ENVIRONMENTALLY FRIENDLY HOLOGRAPHIC RECORDING MATERIAL

PATENTED TECHNOLOGY

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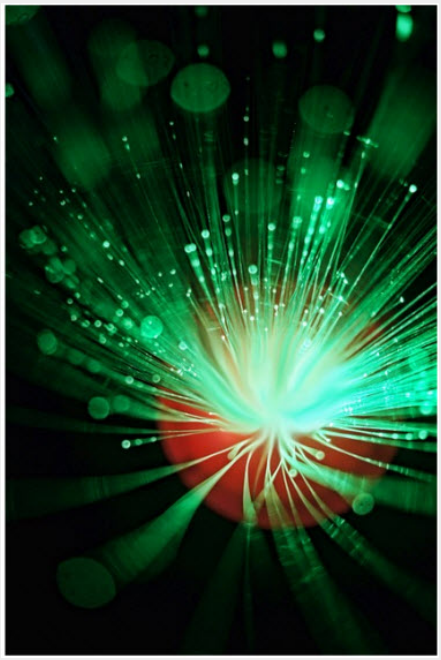
ABSTRACT

Our research group has developed a new photopolymer which may be used as a holographic recording material. It is easy to prepare in layers of the desired thickness and has a lower potential toxicity than conventional materials. It is characterized by being environmentally friendly, since it does not contain any petroleum-derived solvents or other components classified as toxic, biotoxic, explosive, radioactive, oxidising, corrosive, inflammable or environmentally hazardous, and no such substances are used to prepare it.

The only solvent used is water, thus minimizing any risk of contamination and, at the end of its useful life, it is easy to recycle in aqueous phase. It is possible to automatize all the stages of its preparation, and it enables holograms to be obtained in a single stage without the need for subsequent processing.

We are looking for companies interested in acquiring this technology for its commercial exploitation.



INTRODUCTION

Holography is a way of recording optical information from a certain object - either reflected or transmitted by this object - when illuminated by a source of laser light.

A large number of useful materials have been developed for holographic recording, such as photopolymers, organic and inorganic photorefractive materials, dichromated gelatins, silver halide sensitized gelatins, silver halides, photoresins, sol-gel glass, thermoplastic, photochromic and photodichroic materials.

There is such a wide variety of materials available because no one recording material has all the characteristics necessary for each application, that is, sufficient thickness, high capacity of refractive index modulation, high diffraction efficiency, high sensitivity, good optical quality with low levels of light dispersion and losses due to absorption, dimensional stability during recording of the hologram and its subsequent utilization, plus good thermal and chemical stability.

Photopolymers are materials in which photopolymerization reactions take place when they are illuminated by light of a certain wavelength. They are made up of a photopolymerization initiator, sensitizing dye and one or more polymerizable monomers in a polymer matrix which acts as a support. They are usually based on methyl methacrylic or other esters derived from acrylic acid. They are characterised as being incompatible with aqueous phase systems, toxic, biotoxic or harmful. Since they need to be produced in hydrophobic phase, inflammable organic solvents must be used, thus implying a problem of safety, difficulty in handling and a high risk of environmental contamination. Furthermore, when these materials reach the end of their useful life,

toxic inflammable organic solvents are needed to recycle them.

Other photopolymers use acrylamide as the polymerizable monomer. These materials are distinguished by their high toxicity and carcinogenic properties. Derivatives of acrylic acid, epoxidic acrylates or silicon gels impregnated with esters of methacrylic acid have also been used, all of which are insoluble in water.

TECHNICAL DESCRIPTION

A holographic recording material has been developed applying environmental compatibility criteria during both its manufacture and its useful life.

It is a photopolymerizable material that is sensitive to light, with the following composition:

- Metallic or ammonium salts of acrylic acid soluble in water (10-90% by weight, based on total weight) are used as monofunctional monomers.

- Optionally, 1,2-dihydroxiethylene-bis-acrylamide is used as a bifunctional monomer. This substance is soluble in water and acts as cross-linker (0-70% by weight, based on total weight).

- A metallic or ammonium salt of riboflavin 5'-monophosphate, a non-toxic substance soluble in water which allows the recording material to be used in the wavelength range of 200-550 nm (10-99% by weight, based on total weight), is used as sensitizing dye capable of undergoing a photochemical oxidation or reduction reaction after absorbing light at the appropriate wavelength.

- 4,4'-azo-bis(4-cianopentanoic) acid, which enables the length of the polymeric chains formed during recording to be controlled, is used as chain transfer agent (0.01-10% by weight, based on total weight).

- Triethanolamine, which enables the energetic sensitivity of the recording material to be controlled (0-20% by weight, based on total weight), is used as deactivator of free radicals.

- Glycerine is used to modify the thickness of the photopolymer layer (0-20% by weight, based on total weight).

- Deionised or distilled water (0.1-20% by weight, based on total weight) is used as regulator of the molecular diffusion processes that take place in the material .

