Dielectric properties and structure particularity of silver stearate

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Abstract. Dielectric properties, parameters and structure particularity of silver stearate are studied. The silver stearate sample in monolithic formation was researched by method of dielectric spectroscopy. Measurements were realized by spectrometer Novocontrol Technologies "Concept 41" in wide range of frequencies and temperatures. Dielectric parameters of silver stearate were measured and calculated. γ-relaxation process in temperature band 80 – 130^0 C and first phase transition at 126^0 C. are found.

1.Introduction

The photothermographic materials wide used in operate registration of image. Those materials are consist of silver halides and silver salts of fatty acid, in particularly silver stearate. During the manufacture process of photosensitive composition silver halides are synthesized on surface of silver stearate particle. By different dyes-sensitizators the heat-developable composition may be sensitized for visible-light and for nearest infra-red spectrum [1, 2]. The silver stearate takes parts as in the process of sensitization according the lightguide mechanism, and in the heat-developing process of latent images at temperature range 120 – 140^0 C [3, 4, 5]. Therefore investigations of the silver stearate structure peculiarities, optical and electric properties are actual problems.
The structure of the silver stearate molecule is showed in figure 1.

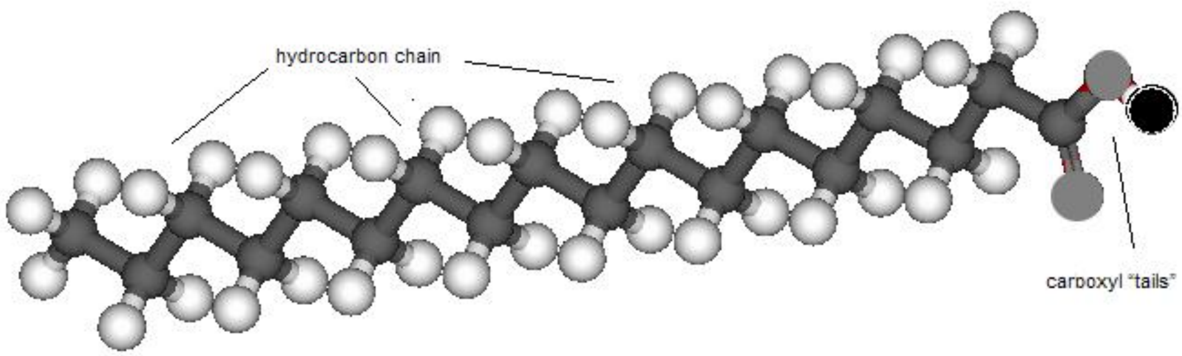

Figure 1. The molecule of silver stearate

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2. Experiment

The dielectric measurements of silver stearate sample were realized with help dielectric spectroscope Novocontrol Technologies "Concept 41". Dielectric spectroscopy method allows to measure and to calculate dielectric and other parameters of complex materials [6]. More importantly, dielectric spectroscopy method allows studying structure particularities in such materials. The silver stearate ($CH_3-(CH_2)_{16}-COOAg$) are synthesized by exchange reaction of replacement sodium at superfluous concentration nitrate silver in microparticle formation with size around one micrometer, so it was necessary to prepare monolithic sample. The monolithic sample of silver stearate was prepared by pressing method. Then received sample was inserted in sample cell between gold-plate electrodes. Sample diameter – 10 mm, sample thickness – 0.5 mm. Work voltage – 1 V. Dielectric permittivity, loss factor, tanδ and other dielectric parameters were measured in frequency range $10^{-2}-10^{2}$ Hz in isothermic regulation. Temperature range- 0^0C-130^0C. Temperature step – 10^0C in temperature range 0^0C-120^0C, and temperature points 125^0C and 130^0C in region of supposed phase transition. Temperature stability of the instrument was controlled within $\pm 0.2^0C$.

The measurement results were approximated by Havriliak - Negami function [7, 8], using software Novocontrol WinFit:

$$\varepsilon^*(\omega)=\varepsilon_{00}+\frac{\Delta\varepsilon}{\left[1+(i\omega\tau)^{\alpha_{PT}}\right]^{\beta_{PT}}} \quad (1)$$

where ε_{00} – nonrelaxing dielectric permittivity, $\Delta\varepsilon$ – dielectric increment, τ – relaxation time, ω – circular frequency, α_{HN} and β_{HN} – HN parameters, describe symmetrical and asymmetrical expansion of relaxation function corresponding [9].

