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PHENOMENOLOGICAL AND STATE COEFFICIENTS FOR POLY-ISOBUTYLENE IN KLUITENBERG – CIANCIO THEORY

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The aim of this work is to calculate some mechanical phenomenological an state coefficients as function of frequency dependent quantities experimentally measurable. This make possible to obtain numerical values for the aforementioned coefficients as function of frequency in a direct way. Moreover analytical expression of these coefficients allow us to verify some inequalities that follow from principle of entropy production

It is well known that fundamental problem of continuum medium dynamics [1] has no general mathematical solution because the number of differential equations that follow from general physical principles make a system with a number of equations insufficient for his integration if compared with the number of unknown functions which appear in these equations.

Therefore, it is clear that the determination of the equations to add to the system is very important to pursue the last aim of the continuum medium dynamics. To this hope we consider a shear deformation ε (extensive variable) as cause and the stress τ (intensive variable) as effect; this allows us to study relaxation phenomena.

The Kluiteberg-Ciancio model for isotropic viscoanelastic medium [4],[5]of order one with memory lead to a differential equation "stress-strain" in which phenomenological and state coefficients appear; for one-dimensional case and neglecting cross-effect between viscous and inelastic flow, this equation is :

$$\frac{d\tau}{dt}+R_0^{(\tau)}\tau=R_0^{(\varepsilon)}\varepsilon+R_1^{(\varepsilon)}\frac{d\varepsilon}{dt}+R_2^{(\varepsilon)}\frac{d^2\varepsilon}{dt^2}$$

$$R_0^{(\tau)}=a^{(1,1)}\eta_s^{(1,1)};\quad R_0^{(\varepsilon)}=a^{(0,0)}\left(a^{(1,1)}-a^{(0,0)}\right)\eta_s^{(1,1)}$$

$$R_1^{(\varepsilon)}=a^{(0,0)}+a^{(1,1)}\eta_s^{(1,1)}\eta_s^{(0,0)};\quad R_2^{(\varepsilon)}=\eta_s^{(0,0)}$$

where $a^{(0,0)},a^{(1,1)}$ are state coefficients while $\eta_s^{(1,1)},\eta_s^{(0,0)}$ are phenomenological coefficients. The solution of equation (1) combined, by appropriate considerations, with experimental approach on linear response theory ([6],[7],[8]) lead us to obtain for such a medium subject to one-dimensional harmonic shear deformation, the following expression for phenomenological an state coefficients as function of the frequency at constant temperature:

$$a^{(0,0)}(\omega)=\frac{G_1\left(1+\omega^2\sigma^2\right)-G_{1R/H}}{\omega^2\sigma^2}$$

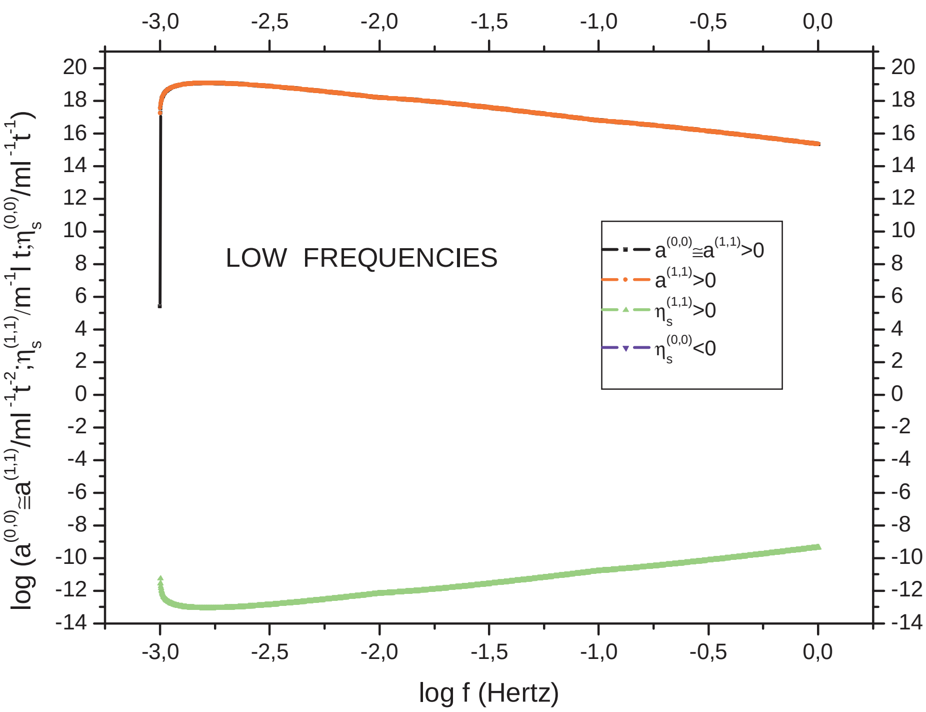
$$a^{(1,1)}(\omega)=\frac{1}{\omega^2\sigma^2}\left\{\frac{\left[G_1\left(1+\omega^2\sigma^2\right)-G_{1R/H}\right]^2}{\left(G_1-G_{1R/H}\right)\left(1+\omega^2\sigma^2\right)}\right\}$$

