Photomobile properties of liquid crystal polymers with or without azobenzene units and carbon-based particles

A. De Girolamo Del Mauro [*a], F. Loffredo [a], F. Villani [a], M. F. Caso [a], T. Fasolino [a], R. Miscioscia [a], A. Vestri [b], D. Sagnelli [b], A. D'Avino [b], L. Petti [b], G.Nenna [a]

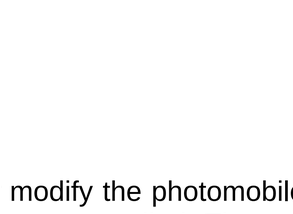
[a] ENEA, Portici Research Centre, I-80055 Portici, Naples, Italy
[b] ISASI-CNR, I-80072 Pozzuoli, Italy;
* anna.degirolamo@enea.it

ABSTRACT

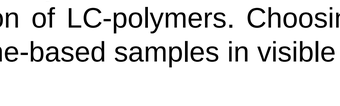
In this work, the possibility to induce or modify the photomobile properties of liquid crystal polymers by introducing different concentrations of carbon black (CB) (from 0 up to 1 wt.%) in polymers containing or not azobenzene mesogens was studied. These units can undergo a reversible photoisomerization from trans to cis configuration in presence of UV light by inducing bending in the corresponding films. The morphological and optical properties, as well as and the photomobile behavior of pristine and composite films, were investigated and compared. Concerning the photomobile properties, photoresponsivity measurements were studied in the wavelength range 457-747 nm to investigate how the presence of the CB affects the photomobile response inside and outside the absorption spectral region of LC-polymers. Choosing appropriately the CB concentration, it is possible to induce photomobile behavior in not active polymers or enlarge the usable spectral bandwidth of the azo-benzene-based samples in visible region towards the visible and near infrared spectral region.

INTRODUCTION

Liquid Crystal-Photopolymer (LC-POL) are smart materials based on crosslinked elastic polymers chemically bounded to liquid crystal and azobenzene mesogens.
The mesogens present in the polymer can exhibit spontaneous orientational ordering. [1-3].
Azobenzene derivatives are photochromic molecules, which show reversible trans–cis isomerization under light irradiation [4] leading to the film deformation up to a macroscopic level [4-7] . The result is the macroscopic contraction of the sample. The process is reversible because cis azobenzenes isomerize back to their trans forms upon irradiation with visible light or heating and the sample returns to the initial state. In order of sensitizing LC-POLs to light, different routes can be investigated as for example incorporation of photochromic groups and/or nanoparticles [5,8].
In this work, the effect of low concentration of carbon black (CB) in LC-POL with and without azobenzene unit was studied. CB was chosen as filler to induce photoactive properties in the polymer because it is a low cost, commercially available filler having high absorption of the solar spectra and good thermal conductivity.

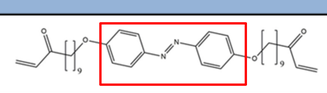
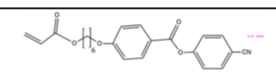
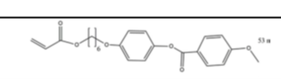
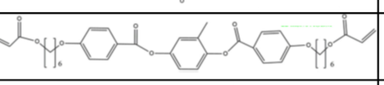
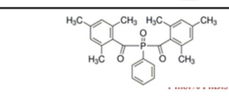


Isomerization of azobenzene derivatives

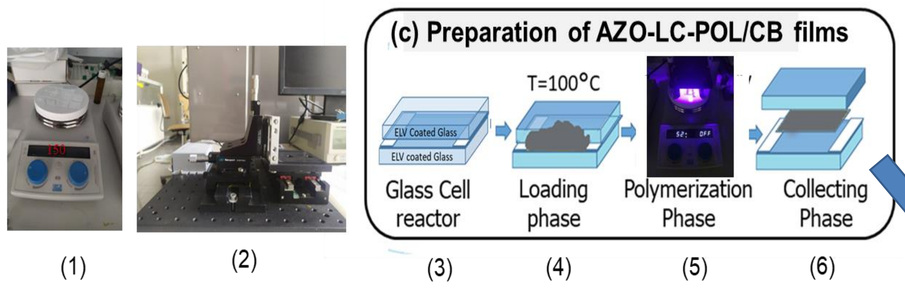


The isotropic *cis* occupies less space and disturbs the LC phase inducing the bending of the films under UV light

