

# LINEAR ELECTROMECHANICAL EFFECT IN A POLYMERIC FERROELECTRIC LIQUID CRYSTAL

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**N. Éber, L. Bata, G. Scherowsky, A. Schliwa:** Linear electromechanical effect in a polymeric ferroelectric liquid crystal. KFKI-1991-07/E

#### ABSTRACT

A linear electromechanical effect was detected in a ferroelectric side chain polymeric liquid crystal. Preliminary data on temperature and frequency dependence are presented.

**Н. Эбер, Л. Бата, Г. Шеровски, А. Шлива:** Линейный электромеханический эффект в сегнетоэлектрических полимерных жидких кристаллах. KFKI-1991-07/E

#### АННОТАЦИЯ

Наблюдался линейный электромеханический эффект в сегнетоэлектрическом гребнеобразном полимерном жидком кристалле. Показаны предварительные данные о зависимости от температуры и частоты.

**Éber N., Bata L. Scherowsky G., Schliwa A.:** Lineáris elektromechanikai effektus ferroelektromos polimer folyadékkristályban. KFKI-1991-07/E

#### KIVONAT

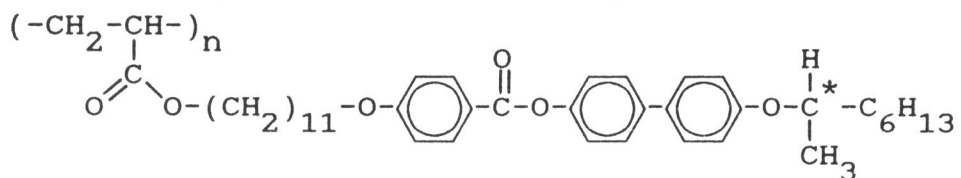
Lineáris elektromechanikai jelenséget találtunk ferroelektromos fésűs polimer folyadékkristályban. Bemutatjuk a jelenség hőmérséklet- és frekvenciafüggésére vonatkozó első adatokat.

Ferroelectricity is one of the most remarkable features of the chiral smectic C\* ( $S_C^*$ ) liquid crystals<sup>1</sup>. Due to the presence of spontaneous polarization this phase exhibits a fast electrooptical switching<sup>2</sup> as well as a linear electromechanical effect<sup>3</sup> which has been studied in detail for various monomeric liquid crystals.<sup>4-8</sup>

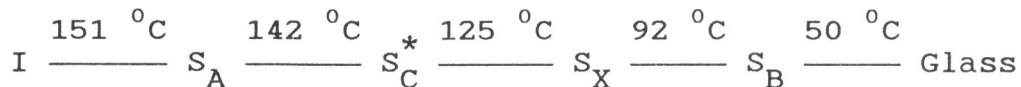
Some polymeric liquid crystals also possess a  $S_C^*$  phase, hence these polymers are ferroelectric too.<sup>9-12</sup> Recently two of us synthesized ferroelectric polymers exhibiting fast electrooptical switching.<sup>13-15</sup>

In this letter we would like to announce that we were able to detect the linear electromechanical effect in one of those polymers. The same effect has just been observed independently on another polymeric  $S_C^*$  substance as well.<sup>16</sup>

Our measurements were carried out using a polyacrylate side chain polymer with a chemical formula<sup>13,14</sup>



having  $M_w=15000$  and its polydispersity characterised by  $M_w/M_n=1.5$ . Polarisation microscopy of 2  $\mu\text{m}$  samples and DSC yielded the following phase sequence:



In the  $S_C^*$  phase the sample exhibited fast ferroelectric switching, however, in the  $S_X$  phase only a switching of electroclinic type could be detected.<sup>14</sup>

In order to determine the electromechanical response of the polymer we prepared a 15  $\mu\text{m}$  thick sample using the same experimental set-up as for monomers.<sup>4,5,7</sup>

This sample possessed a very broad  $I-S_A-S_C^*$  phase transition, i.e. a coexistence of three phases was detected over a 10  $^\circ\text{C}$  temperature interval. The transitions into the other smectic phases were much sharper, however, in various domains they occurred at different temperatures within a range of 5-10  $^\circ\text{C}$ . This inhomogeneity of the cell remained even after repeated heating-cooling cycles.

Due to the merging  $I-S_A-S_C^*$  phase transitions the shear method of orientation<sup>17</sup> proved to be ineffective. So we simply cooled down the sample in an AC field from the isotropic phase yielding poor orientation with a lot of focal conics.

When a harmonic voltage of 50  $V_{\text{eff}}$  was applied onto the sample in the  $S_C^*$  phase, a harmonic mechanical vibration of the same frequency occurred just as in case of monomeric  $S_C^*$  liquid crystals<sup>3</sup>. Figure 1 presents the temperature dependence of the vibration amplitude measured by a piezoelectric accelerometer.

