# Photochromic properties of 1′,3′,3′-trimethyl-6-nitrospiro[2H-1-benzopyran-2,2′-indoline] doped in PMMA and epoxy resin thin films

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**Abstract**

**Purpose** – The purpose of this paper is to evaluate the photochromic performance of photochromic compounds in polymer matrices.

**Design/methodology/approach** – The poly(methyl methacrylate) (PMMA) and epoxy resin doped with photochromic spirobenzopyran were prepared and the effects of ultraviolet (UV) irradiation were studied using spectrophotometer. The reversible reaction was effected using white light. Photochemical fatigue resistance of these films was also studied.

**Findings** – Irradiation of colourless 1′,3′,3′-trimethyl-6-nitrospiro[2H-1-benzopyran-2,2′-indoline] spiropyran (SP) doped in PMMA and epoxy resin with UV light (366 nm) results in the formation of an intense purple-red coloured zwitterionic photomerocyanine (PMC). The reverse reaction was photochemically induced by irradiation with white light. Photocolouration of SP doped in PMMA follows a first-order rate equation ($k = 0.0011\ s^{-1}$), while that doped in epoxy resin deviates from linearity. It was found that photobleaching follows a first-order equation in both matrices. The photobleaching rate constant of PMC in both matrices is the same and equals $0.0043\ s^{-1}$. Spirobenzopyran doped in PMMA shows better fatigue resistance than that doped in epoxy resin.

**Research limitations/implications** – The PMMA and epoxy resin polymers doped with photochromic spirobenzopyran described in the present paper were prepared and studied. The principle of study established can be applied to any type of polymer or to any type of photochromic compounds.

**Practical implications** – The photochromic materials developed can be used for different applications, such as coatings and holography.

**Originality/value** – The method developed may be used to enhance the performance of photochromic materials.

**Keywords** Films (states of matter), Electromagnetic radiation, Epoxy resins, Thermoplastic polymers

**Paper type** Research paper

## Introduction

Since the discovery of the photochromic reactions of spiropyrans (SPs) in 1952 by Fisher and Hirshberg (1952) and Hirshberg's announcement in 1956 of the possible use of photochromism as a "photochemical erasable memory" (Hirshberg, 1956), intensive investigations of the photochromic and thermochromic properties of SPs were undertaken (Berkovic *et al.*, 2000). SPs, one of the promising families of organic photochromic compounds, have found various applications in ophthalmic lenses, display and communication systems, and optoelectronic devices, such as memories and switches (Raschella *et al.*, 2006; Katsonis *et al.*, 2007), and nonlinear optics (Berkovic *et al.*, 2000). SPs have been recently used as nucleic acid hybridisation probes (Guo *et al.*, 2005), as photoswitching of protein activity (Tomizaki *et al.*, 2005), and as optical control of ion penetration through biological membranes (Kumar *et al.*, 2008). The recent interest in the photochromism of SPs is due to their fast colouration rate under UV irradiation, fast thermal fading and excellent fatigue resistance which are crucial for their use.

The photochromism of these colourless or weakly coloured spiro compounds SP arises from the photo cleavage of the C—O spiro bond upon the UV irradiation. Such cleavage results in the formation of an intense coloured zwitterionic open form known as photomerocyanine (PMC) which absorbs in the visible region. The reverse reaction (bleaching) proceeds thermally or under irradiation with white light (Scheme 1). Time-resolved absorption spectroscopy (Zhang *et al.*, 1992; Tamai and Miyasaka, 2000) and nuclear magnetic resonance studies (Berthet *et al.*, 2006) reveal the coexistence of several quinoidal isomers of the zwitterionic open form depending on solvent or medium polarity and temperature. In continuation to our interest in the synthesis and photochromic properties of organic photochromes, we have studied several photochromic compounds such as fulgides, spironaphthooxazine and spirobenzooxazine (Asiri, 1997; Bahajaj and Asiri, 2006, 2007, 2008; Bahajaj *et al.*, 2008). Now, we report the

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