Flavin-mononucleotide-doped jelly-like gelatin as a new fully biological photosensitive medium for holography and biophotonics applications

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Biophotonics is a relatively new intensively developing interdisciplinary field of research, which applies photonics technologies for investigating biological systems. On the other hand, biology is also advancing photonics, since biomaterials, in particular, biopolymers, are showing promise as new photonic media for technological applications [1]. Among them, gelatin is one of the most common biopolymers used today. A wide variety of photonics devices including miniature biological distributed feedback (DFB) lasers [2] were successfully realized based on the thin gelatin films as matrixes for holographic recording and lasing media. At the same time, not only thin dry gelatin films but also thick jelly-like gelatin layers were found to be useful for photonics applications. Earlier, jelly-like gelatin doped with laser dyes was proposed and investigated by us as a very suitable selfdeveloping photosensitive active medium for volume holography and DFB dye lasers [2, 3]. However, as applied to biophotonics, such material suffers from the use of synthetic lasing dyes most of which are harmful and toxic substances. One of the possible ways to solve this problem is replacement of synthetic dyes with natural ones.

In this work, a new registering medium – jelly-like gelatin doped with flavin-mononucleotide (FMN) as a photosensitizer is reported. Since FMN is a bioactive water-soluble form of riboflavin (vitamin B), such a medium is completely biocompatible and biodegradable. Below, some preliminary results of testing such material on its ability to store holographic information are presented.

In our experiments, we used FMN-doped 10 % water-gelatin solution placed in a sealed plane-parallel quartz cell with a thickness of ~ 1 mm. To record grating, an interference pattern with a spatial period of ~ 8 μm formed with the two intersecting *s*-polarized beams of a 488 nm CW Ar laser was employed. Optical density of the gel layer at the recording wavelength was ~ 0.9 (Fig.) upon a diameter of the irradiated zone of ~0.4 cm. The average intensity of the recording beams did not exceed ~1.7 W/cm^2. Diffraction efficiency of the obtained grating η was measured using a Bragg-matched beam from a 632 nm He-Ne laser, which is beyond the absorption band of the sample.

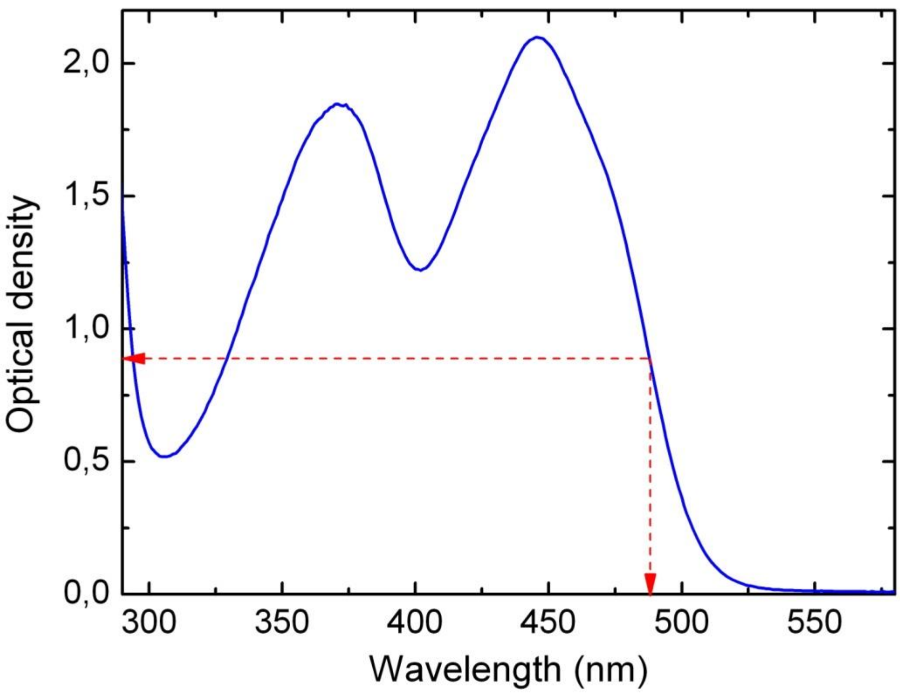

Fig. Absorption spectrum of the flavin-mononucleotide doped 1 mm thick 10 % jelly-like gelatin sample

It was found that η value progressively grows with exposure energy until it attains some maximum level η_{max}. In our case, η_{max} ~ 1.6 % was reached after ~2 min. exposure. The angular selectivity of a grating was measured to be $\Delta\theta_{0.5} \approx 18$ %. It is to be noted that irradiation of the gel was accompanied by a change in its color and an appreciable deformation of the absorption spectrum. However, within 1 to 2 days after exposure practically complete restoration of the gel irradiated zone color and absorption spectrum along with a noticeable (about two-fold) increase in the grating diffraction efficiency was observed. After ten days and two months, as a result of the postexposure self-enhancement, diffraction efficiency of a grating was measured to be ~ 10 and ~ 20 %, respectively. We expect a further increase in the diffraction efficiency of holograms with an appropriate optimization of the medium composition and experimental recording conditions. Due to its valuable properties, the proposed medium seems to be promising for creating different biophotonics devices including biological DFB lasers.

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