Nonlinear optical properties of metal alkanoates composites with binary noble metal nanoparticles

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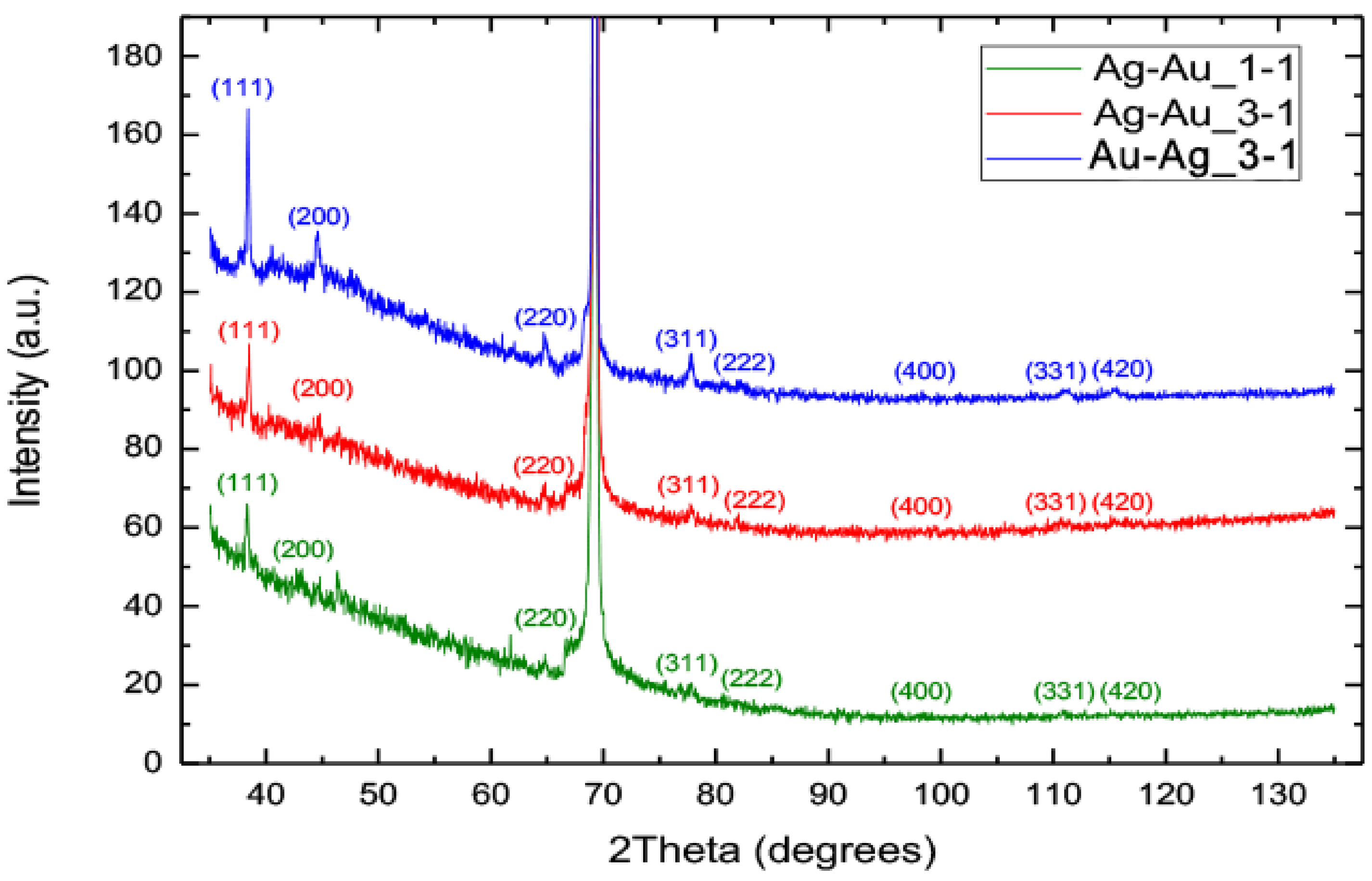
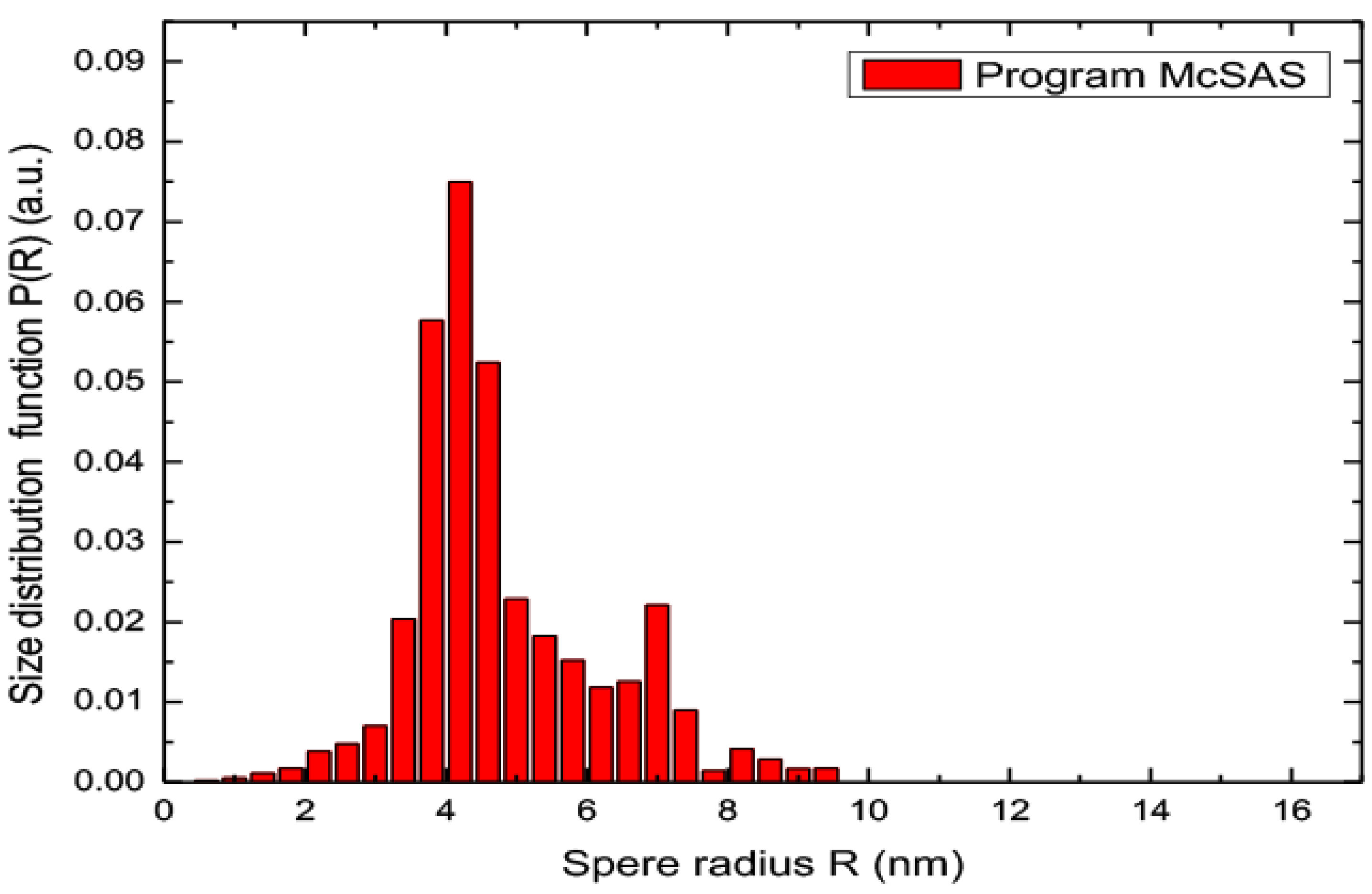
Abstract:

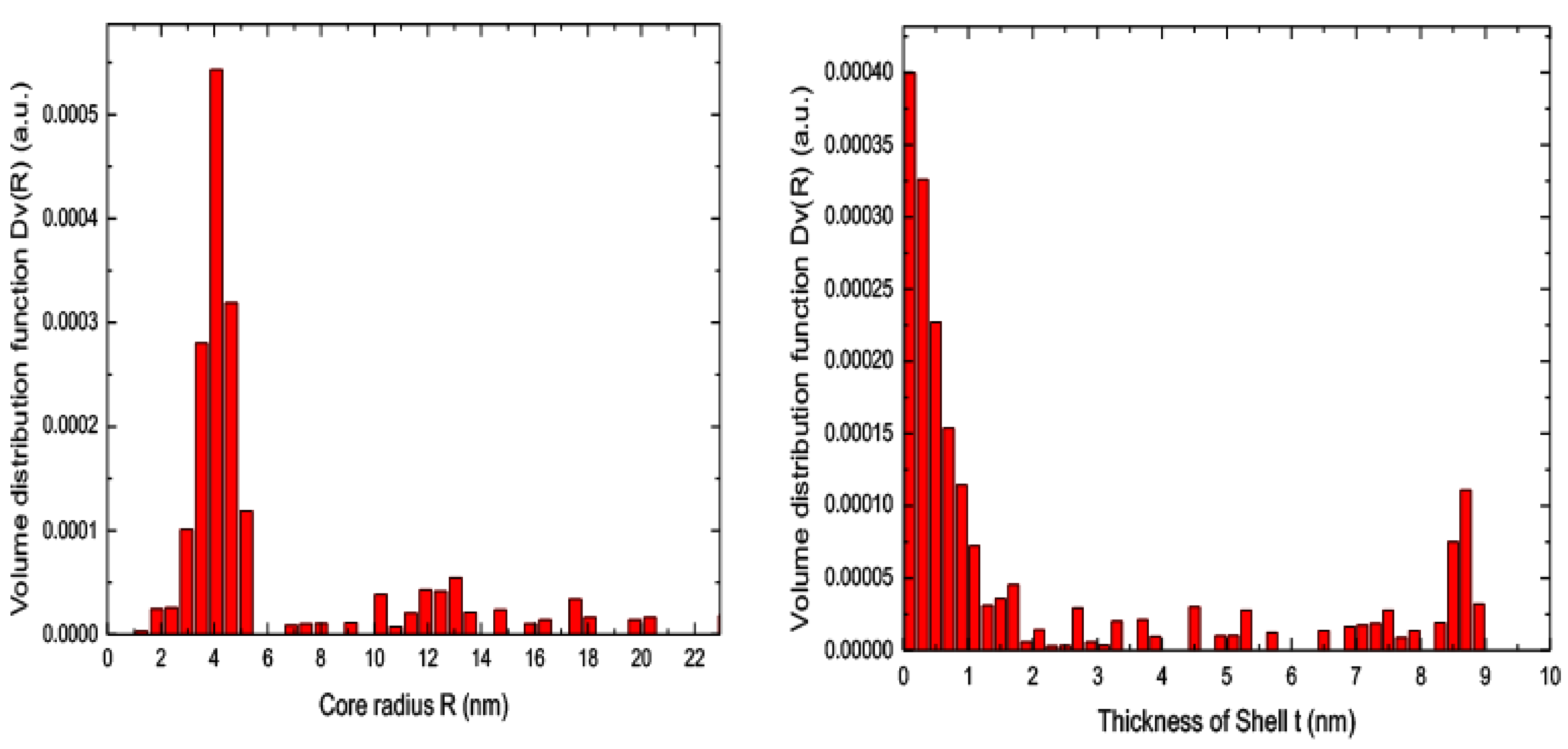
The glass-forming liquid crystals of metal alkanoates with modified binary noble metal Ag/Au, Au/Ag nanoparticles are form new, promising class of the nonlinear optical materials. In this paper the features of nonlinear optical properties of mesomorphic cadmium alkanoates composites with binary noble metal Ag/Au, Au/Ag nanoparticles were studied using Z-scan technique on a Nd:YAG laser with a wavelength 532 nm. These composites with complex binary nanoparticles such as bimetallic alloys or core-shell of the noble metals - (Ag/Au, Au/Ag) demonstrate of considerable scientific interest due to their modified optical and nonlinear optical properties in comparison with similar properties of monometallic nanoparticles. Bimetallic nanoparticles actively absorb light in the visible region of the spectrum due to surface plasma resonance. But unlike monometallic nanoparticles, bimetallic nanoparticles are capable of finely changing the position of the surface plasma resonance maximum in the optical range of 425-580 nm. The metal alkanoate composites with modified binary noble metal nanoparticles exhibit strongly pronounced dependence of the nonlinear absorption coefficient and nonlinear refractive index from the intensity of the laser beam (532 nm).