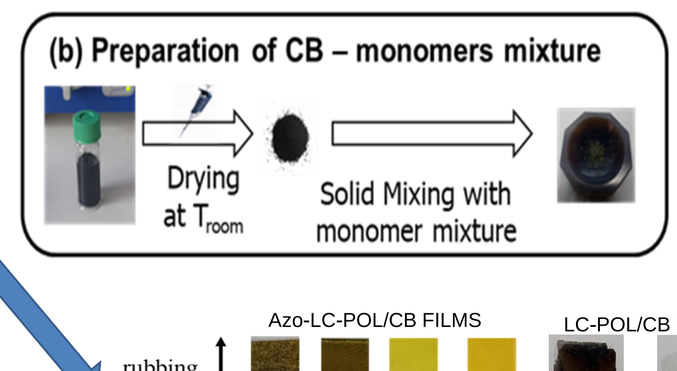
MATERIALS AND FILM FABBRICATION PROCESS

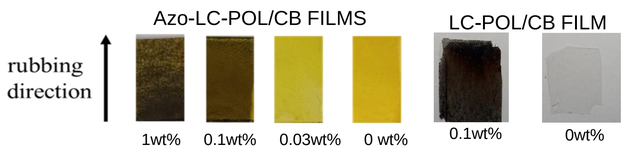
	Monomers	Mol% Azo-LC_POL	Mol% LC_POL
AZO crosslinker		6	0
monomer		18	18
monomer		53	53
monomer		22	28
photoinitiator		1	1

- **Carbon Black Filler Powder**



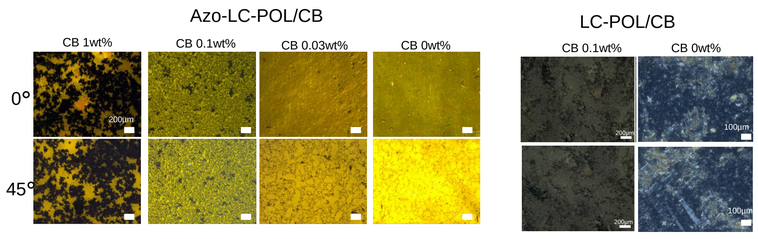
(1)Elvamide (ELV) deposition by spin-coating and thermal treatment at 150°C for 1h
(2) Rubbing process optimitation
(3) Cell preparation
(4) Infiltration of reaction mixture at temperature of 100°C
(5) UV polymerization
(6) Sample detachment





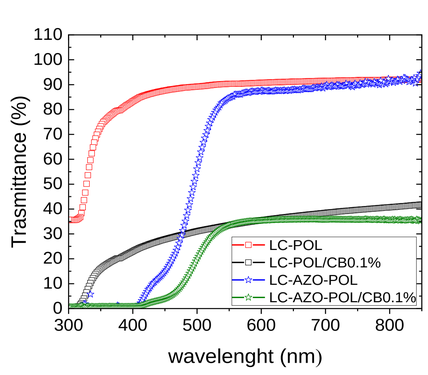
RESULTS

MORPHOLOGICAL AND OPTICAL CHARACTERIZATION (BY POLARIZED MICRSOSCOPY)

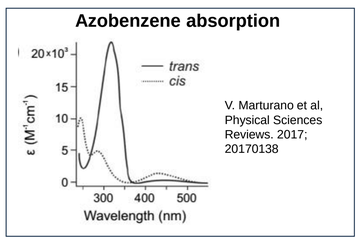


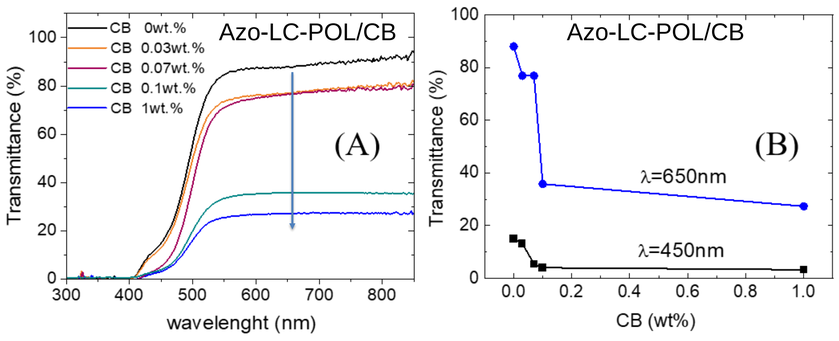
The change of intensity for pristine Azo-LC-POL and its composites with CB wt%<0.1% suggests that in these samples there is the presence of orientational organization.

