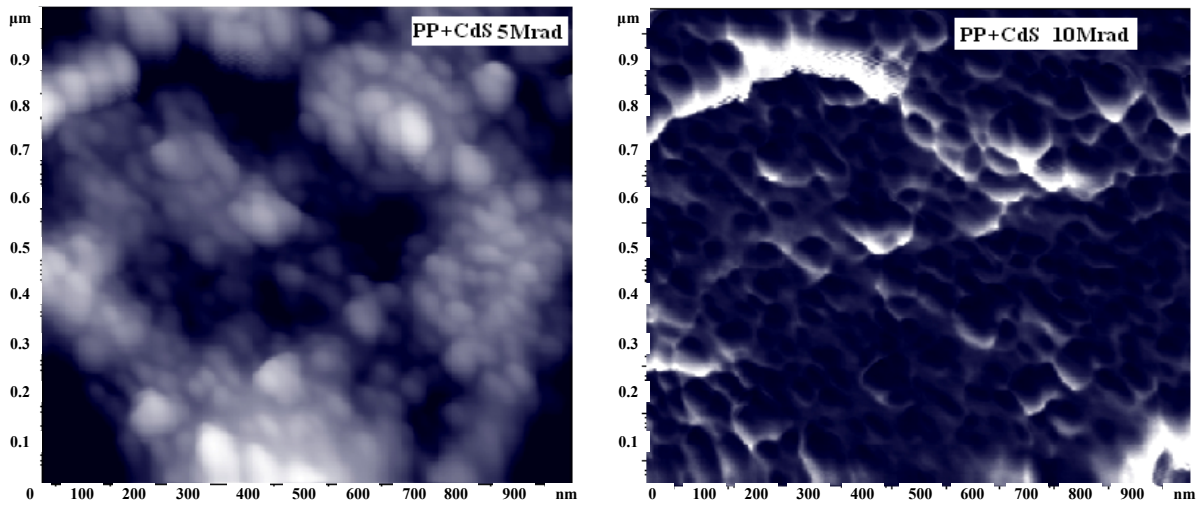

Fig. 2. 2D images of PP + CdS nanocomposites samples treated by γ-radiation (5 Mrad and 10 Mrad).

The ability of polymeric matrix to form complex increase with γ-radiation treatment, i.e. the majority of dispersed component forms around the oxidation centers in polymer. The AFM-scanning of PP + CdS samples shows the sizes of CdS nanoparticles do not change with change of radiation dose, and the concentration of CdS nanoparticles in polymeric matrix increases. The further increasing of radiation dose leads to polymer structure decomposition. The concentration change of CdS in PP with γ-radiation treatment seemingly is correlated with

forming of oxidizing centers in polymer, which are the nuclease center for CdS. It was set that CdS nanoparticles size is 25-35 nm and does not depend on γ-radiation dose.

The photoluminiscent spectra of PP + CdS nanocomposite treated and untreated by various dose of γ-radiation are presented in Fig. 3. There are observed two maximum peaks at wavelength interval 534-560 nm and maximum band width changes by changing of γ-radiation dose at the extremum of 10 Mrad.

The intensity of photoluminescence of above mentioned peaks increases at 10 Mrad γ-radiation dose and then began decline. Most likely, it is connected with decomposition processes of nanocomposite in the polymeric matrix.

The photoluminiscent spectra and AFM-scanning shows the dimensions of nanoparticles do not depend on dose of γ-radiation treatment, and the concentration of CdS nanoparticles in polymeric matrix increase with γ-radiation treatment.

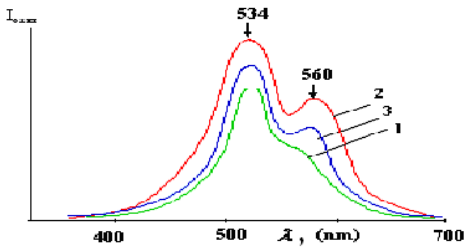

Fig. 3. Photoluminescence spectra of PP+CdS and nanocomposite samples, treated by various doses of γ-radiation 1) 5 Mrad 2) 10 Mrad 3) 15 Mrad.

The further increasing of γ-radiation probably destroys the chemical structure of polymer. The concentration change of CdS in PP with changing γ-radiation dose is correlated with experimental results, getting from photoluminescent spectra and evidently is connected with forming of oxidizing centers in polymer, which are the nuclease center for CdS formation.

4. Conclusions

The mechanism of formation of nanoparticles and structure of nanocomposite with CdS in oxidized polymeric matrix by various doses γ-radiation treatment in the air has considerable distinctions, caused by distinctions in thermodynamical characteristics of dispersed phase and whole composition, such as heat of formation of inorganic nanoparticles and surface free energy of polymer-particle interface.

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