Photoinduced phenomena in fullerene-doped conjugated organic systems

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The finding of the fullerene sensitization stimulates the quest of organic media, which optical properties could be modified by dopant. A fullerene introduction in these materials is widely used due to high electron affinity of fullerenes (2.6-2.7 eV) that allows the intramolecular donor-acceptor interaction to be reinforced.

In the present paper the fullerene-doping effect on spectral and nonlinear optical properties of π-conjugated organic systems based on polyimide (PI), 2-cyclooctylamino-5-nitropyridine (COANP), etc. has been studied. 2–4 μm thick films have been doped with C_{60} and/or C_{70}. The fullerene concentration has been varied from 0.15 wt.% to 5 wt.%. The spectra and formules of the materials are shown in Figs. 1 and 2. The holographic recording and optical limiting experiments have been performed at wavelength of 532, 805, and 1315 nm. The reversible holographic recording experiments have been carried out under the Raman-Nath diffraction conditions at spatial frequency of 100 mm^{-1}.

It has been established, when fullerenes have been introduced in the organic matrix, the diffraction efficiency increases drastically. The sensitization results in a larger increase in the optical absorption for the fullerene-doped structures, in a conformation transformation of organic chain and in a laser-induced photorefractive effect in them. The drastic change of refractive index Δn_i of about 10^{-3} has been observed. It should be noticed that the value of laser-induced change of refractive index due to the high-frequency Kerr effect is more than the one corresponded to thermal grating of about 10^{-5}. The nonlinear coefficients n_2 and $\chi^{(3)}$ have been estimated from holographic recording data. The results are shown in the Table 1.

It has been shown that the fullerene-doped structures can be used for thin reversible hologram recording at the laser energy density up to 0.9 J cm^{-2}. Moreover, the large value of the laser-induced refractive index influences the optical limiting properties of the fullerene-doped structures due to energy losses by diffraction.

From Z-scan experiment, the relation of absorption cross section for the excited and unexcited state of molecules has been estimated to reveal these structures as reverse saturable absorption materials. Moreover, the complex formation between the donor of the matrix conjugated molecule and fullerene as strong acceptor has been shown from photoconductive and mass-spectrometry experiments.

The nonlinear transmission has been observed with attenuation of laser beam by factor of 7-10. Some optical limiting mechanisms have been discussed. The fullerene-doped systems could be applied as laser power attenuators at the laser energy density of more than 1.5-2 J cm^{-2} and at the laser energy density up to 0.8-1 J cm^{-2} in the visible and near infrared spectral ranges, respectively.

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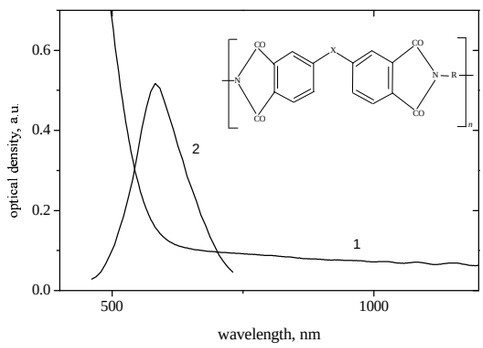

Fig. 1. Absorption spectrum of the 0.2 wt.% C_{70}-PI film (1) and fluorescence spectrum of a PI matrix (2). In the inset: a formula of PI is presented.

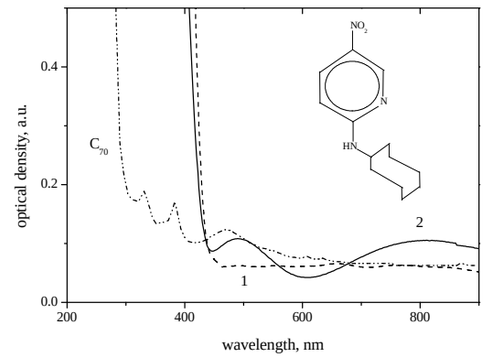

Fig. 2 Absorption spectra of thin films: 1 – pure COANP, 2 – 5 wt.% C_{70}-COANP. In the inset: a formula of COANP is shown.

Table 1. Nonlinear optical coefficients of materials.

Materials	n_2, cm^2 W^{-1}	$\chi^{(3)}$,cm^3 erg^{-1}	Ref.
CS_2	3×10^{-14}	10^{-12}	[1]
Quartz	3×10^{-16}	10^{-14}	[1]
C_{60} film		0.7×10^{-11}	[2]
C_{60} film		8.7×10^{-11}	[3]
C_{60} film		2×10^{-10}	[4]
C_{70} film		2.6×10^{-11}	[3]
C_{70} film		1.2×10^{-11}	[5]
PI + C_{70}	0.78×10^{-10}	2.64×10^{-9}	[6]
COANP+C_{70}	$0{,}77\times10^{-10}$	$2{,}4\times10^{-9}$	[7]
COANP+C_{60}	0.69×10^{-10}	2.14×10^{-9}	now
Si	10^{-10}	10^{-8}	[1]

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