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REAL TIME TRANSMITTANCE FUNCTION IN PHOTOPOLYMERS OF ACRYLAMIDE COMPOSITION : NOISE GRATINGS

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ABSTRACT

Photopolymers have been analyzed as holographic recording materials by measuring their diffraction efficiency in relation to the index modulation that is obtained with these materials, their spatial response and their energetic and spectral sensitivities. However, even though they are considered good recording materials for the storage of information and for the production of holographic optical elements, little information has been offered on the image quality that these recording materials produce.

Among the different sources of noise in holography, noise gratings have been analyzed extensively in photographic emulsion due to the granular nature of these recording materials.

However, information about photopolymers is quite scarce. For materials that work in real time, it is the transmittance function which measures the appearance of noise gratings given that the presence of this noise source manifest itself when transmitted light decreases due to diffraction.

We present a theoretical model that relate the photopolymer transmittance function response with the noise grating structure.

In keeping with the experiments we can say that noise gratings also appear in photopolymers which proves the presence of a certain granular structure in these materials. Their appearance and storage in these materials can be used as a methodology for the optimization of these recording materials.

1.- THEORETICAL MODEL

Photopolymers can be considered holographic recording materials because of their many attractive features. Among these, we could mention their ability to self-development, the fact that dry processing can be used with them, their good stability and thick emulsion layers, their high

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sensitivity, diffraction efficiency and resolution, and finally nonvolatile storage[1].
Among the different sources of noise in holography, self-induced gratings are due to scattering from fack of homogeneity in the recording material and have an important spurious effect on volume holography[2].

We present a thoretical model that explains the results for transmittance as a function of time in the presence of noise gratings. We assume that the probability that "n" noise gratings are recording in a time "t" is given by the Poisson distribution of time in the form:

$$P(n, t) = \exp(-t) \frac{t^n}{n!} \qquad (1)$$

Transmittance can be considered as the result of two effects. The first one is the effect that noise gratings produce on the photopolymer, and the second one is the effect on transmittance tproduced by the variation in time of dye concentration. Taking into account both effects, the transmittance as a function of time, T(t) could be expressed as:

$$T(t) = \langle T_{ng}(t) \rangle \, T_a(t) \qquad (2)$$

where <...> is the factor due to noise gratings and Ta is the factor due to dye concentration as a function of time. We assume that the diffraction efficiency η of each noise grating is the same, so the transmittance for "n" noise gratings, can be expressed as:

$$T_n = (1 - \eta)^n \qquad (3)$$

Using equations (1) and (3) we can obtain the expression for <Tng(t)>:

$$\langle T_{ng}(t) \rangle = \sum_{n=0}^{\infty} P(n, t)\, T_n = \sum_{n=0}^{\infty} \exp(-t) \frac{t^n}{n!} (1 - \eta)^n \qquad (4)$$

If we sum equation (4), we find that the effects of noise gratings on transmittance can be expressed as:

$$\langle T_{ng}(t) \rangle = \exp(-\eta\, t) \qquad (5)$$

For studying the effects of dye concentration on transmittance, we assume that the dye reacts photochemically to produce transparent products. For this case Simmons[3] has shown that Ta(t) can be expressed as:

$$Ta(t) = \frac{Ti}{(1 - Ti)\exp(-k\,t) + Ti} \qquad (6)$$

where Ti is the initial transmittance, and k is a constant which includes the quantum yield, the absorption coefficient and the incident intensity. Inserting equations (5) and (6) in equation (2), we find that transmittance T(t) can be expressed as:

$$T(t) = \frac{Ti\,\exp(-\eta\,t)}{(1 - Ti)\exp(-k\,t) + Ti} \qquad (7)$$

2.- NUMERICAL RESULTS

Figures 1,2,3,4 shows the numerical results of the proposed model given by equation 7.

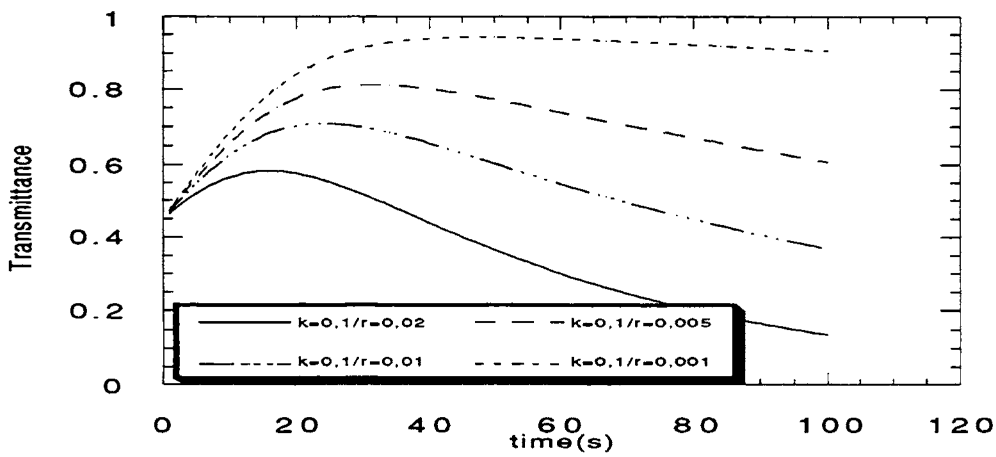

Figure 1: Transmittance vs time for k = 0,1 and different values of η.

