

## MODERN AVIATION AND SPACE TECHNOLOGY

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Hanna Bordyuh<sup>1</sup>  
Arkadiy Polishchuk<sup>2</sup>HOLOGRAPHIC GRATING RECORDING  
IN "LYOTROPIC LIQUID CRYSTAL – VIOLOGEN" SYSTEMNational Aviation University  
Kosmonavta Komarova avenue 1, 03680, Kyiv, Ukraine  
E-mails: <sup>1</sup>a.bordyuh@gmail.com; <sup>2</sup>ark.nau@gmail.com

**Abstract.** *This work presents the results of nonlinear optical experiment run on the samples of lyotropic liquid crystal (LLC) with viologen admixtures. During the experiment we obtained dynamic grating recording on bilayered LLC-viologen samples and determined main characteristics of recorded gratings. It was found out that the recording takes place in a thin near-cathode coloured viologen layer. The analysis of kinetics of thermal gratings erasing showed that contribution of a thermal nonlinearity into general diffraction efficiency is negligible small. The last fact is connected with a separation of LLC-viologen samples under the action of an electric field and heat sink into the liquid crystal layer.*

**Keywords:** diffraction efficiency; diffraction grating; lyotropic liquid crystals; nonlinear optics; viologens.

### 1. Introduction

The article [Bordyuh, Polishchuk 2012] is devoted to a detailed investigation of optical and electrooptical properties of the new-created composite liquid crystalline materials based on lyotropic liquid crystal (LLC) of Potassium caprylate doped with viologen admixtures. It was shown that there is a possibility to manage electrooptical properties of the investigated composites. Furthermore, their structural peculiarities let us foretell nonlinear properties of LLC-viologen materials.

### 2. Analysis of investigations and publications

Nonlinear properties of liquid crystals still remain insufficiently known. However, studying of nonlinear properties of the lyotropic ionic Smectic formed by Potassium caproate and doped with polymethine dyes was presented in the works [Bugaychuk et al. 2005; Garbovskii et al. 2006; Klimusheva et al. 2006]. These works prove the possibility of using doped liquid crystals for diffraction grating recording.

The **aim** of the present work is to reveal nonlinear properties of LLC-viologen composites, realize grating recording, and study the main nonlinear optical characteristics of the investigated samples.

### 3. Materials and methods

Lyotropic Liquid Crystalline phase was formed at mixing powder of a Potassium caprylate

(C<sub>7</sub>H<sub>15</sub>COO<sup>-</sup>K<sup>+</sup>) with water in 1:1 weight proportion at the room temperature ( $T = 293$  K). Then samples of LLC were doped by the viologens of two types:

N,N'-diheptyl-4,4'-dipyridilium dibromide (HD<sup>2+</sup>2Br<sup>-</sup>);  
N,N'-di(2-carboxyethyl)-4,4'-dipyridilium dichloride (CED<sup>2+</sup>2Cl<sup>-</sup>).

The viologens differ in substitutes at Nitrogen atoms and counterions. X-ray investigations [Bordyuh, Polishchuk 2012; Bordyuh 2010] have shown that the created LLC obtains the structure of Smectic A. The Smectic ordering remains when doping liquid crystalline matrix by viologen admixtures (2% by weight).

Nonlinear optical investigations of LLC-viologen samples were conducted with using glass sandwich-cells whose inner surface was covered with ITO-electrodes.

In the case of external electric field application to the cells filled with LLC-viologen composite one can observe the colouration of the samples taking place due to a reduction of viologen molecules. Thus, one-electron reduction corresponds to the formation of radical cations and blue colouration, while two-electron reduction with subsequent dimerization goes with red colour of the samples [Bordyuh 2010].

Reduction of viologens takes place near cathode which serves as an electron donor for viologen molecules. The reduction results in a formation of a bilayer cell which consists of insoluble coloured layer of viologen reduction products and a liquid crystal layer.