This proves that the linear electromechanical effect does exist in a polymeric  $S_C^*$  liquid crystal. Despite of the poor orientation, the vibration amplitudes are of similar order of magnitude as in  $S_C^*$  phase of low molar mass compounds<sup>7</sup>. Figure 1 illustrates that this electromechanical effect is existing even in the lower temperature  $S_X$  phase of

## LINEAR ELECTROMECHANICAL EFFECT IN A POLYMER

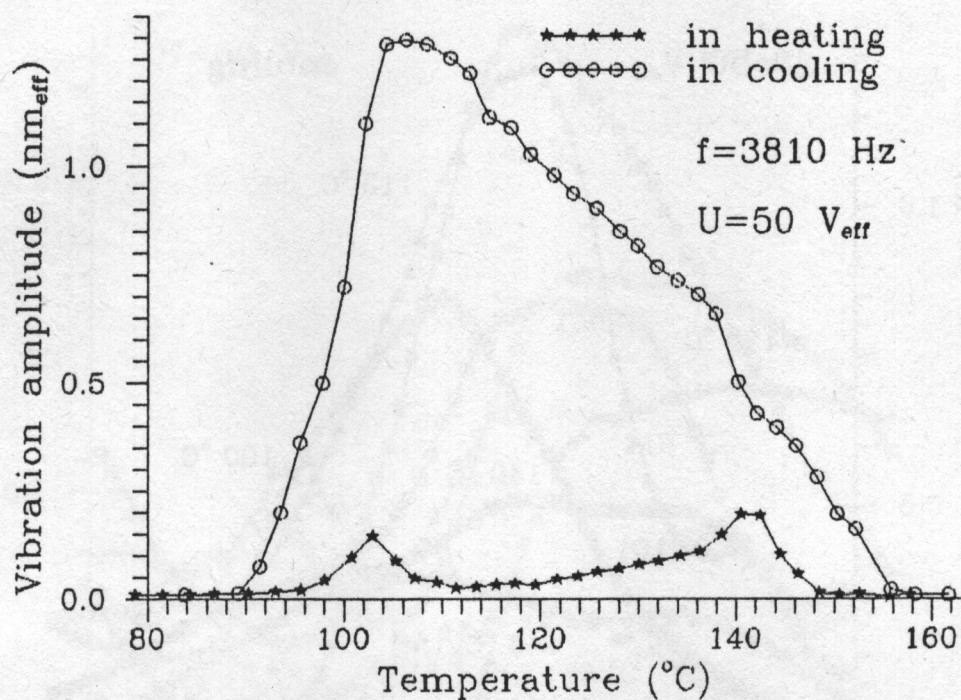


FIGURE 1 Temperature dependence of the vibration amplitude

the same compound, moreover, it may be stronger in  $S_X$  than in  $S_C^*$ .

As in case of monomers<sup>7</sup>, the plot of the frequency dependence of the vibration amplitude exhibits several maxima in the 0.1-6 kHz range. We mapped the spectrum around the most pronounced resonance peak (3.81 kHz) by changing the frequency of the applied voltage in 10 Hz increments. Some typical spectra are plotted in Figs. 2 and 3 for cooling and heating the sample respectively.