3. Results and discussion

The measurements of dielectric spectrums in wide range frequency and temperature allowed studying γ-relaxation dielectric process in the silver stearate [10]. The values of different parameters such as, relaxation strength, relaxation time, nonrelaxing dielectric permittivity, parameters of HN-function are showed in table 1.

Table 1. Different dielectric parameters of silver stearate

T,^{0}C	τ_{max}, s	ΔE	τ, s	ε_∞	α	β
80	0.57	0.15	0.80	0.56	0.94	0.68
90	0.27	0.02	0.34	0.24	0.92	0.77
100	0.16	0.03	0.19	0.28	0.91	0.83
110	0.11	0.02	0.13	0.22	0.91	0.85
120	0.08	0.06	0.10	0.37	0.92	0.86
125	0.09	0.78	0.10	1.02	0.95	0.82
130	0.09	0.84	0.11	1.13	0.98	0.80

In many occurrences dielectric modules are used for analyze. In figure 2 frequency dependence dielectric module losses are showed for different temperature. In set figure visible displacement maximums dielectric module losses in size of increase frequency with increase temperature is observed. This displacement allows studying γ-relaxation dielectric process silver stearate in considered temperature range [10].

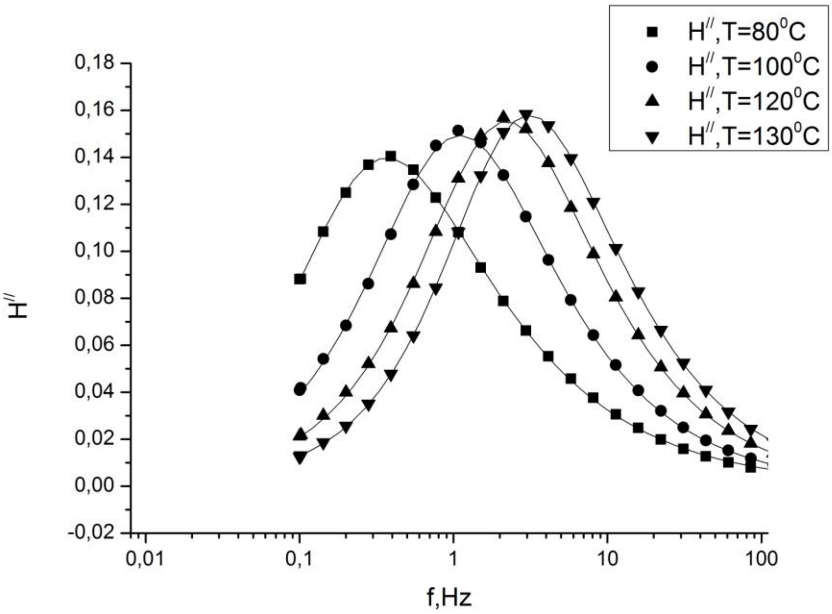

Figure 2. Dependence of dielectric module losses from frequency for different temperature

According to the available literature the dielectric relaxation process stipulated, apparently, by progressive absorting in carboxyl "tails" [11].

Also dependence $-\ln(\tau)$ from reverse temperature was plotted (figure 3), where $\tau = \tau_0 \exp\left(-\frac{E_a}{kT}\right)$.

This graph shows existence γ-relaxation too. Also activation energy was calculated. For silver stearate the activation energy is $(0.46 \pm 0.01)eV$.

