Holograms recorded in dichromated with simple sugars

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Abstract Sugars as glucose and fructose can be used to holographic record. These materials have the advantage to mix very well with K₂Cr₂O₇. Holographic gratings recorded in sugars, were made by a lineal setup to producing interference pattern using a wavelength at 473 nm. These materials have the ability to register information in real time.

1. Introduction

The simple sugars used as emulsion to holographic record are glucose and fructose; the more simple glucides of chemistry formulate C₆H₁₂O₆ [1].

Structurally fructose contain one ketonic group (R-CO-R, where R are hydroxyls groups), two hydroxyl groups primary or primary alcohol (-CH₂OH) and three secondary hydroxyl group (-CHOH) [2]. Its chemical structure more stable is a cyclic structure five members knows alpha-D-fructose and beta-D-fructose [3].

Structurally glucose contains one aldehyde group (-R₂-COH, where R is hydroxyls groups), one hydroxyl group primary or primary alcohol and the remaining are four hydroxyl group secondary [2]. It has a cyclic structure six members know as D-glucose (alpha-D-glucose and beta-D-glucose) as chemical structure more stable [3].

Figure 1 show different chemicals structures of the simple sugars: linear open chain knows as Fisher projection, cyclic chain knows as Haworth projection and the two anomers more stable [3].

The primary hydroxyl groups react mainly [2], in our case with the added photosensitive salt, potassium dichromate, K₂Cr₂O₇.

Glucose and fructose were used as emulsion for holographic record.

These materials have the disadvantage of a high absorption of environmental humidity (hydrophilia). For this reason, is necessary to protect the sugars films after to make holographic record [4].

Another limitation of holograms with simple sugars has been its natural spectral response, generally found at the ultraviolet region between 190nm to 300 nm [4] and due to our interest is to achieving record holographic of sugars as biopolymer device, was necessary to add chemical compounds as potassium dichromate salt that has absorption spectral between 350-550 nm approximately. [5].

In this work we showed some obtained results using a wavelength of 473 nm, and a linear setup to register diffraction gratings.
Holograms recorded in dichromated with simple sugars has the advantage do not need processes of developing and fixing of the recorded image, it is auto revealable [4]. Important idea is to compare the behavior of the gratings built with glucose and fructose with same conditions.

**Figure 1.** Simple sugars structures. (Reference: Wade L G 1993 *Química Orgánica* Mexico: Pearson Education pp 1109-1123)

2. **Materials and methods**

The material used was simple sugars, glucose and fructose, mixed with potassium dichromate, K₂Cr₂O₇ (Meyer Chemical, Purity 99.7%, FW = 294.18).

Films in dichromated with simple sugars were prepared mixing 10.0 ml of glucose or fructose with 0.30 grams potassium dichromate and 1.00 ml distiller water. Mixture was shaken constantly during 10 minutes.

The liquid solutions were poured and coated on clean glass substrates (5x5 cm and 2 mm of thickness) and we dried the films for gravity into a stove graduate to 60°C.

We prepared some films at average temperature 25°C and 42% relative humidity environment as environmental conditions. The thickness layers form the emulsion made with dichromated and simple sugars were on the average of 122 microns.

The films were exposed with blue line recording beams came from of diode laser (473nm). The reading beam came from coherent He-Ne laser (632 nm).

The experimental setup is shown in Figure 2.
Figure 2. Setup used to register holographic diffraction gratings.

3. Results

The dependence of the diffraction efficiency parameter with exposure energy from the dichromated with simple sugars was measured after the registration, but before 48 hours because after that threshold of time the diffraction efficiency parameter decays.

Figure 3 presents the behavior of diffraction efficiency parameter curves at first order as a function of the exposition energy from films like dichromated with simple sugars and dichromated with corn syrup.

Figure 3. Diffraction efficiency parameter at first order recorder with diode laser (473 nm) of films layers made with dichromated with simple sugars.
We can see that the diffraction efficiency parameter present a maximum for dichromated with glucose the order of 7.3 % applying an energy of 0.6 J/cm$^2$ approximately. The spatial frequency from the diffraction gratings was of 570 lines/mm.

While the diffraction efficiency maximum for dichromated with fructose was 6.8 % using the same energy and setup. The spatial frequency from the diffraction gratings it was the same.

Figure 4 corresponds to optical reconstruction that shows the diffraction pattern from some gratings using a He-Ne laser, where the emulsion was made with dichromated and simple sugars.

A particular point in this photograph are the orders of diffraction, both gratings were registered with same conditions, energy and setup geometry, given the nature of this behavior; we considered to measure the diffraction efficiencies of the orders of more high energy like sample in the Fig.(3) first order to gratings made with glucose and fructose.

Figure 4. Optical reconstruction from gratings made with dichromated and simple sugars.

Dichromated glucose and dichromated fructose

4. Conclusion
Holographic gratings recorded with dichromated and simple sugars presented acceptable diffraction efficiency. According to the measures diffraction efficiency realized, the holographic gratings made with these materials require of a stabilization process of charges for to determine the diffraction efficiency maximum, due probably the interactions ion chromium with hydroxyl ions of simple sugars when the sample is irradiated with laser light to form diffraction gratings.

5. References
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