The figures show that the behaviour of the sample in



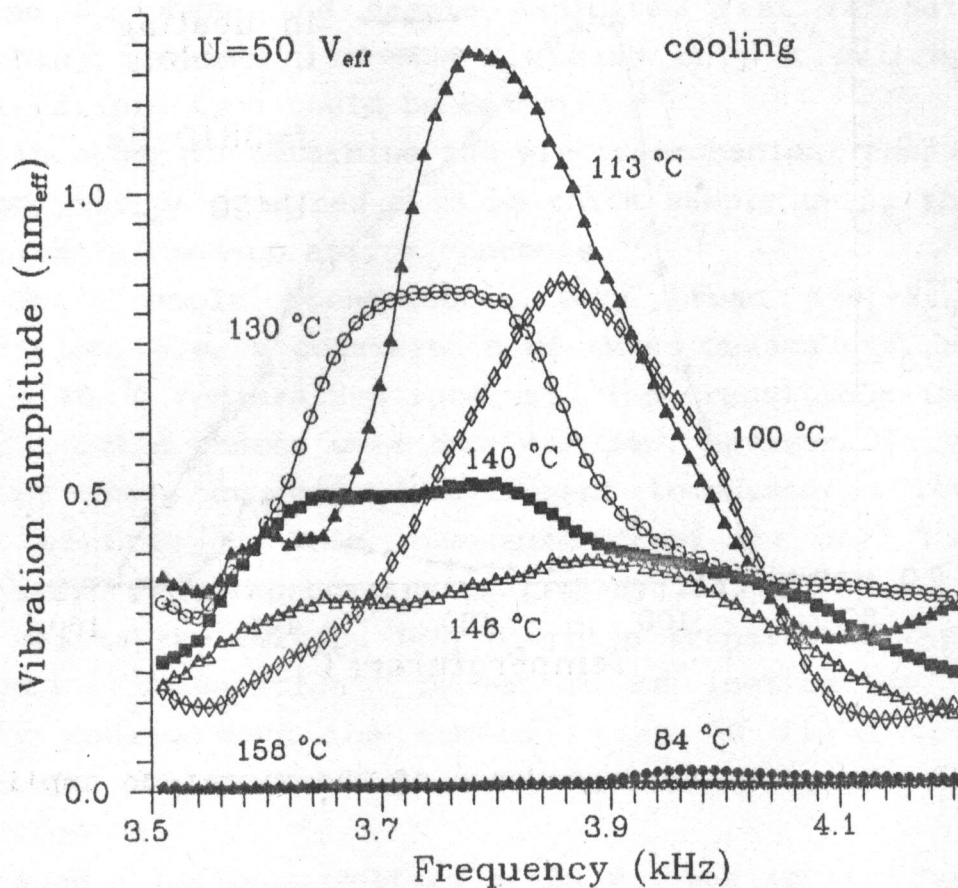


FIGURE 2 Frequency dependence of the vibration amplitudes at some temperatures during cooling

heating (Fig.3) the resonance frequency is shifting with the temperature, this may explain the presence of the double peak in Fig. 1.

We guess that the resonances in the vibration spectrum of the polymer are connected with the defect structure of the sample<sup>18</sup>. So the different spectra in Figs. 2 and 3 cooling is remarkably different from that in heating. In

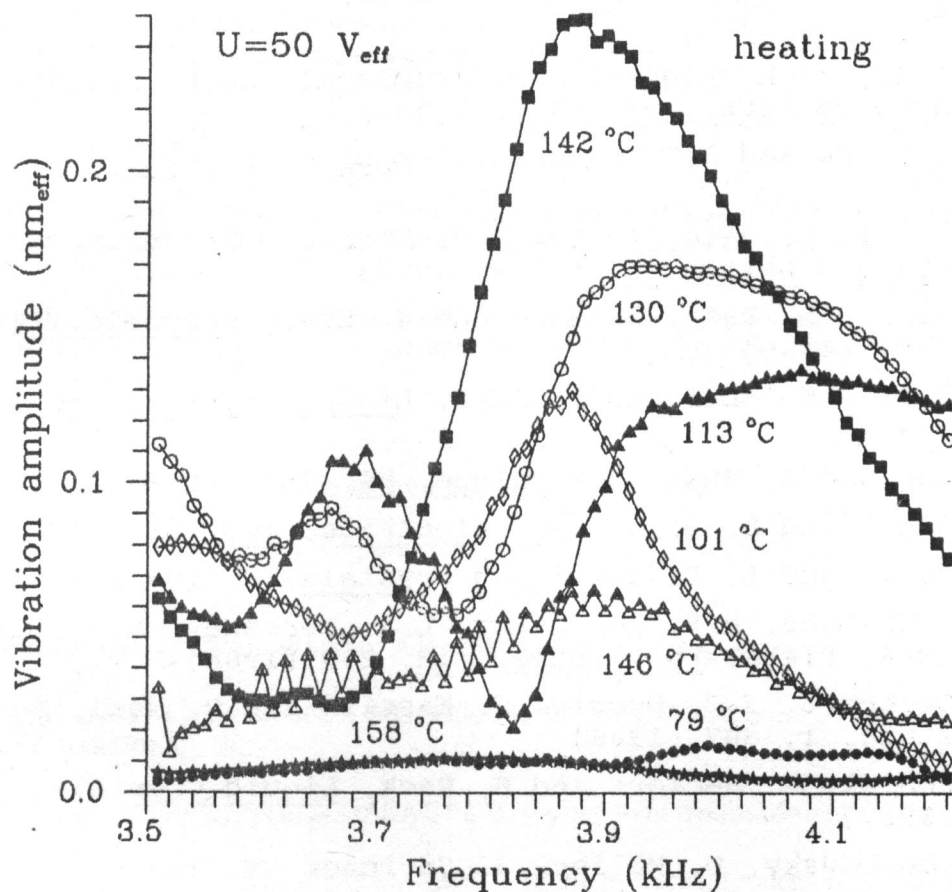


FIGURE 3 Frequency dependence of the vibration amplitudes at some temperatures during heating

render probable that the textures depend on whether the sample was cooled down from the isotropic phase or it was heated up from the glassy or  $S_B$  phase. For example in cooling the sample might be more planar and this may be the reason for the larger vibration amplitudes.

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