- A hydrophilic organic polymer, soluble in water, with a mean molecular weight of 25,000 and 200,000 uma is used as the matrix containing all the other components. It is selected from the following: xanthan gum, polyvinyl alcohol, the sodium salt of carboximethyl cellulose, methyl cellulose, ethyl cellulose, gelatin (1-90% by weight, based on total weight).

PREPARATION OF THE MATERIAL:

All the components except the organic polymer are dissolved in water at room temperature. The organic polymer is heated to aid dissolution. The final solution is obtained by mixing and stirring the appropriate quantities of each of the solutions of the components in order to obtain the desired concentration without using heat or electromagnetic radiation. The mixture is prepared in a stirred tank which makes it possible to create a vacuum and introduce an inert gas (nitrogen or argon) so as to prevent interference due to the presence of atmospheric oxygen.

Before the sensitising dye is added, the process may be carried out under natural or artificial light. However, when the dye is added, the mixture must be in complete darkness or illuminated by a source emitting at a wavelength at which the dye is not absorbed. Although the resulting solution may be stored, it is not advisable since aging phenomena may occur.

The solution is deposited in open moulds made of a chemically inert material, or on a transparent or partially transparent support. They are placed on a level surface in a dark chamber which allows the temperature and humidity to be controlled. After the water content has partially evaporated, a flexible plastic film between 20 and 2,000 micrometers thick is obtained and may be removed from the mould. This is the light sensitive holographic recording material.

RECORDING AND RECOVERING INFORMATION:

This holographic recording material is used to record holograms by means of any holographic technique. The holograms are obtained by exposure to light in a single stage and without the need for subsequent processing. The material exposed to light may be protected with totally or partially transparent plastic so as to guarantee its mechanical properties.

Photopolymerization reactions produce changes in the chemical characteristics of the material which affect its optical properties (changes in refractive index). Using a laser that operates at the appropriate wavelength, information is recorded in the material. This information may be recovered as many times as necessary by means of a holographic reading system that operates with a reconstructing laser.

ADVANTAGES AND INNOVATIVE ASPECTS

ADVANTAGES:

- It allows holograms to be obtained by exposure to light in a single stage and without the need for subsequent processing.

- The material may be covered in totally or partially transparent plastic, before or after obtaining the hologram.

- It does not contain solvents derived from petroleum or other components classified as toxic, biotoxic, explosive, radioactive, oxidising, corrosive, inflammable or hazardous for the environment (under Commission Directive 2001/59/EC) and no such products are used in its preparation.

- The material itself and all its components are soluble in water.

- After its useful life, it may be eliminated by aqueous phase processes.

- It is compatible with the environment, thereby minimizing any potential risk of contamination.

- Its fabrication process is completely safe for workers, since water is the only solvent used.

- The processes of preparing the solution, depositing it in moulds and subsequently extracting it may all be automatized.

INNOVATIVE ASPECTS:

- Due to its characteristics and the fact that during the preparation process, its useful life and subsequent elimination, water is the only solvent used, the negative impact of this material on the environment is minimized.

- It does not contain any components classified as toxic, biotoxic, explosive, radioactive, oxidising, corrosive, inflammable or hazardous for the environment.

- Although the fabrication process is totally safe for workers, it is possible to automatize all the stages, thereby reducing the production costs.

- Layers of different thicknesses may be easily obtained and they may be used at different wavelengths.

CURRENT STATE OF DEVELOPMENT

Holographic gratings were recorded in the material developed in our laboratory. To do this, several parameters were varied (intensity of the recording beams, spatial frequency, angle of rotation between the layer of material and recording beams, and the angle between the layer of material and reconstructing beam) in order to evaluate the characteristics of the material and obtain values for the main holographic parameters.

In a 1 mm thick layer, using a recording beam intensity of 5 mW/cm^2, a diffraction grating of 1125 lines/mm was obtained with an effective thickness greater than 80% of the thickness of the layer and a diffraction efficiency, or ratio between diffracted intensity and incident intensity, of 90%, with losses due to absorption and dispersion of light of 10%, and energetic sensitivity, or energy necessary to reach maximum diffraction efficiency, of 50 mJ/cm^2.

MARKET APPLICATIONS

This is a light sensitive material used in various optical technologies, in particular as holographic recording material (support for holographic optical elements and holographic memories). Its main applications include:

- Holographic interferometry.

- Production of three dimensional images for coded labels and security systems.

- Manufacturing of holographic optical elements such as lenses, filters, systems for processing images and optical fibre network intercommunication devices.

- Holographic data storage.

- Other applications of photopolymerizable systems: dental treatments, protection of vehicle lights, flexoprinting, etc.

COLLABORATION SOUGHT

We are looking for companies interested in acquiring this technology for its exploitation. Any of the various forms of technology transfer (patent license agreement, transfer of user, manufacturing or commercializing rights to third parties, etc.) may be used.

INTELLECTUAL PROPERTY RIGHTS

This technology has patent protection:

- Application number: P200503113.

- Application date: 19/12/2005.

MARKET APPLICATION (5)

Pollution and Environmental Impact
Computer Science, Language and Communication
Engineering, Robotics and Automation
Materials and Nanotechnology
Chemical Technology