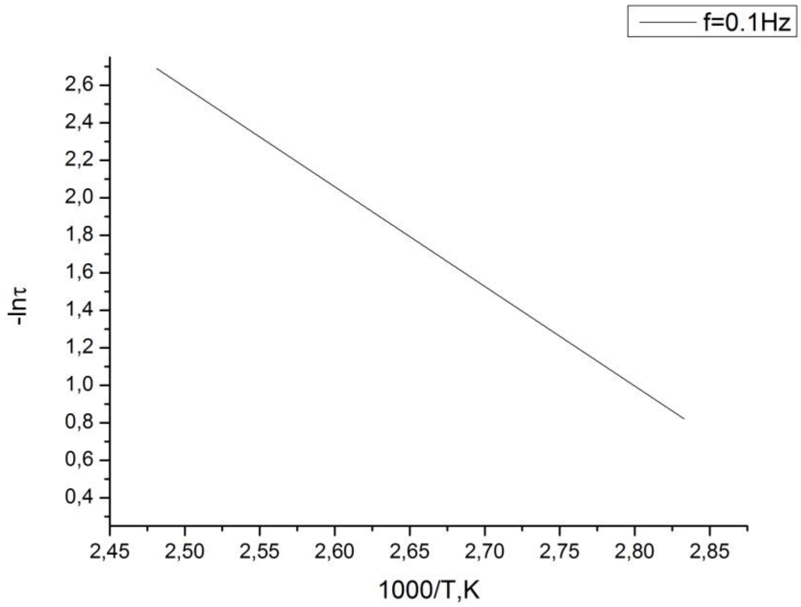

Figure 3. Dependence $-\ln(\tau)$ from reverse temperature for $f = 0.1Hz$

The measurements of dielectric spectrums and approximation experimental results allowed detecting phase transition in silver steatrate. In figure 4 the dependence of relaxation strength from reverse temperature is showed. On set figure visible surge leap of relaxation strength at $126^0 C$ is observed.

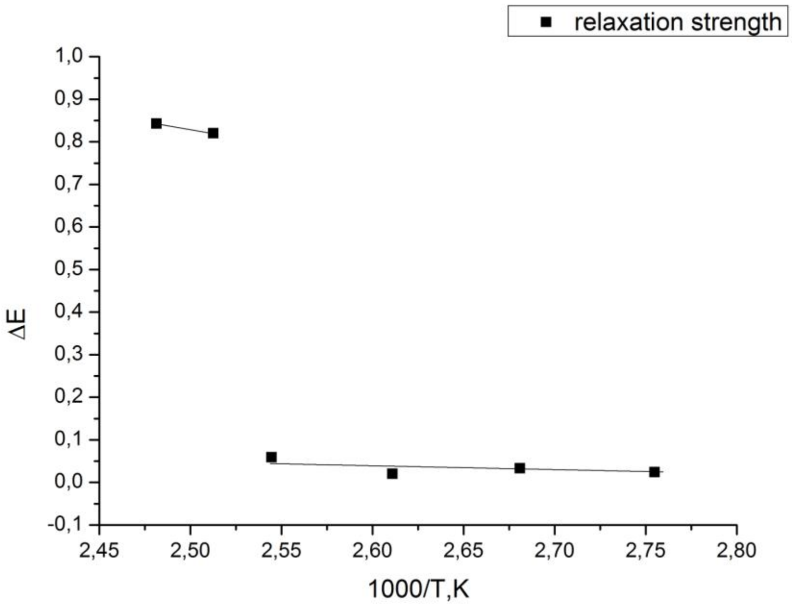

Figure 4. Reverse temperature dependence of relaxation strength

According previous literature [11, 12] this surge leap shows phase transition, defined "crystal-curd" in [11], or first phase transition in [12]. Also according previous articles this phase transition is stipulated by melting of hydrocarbon chains. However in [12] authors said, that destruction of ion silver layers was not arise at this phase transition. This fact confirms, that usage of silver stearate in photothermographic materials is optimum solution.

4. Conclusion

The dielectric parameters of silver stearate, fabricated by pressing method, were measured by dielectric spectroscope method. Dielectric measurements were realized by dielectric spectroscope Novocontrol Technologies "Concept 41" in wide frequency and temperature range. Due to results of measurements and calculations γ – relaxation process in range $80^0 C - 130^0 C$ at low frequency range was detected. Also activation energy of silver stearate was calculated. The different dielectric parameters of silver stearate, such as relaxation strength, relaxation time, nonrelaxing dielectric permittivity, HN parameters, were obtained. The first phase transition was detected at $126^0 C$, that accords with available reference very well. The silver stearate has sufficient complex structure and pronounced dielectric properties. There are shown the silver ion structure is not distract at temperature of phase transition, so usage of silver stearate in photothermographic compositions is reasonable.

5. Reference

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