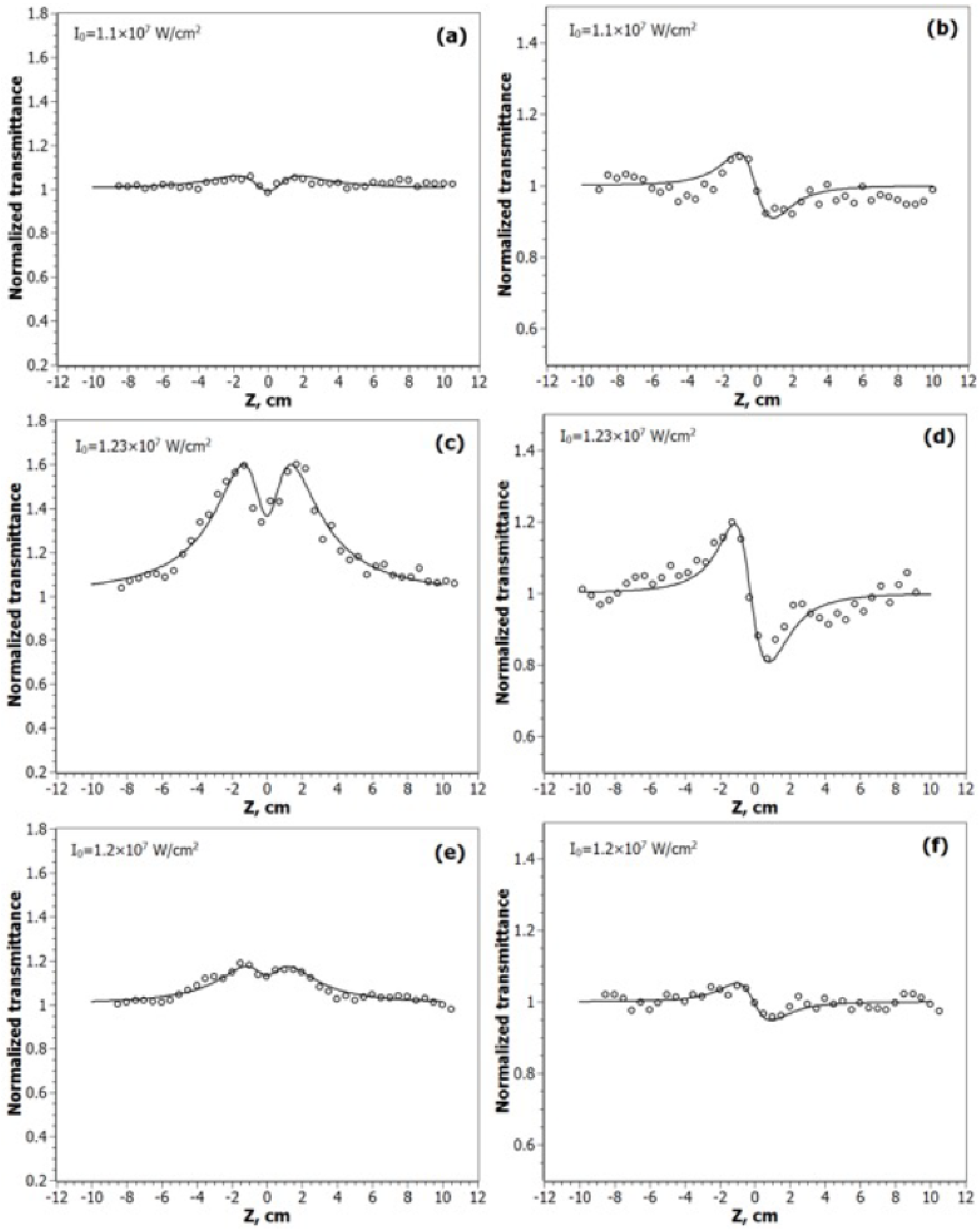
X-ray diffraction patterns of three CdC_8 + Ag/Ag, Au/Ag nanocomposites with different Au and Ag molar ratios.



