

INTISARI

Pengaruh Konsentrasi *Cross-Linker* Terhadap Sifat-Sifat Fisis Main Chain Liquid Crystal Elastomer

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Penelitian ini bertujuan menelaah pengaruh konsentrasi *cross-linker* dalam rentang 8% -16% terhadap sifat-sifat fisis material *main chain liquid crystal elastomer* (MCLCE), yaitu efek mekanik induksi-termal, kristalinitas dan transisi fase nematik-isotropik, serta pengaruhnya terhadap besaran-besaran fisis: deformasi spontan, energi bebas elastik dan parameter benahan.

Tiga metode telah digunakan, yaitu induksi-termal, difraksi sinar-x dan kalorimetri. Metode induksi termal diterapkan dengan memapar panas pada sampel dengan suhu bervariasi. Deformasi diamati melalui mikroskop polarisasi yang terhubung dengan PC. Metode difraksi sinar-x dilakukan dengan menempatkan sampel di dalam palung magnetik difraktometer sinar-x dan mensetting jangkauan sudut berkas sinar datang θ . Hasilnya dinyatakan dalam sebuah difraktogram yang menyatakan intensitas difraksi terhadap sudut hamburan 2θ . Metode kalorimetri dilakukan dengan menempatkan sampel di dalam panci sampel sebuah alat *differential scanning calorimeter* (DSC) dan dipapar rentang suhu tertentu. Hasilnya berupa *scanning thermal* yang menyatakan aliran panas terhadap suhu.

Hasil penelitian menunjukkan, meningkatnya konsentrasi *cross-linker* menyebabkan meningkatnya kontraksi maksimum dari ~170% hingga ~208%. Banyaknya ikatan silang pada LCP memungkinkan MCLCE melakukan *stretching* lebih besar sehingga kontraksi dan ekspansi semakin besar. Bidang-bidang kristalin bertambah pada konsentrasi 8%-14% karena *cross-linker* efektif mengikat silang LCP. Meningkatnya kristalinitas diikuti kenaikan suhu transisi nematik-isotropik. Setelah konsentrasi 16%, kristalinitas turun drastis karena sebagian molekul *cross-linker* tidak efektif lagi mengikat silang LCP. *Cross-linker* yang tidak mampu mengikat silang LCP tersebut justru meningkatkan kompleksitas ikatan di dalam sampel sehingga kristalinitas menurun diikuti oleh menurunnya suhu transisi fase. Meningkatnya konsentrasi *cross-linker* juga menentukan tingkat kecepatan dan kemudahan deformasi serta tingkat keberaturan unit-unit mesogen. Jumlah LCP yang terikat silang semakin besar saat konsentrasi *cross-linker* meningkat. Akibatnya, sampel lebih sensitif menerima rangsang sehingga energi elastik yang dibutuhkan untuk deformasi juga lebih kecil. Semakin mudah kontraksi, semakin besar potensi sampel meregang hingga strain yang dihasilkan lebih tinggi. Akibatnya, parameter benahan maksimumnya juga meningkat.

Kata kunci: MCLCE, konsentrasi *cross-linker*, induksi termal, kristalinitas, deformasi spontan, energi bebas elastik, parameter benahan.

ABSTRACT

Cross-Linker Concentration Effects on Physical Properties of Main Chain Liquid Crystal Elastomer

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This study aims to examine the cross-linker concentration effects in the range of 8%-16% on physical properties of main chain liquid crystal elastomer (MCLCE), namely thermo-induced mechanical effect, crystallinity, and nematic-isotropic phase transition. This also examines the effect on physical quantities, i.e spontaneous deformation, elastic free energy, and order parameter.

Three methods have been applied, namely thermal induction, x-ray diffraction, and calorimetry. The thermal induction was applied by exposing heat to the sample with varying temperature. Deformation was observed through a polarization microscope connected to a PC. The x-ray diffraction was carried out by placing the sample in the magnetic trough of x-ray diffractometer and setting up the range of incident beam angle θ . The result was displayed in a diffractogram which expressed diffraction intensity with respect to deflected angle 2θ . The calorimetry method was carried out by placing the sample on a pan of differential scanning calorimeter (DSC) and exposed to a certain temperature range. The result was a thermal scanning which expressed the heat flow with respect to temperature.

The result showed that increasing the cross-linker concentration led to increasing the maximum contraction from ~170% to ~208%. The number of crosslinks on the LCP allowed MCLCE to stretch more largely so that the contraction and expansion increased. The crystalline planes grew at a concentration of 8%-14% as the cross-linker cross-linked the LCP effectively. Increasing the crystallinity was followed by increasing the nematic-isotropic phase transition. After reaching 16%, the crystallinity decrease abruptly as many cross-linker molecules were no longer effective in cross-linking LCP. The cross-linkers that were not able to crosslink the LCP were actually increasing the complexity of bonding in the sample so that crystallinity decreased, followed by decreasing the nematic-isotropic phase transition. Increasing the cross-linker concentration also determined the level of deformation speed and ease and regularity degree of mesogenic units. The number of cross-linked LCP got largely as the cross-linker concentration increased. As a result, the sample was more sensitive to receive the stimuli so that the elastic free energy required to deform was also smaller. The easier the contraction, the greater the sample stretching so that the resulting strain was higher. As a result, the maximum order parameter also increased.

Keywords: MCLCE, cross-linker concentration, thermal induction, crystallinity, spontaneous deformation, elastic free energy, order parameter