As we can see in this figures, transmittance increases during the first seconds due to the bleaching of the dye. After a certain level of exposure has been reached, transmittance falls, because noise gratings have been stored and incident light is diffracted. The model predictions give us information about the optimization procedure to avoid noise gratings.

In figures 1 and 2 we can be observe the effects of noise gratings in the transmittance function for a fixed value of parameter k(fixed intensities, quantum yield and absorption). When the recording intensity is modified (k>>) high transmission curves are obtained as we can see in figures 3 and 4 for different diffractions efficiencies for noise gratings.

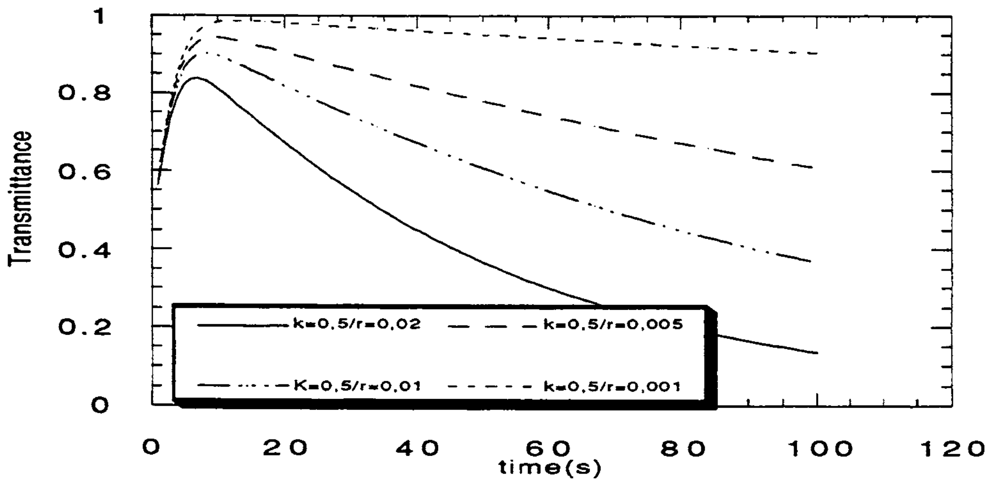

Figure 2: Transmittance vs time for k = 0,5 and different values of η.

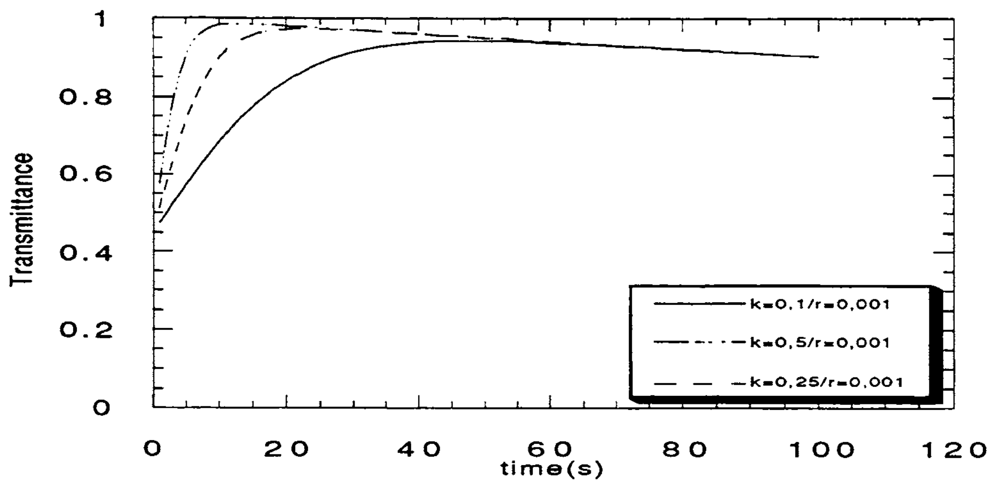

Figure 3: Transmittance vs time for η = 0,1 and different values of k.

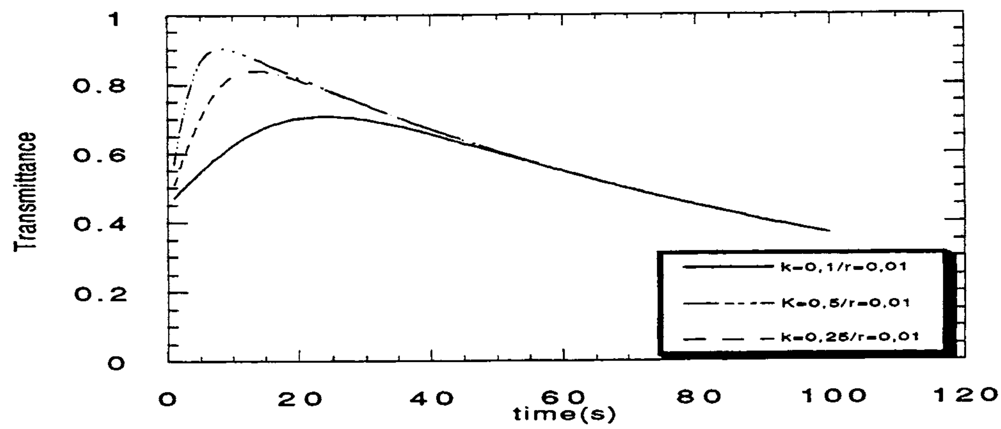

Figure 4: Transmittance vs time for η = 0,01 and different values of k.

The model has been experimentally analysed by using a photopolymer with a single beam from a He-Ne laser with normal incidence[4].

3.- ACKNOWLEDGEMENTS

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