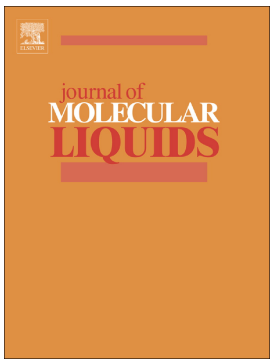

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PII: S0167-7322(17)34229-0
DOI: https://doi.org/10.1016/j.molliq.2017.12.070
Reference: MOLLIQ 8366

To appear in: *Journal of Molecular Liquids*

Received date: 11 September 2017
Revised date: 20 November 2017
Accepted date: 14 December 2017

Please cite this article as: Victor Yu. Reshetnyak, Igor P. Pinkevych, Dean R. Evans , Impact of photo-transformed molecules on two-beam energy exchange in hybrid photorefractive cholesteric cells. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Molliq(2017), https://doi.org/10.1016/j.molliq.2017.12.070

Impact of photo-transformed molecules on two-beam energy exchange in hybrid photorefractive cholesteric cells

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Abstract

We develop a theory describing two-beam energy exchange in a hybrid photorefractive cholesteric cell with photosensitive molecules. A cholesteric liquid crystal (LC) layer is placed between two inorganic substrates. One of the substrates is photorefractive. Weak and strong light beams are incident on the hybrid cell. The interfering light beams induce both a periodic space-charge field in the photorefractive substrate and the photo-transformed molecules (PM) in the LC layer. The PM have the helical twisting power different from that of the initial molecules. The space-charge field penetrates into the cholesteric LC slab and modulates the director interacting with the LC flexopolarization. The PM are periodically distributed in the cell and modulate the cholesteric pitch. The periodic director modulation (director grating) arising in the cell is a sum of two in-phase gratings, the flexoelectric effect driven grating and the PM-driven grating. The director grating gives rise to the dielectric permittivity grating. Each light beam diffracts from the induced permittivity grating leading to an energy exchange between the beams. We calculate the signal beam gain coefficient and analyze its dependence on the PM parameters and concentration. We show that doping the LC with photosensitive molecules provides a control of the gain of the two-beam energy exchange in the hybrid cholesteric cell.

Keywords: liquid crystals; director grating; photosensitive molecules.
PACS: 42.70.Df, 42.79.Kr, 42.65.Hw

1. Introduction

Two light beams coupling and energy transfer between them due to the photorefractive effect in solid inorganic crystals is a well-known effect [1]. In hybrid organic-inorganic photorefractives a liquid crystal (LC) sample is placed adjacent to a solid photorefractive layer or between two solid photorefractive layers. Incident intersecting coherent light beams interfere and generate space charges in the inorganic photorefractive layers. These charges create a spatially modulated space-charge field, which penetrates into the adjacent LC layer, causing a director-modulation-induced grating of the LC permittivity. Both incident light beams propagate across the LC layer and diffract on the grating. Due to the beams coupling on the grating, one of the beams is amplified. For the LC systems, very strong two-beam energy transfer between coupled beams has been observed with the gain coefficient values more than two orders of magnitude larger than those in solid inorganic photorefractive crystals (see Refs. [2–7] and references therein).

In discussing the formation of a director grating in hybrid organic-inorganic photorefractives in our previous paper [8], we supposed that the light-induced space-charge electric field penetrating from photorefractive substrates into LC couples with the director through interaction with the LC flexoelectric polarization, rather than through the LC static dielectric anisotropy [9, 10]. Together with the additional assumption that the magnitude of the director grating is a non-linear function of the space-charge field, it allowed for a description of the experimental results obtained for both the nematic [8] and cholesteric LC cells [11, 12].

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