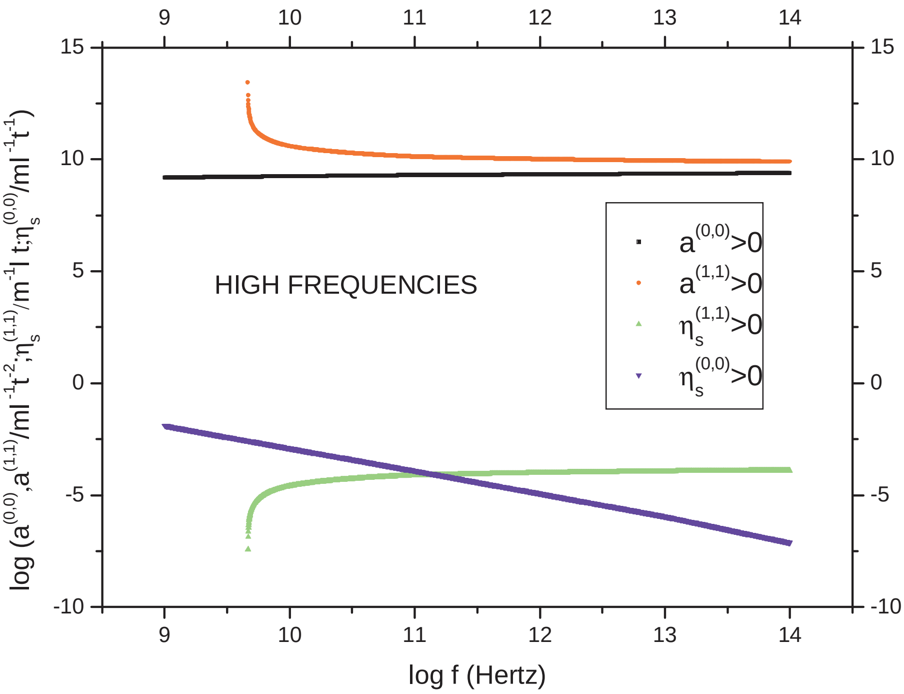
$$\eta_s^{(1,1)}(\omega)=\omega^2\sigma\left\{\frac{\left(G_1-G_{1R/H}\right)\left(1+\omega^2\sigma^2\right)}{\left[G_1\left(1+\omega^2\sigma^2\right)-G_{1R/H}\right]^2}\right\}$$

$$\eta_s^{(0,0)}(\omega)=\frac{G_{1R/H}+G_2\omega\sigma-G_1}{\omega^2\sigma}$$

where we select the values G_{1R} or G_{1H} for the symbol $G_{1R/H}$ depending on we refer to low or high frequency respectively, being $G_1(\omega)$, $G_2(\omega)$, G_{1R}, G_{1H} and σ experimentally determined

The study of these coefficients lead us to determine some analytical general properties confirmed by application to polymeric material as PolyIsobutilene maintained at a constant temperature. The so obtained results are show in the following curves:





Poly-isoButylene; M.w. = 106 g/mol; T_0 = 273 K
($G_{1R} \cong 10^{5.4}$Pa; $G_{1U} \cong 10^{9.38}$ Pa; $\sigma \cong 10^{-6}$ s).

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