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Optical gate controlled by temperature

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Light scattering and transmission of a porous silicate glass-based composition material with poly-2-ethylhexylacrylate immobilized in the pores have been investigated. A temperature transition (47 – 50 °C) in transmittance has been observed and interpreted. The hysteresis found indicates that the second order transition occurs.

In our previous works [1] – [3], a number of new physical phenomena have been investigated which concern light scattering in the composition materials on the basis of porous matrices.

In the present investigation, the porous silicate glass was used with the average pore radius of about 150 – 200 nm, volume porosity of about 40%, specific area of the porous matrix $1.6 \cdot 10^7$ m^2/m^3, apparent density $1.2 \cdot 10^3$ kg/m^3. Monomeric 2-ethylhexyl-acrylate was put into pores of a sample and then polymerized. Optical spectral transmittance within the wave range of 380 – 1000 nm was measured at a temperature changing from +20 °C to +80 °C.

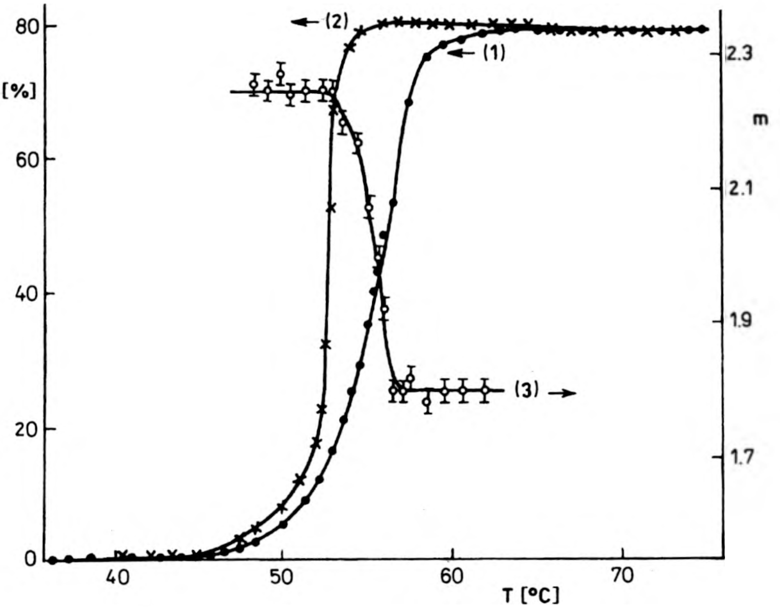
In the Figure, the transmittance dependence on temperature at a wavelength of 550 nm is shown. One can see that transmittance of the sample changes by the factor of 160 at the temperature rise from +47 °C to +59 °C (curve 1). Upon cooling of the sample the transmittance returns to the initial level (curve 2).

As both the porous matrix and the polymer do not absorb light in the measured wave range, the microcomposition on the whole is responsible for the light scattering. We may suggest the observed scattering to be only elastic one.

Analysis of the spectral characteristics indicates the scattering cross-section (σ is about 10^{-10} cm^2) to be much larger than that of Rayleigh type. In the latter case a vibration frequency ω_0 of the electron itself is significantly higher than that of the incident light ω.

That fact may be considered as occurrence of resonance light scattering ($\omega_0 \approx \omega$), being as a matter of fact resonance fluorescence [4]. Nevertheless, the occurrence of resonance fluorescence in solids seems to be unlikely, since the metastable states inevitably appear in solids.

Another probable mechanism of scattering, which causes a decrease of an index m in the function of scattered light intensity I at a wavelength λ: $I \approx 1/\lambda^m$ (compare with $m = 4$) may be as follows. Mandelstamm observed the light scattering at



Temperature dependence of optical transmittance τ (1 – heating, 2 – cooling) and 3 – index *m* of porous glass-polymer composition.

interface of two non-mixing liquids near the point of their exfoliation [5], [6]. In those experiments, index *m* was about 2 like in ours.

In the Figure, the dependence $m = f(T)$ is given (see curve 3). As one can see, there is a drastic change of index *m* within temperature range of 54–56 °C, for the case of approximation of experiment results by the function $\sigma = 1/\lambda^m$.

Such changes of the index *m* within narrow temperature range and the rapid rise of transmittance within the same range indicates the process similar to a phase transition.

It is noteworthy that both the porous silicate matrix (about 95% SiO_2) and the poly-2-ethylhexylacrylate do not have any phase transitions in this temperature range. Therefore, one could suggest that in the experiments presented a phenomenon previously not observed and not being the result of an impact of separate components of the "porous glass–polymer" composition was investigated.

Multiple measurements have demonstrated a high reproducibility of the data presented in the Figure. The observed hysteresis indicates an appearance of the first kind phase transitions [7].

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