PHOTOCHROMIC MATERIALS IN HOLOGRAPHY

R. A. LESSARD\textsuperscript{a}, C. LAFOND\textsuperscript{a,b}, A. TORK\textsuperscript{a,c}, F. BOUDREULT\textsuperscript{a}, T. GALSTIAN\textsuperscript{a}, M. BOLTE\textsuperscript{b}, A. RITCEY\textsuperscript{c} and I. PETKOV\textsuperscript{d}

\textsuperscript{a} Centre d’optique et Photonique et Laser, Département de Physique Faculté des Sciences et Génie, Université Laval, Québec, G1K7P4, Canada
\textsuperscript{b} Laboratoire de Photochimie Moléculaire et Macromoléculaire Université Blaise Pascal F-63177 Aubière Cedex France
\textsuperscript{c} CERSIM, Département de Chimie, Faculté des Sciences et Génie, Université Laval, Québec, G1K7P4, Canada
\textsuperscript{d} Department of Organic Chemistry, University of Sofia, 1 James Bouchier Avenue, 1126 Sofia, Bulgaria

Abstract

Fulgide Aberchrome 670-doped polymer films were studied. Two approaches were considered: photochemical characterization and holographic recording. In PMMA matrix, the closed form presents a maximum of absorption centered at 525 nm upon irradiation at 365 nm. We have determined the photoreaction rate constants $k_{\text{UV}}$ and $k_{\text{VIS}}$ respectively for the coloring and bleaching process: $k_{\text{UV}}=1.2\times10^{-3}$ s\(^{-1}\) and $k_{\text{VIS}}=1.1\times10^{-3}$ s\(^{-1}\). Photochemical fatigue resistance in different polymer matrices was investigated. We found a loss of 9, 11, 13 and 35\% respectively in PS, CA, PMMA and PVK. Concerning holographic recording, we obtained diffraction efficiency $\eta=0.65\%$ in PMMA films 30 \(\mu\text{m}\) thick.

1. Introduction

Properties of photochromic compounds introduced in polymer films are of great interest because of their practical use in holographic recording\textsuperscript{1,2}. Among these systems, fulgides\textsuperscript{3,4} are of particular concern. Organic photochromism is usually defined as the reversible color change of a molecule upon irradiation with UV or visible light\textsuperscript{5}. The photoreaction between the involved species proceeds via electronically excited states and causes a change on molecular structure or conformation, thereby altering the UV/visible absorption spectra of the sample.

Fulgides show completely reversible photochromism. We studied the 2-(1-(2,5-Dimethyl-3-furyl)ethylidene)-3-(2-adamantylidene) succinic anhydride\textsuperscript{6} 1 known in commerce as Aberchrome 670 (figure 1). The 1E-isomer (open form) presents an

absorption band only in UV (between 320 and 400 nm). Therefore, upon UV irradiation, at 365 nm, a coloring process due to an electrocyclic ring-closure occurs, leading to the formation of the deeply colored 1C-isomer (closed form) which presents a strong absorption in the visible. Irradiation with visible light at 514 nm (bleaching process) induces back-conversion to the open form. However, upon UV irradiation, side reactions such as E/Z isomerisation, occurs and implies formation of non-photochromic Z-isomer but, in solid matrix, this process is less prevailing compared in solution.

In this study, first, we have described the photochemical characterization of Aberchrome 670 in polymethylmethacrylate, PMMA, matrix (absorption spectral changes, and kinetic study upon irradiation). Moreover, one of the indispensable properties required should be high resistance to photochemical degradation. In these conditions, we have compared the photochemical fatigue resistance of this fulgide in different polymer matrices (PMMA, polyvinylcarbazole (PVK), polystyrene (PS), and cellulose acetate CA) under UV and visible irradiation cycles. Next, for two polymer matrices (PMMA and CA), we have compared the photochemical fatigue resistance between fulgide Aberchrome 670 and the spiropyran :1’,3’,3’-Trimethylspiro-8-nitro-2H-1-Ben-zopyran-2’,2’-Indoline 2. Figures 1 et 2 shows the photochemical reactions between both molecular species.

Finally, for fulgide A670, we have studied the real-time holographic recording in PMMA and CA films.