The size distribution function P(R) of nanoparticles Ag/Au (1:1) calculated by Monte Carlo method



The size distribution function of Ag/Au (3:1) nanoparticle core (a) and the shell thickness distribution (b) calculated by the Monte-Carlo method in the core-shell model



Z-scan profiles of the normalized transmittance measured for CdC_8 + Ag/Au NPs in the open-aperture scheme: CdC_8 + Ag/Au (1:1) – (a), CdC_8 + Ag/Au (3:1) – (c), CdC_8 + Au/Ag (3:1) – (e); and the closed-aperture scheme: CdC_8 + Ag/Au (1:1) – (b), CdC_8 + Ag/Au (3:1) – (d), CdC_8 + Au/Ag (3:1) – (f). Solid lines are theoretical fits of the experimental data.

Sample	I_0, MW/cm²	I_s, MW/cm²	n_2, cm²/W	Re$\chi^{(3)}$, esu	β, cm/W	Im$\chi^{(3)}$, esu
CdC8 +Ag/Au(1:1)	11	17	-2.39×10^{-10}	-1.02×10^{-8}	3.7×10^{-5}	8.92×10^{-9}
CdC8 +Ag/Au(3:1)	12.5	8	-3.55×10^{-10}	-1.52×10^{-8}	2.5×10^{-5}	6.03×10^{-9}
CdC8+Au/Ag(3:1)	12	13	-1.04×10^{-10}	-0.44×10^{-8}	2.95×10^{-5}	7.11×10^{-9}

Nonlinear optical parameters of the three nanocomposites (CdC_8+Ag/Au (1:1) NPs, CdC_8+Ag/Au (3:1) NPs, and CdC_8 + Au/Ag (3:1) NPs)

Conclusions:

The used metal alkanoates class is a promising class for the design and study of nonlinear optical properties of nanomaterials. The thermotropic liquid-crystalline phase T = 100-150°C of cadmium alkanoates allows the chemical synthesis of various nanoparticles, including bimetallic noble nanoparticles. Thus, varying the composition of the reaction mixture and the duration of the synthesis Ag/Au NPs in the cadmium alkanoates allow to get nanoparticles such as bimetallic homogeneous or gradient alloys. Inside the nanocomposites CdC_8 + Ag/Au (1:1) NPs according to the data of the small angle X-ray scattering method the nanoparticles of the metal alloy Ag/Au type with average radii of 6.2 nm were observed. In the case of the nanocomposites CdC_8 + Ag/Au (3:1) NPs were formed core (Ag/Au) NPs (with medium radii 13.0 nm), coated shell – Au NPs with a thickness of 8.5 nm. In this article, we explored fast and quite high values of nonlinear optical properties of new glassy nanocomposites on a wavelength of 532 nm. nm).