UV-VISIBILE CHARACTERIZATION



- Differences between pristine polymers are visible for λ<500nm where Azobenzene units absorb.
- For both types of composites, the presence of CB induces a decrement of transmittance for all the investigated λ

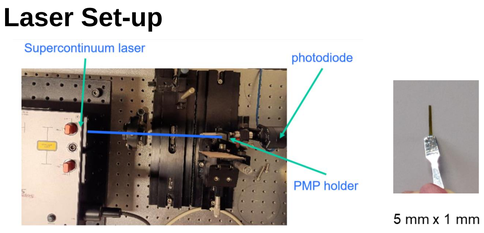




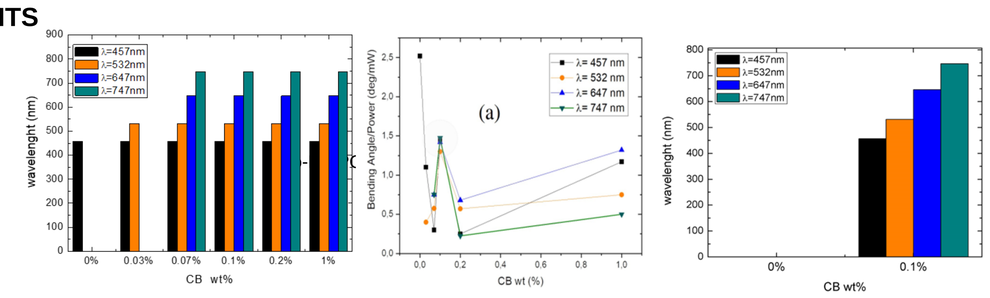
Already with small wt% of CB is possible to tune the optical properties of the polymers

PHOTORESPONSIVITY AT DIFFERENT WAVELENGHTS

Laser Set-up



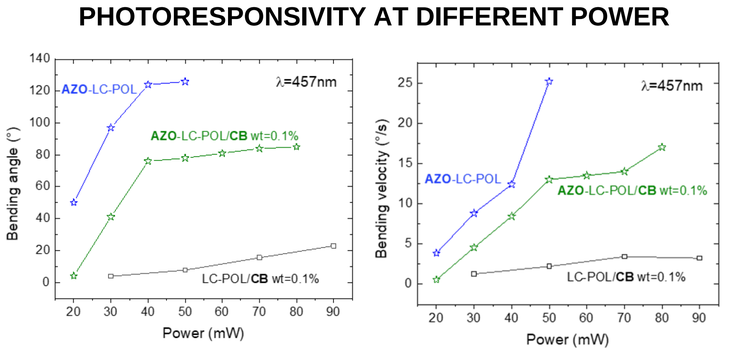
The lasers used are:
- 532 nm green DPSS (Diode-Pumped Solid-State) laser
- 457nm Solid-State laser
- Supercontinuum laser (NKT Extreme)



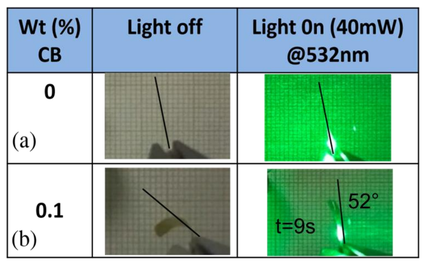
- Azo-LC-POL shows photomobile behaviour only at 457nm
- The 532nm-laser induces bending in all the composites but not in pristine AzoO-LC-POL one
- Laser with λ>600nm can induce bending in the samples with ≥0.07wt% CB
- For all λ the Azo-LC-POL/CB film with 0.1wt% of CB presents the greatest bending angle

Photomobile behaviour is observed only in LC-POL/CB

PHOTORESPONSIVITY AT DIFFERENT POWER

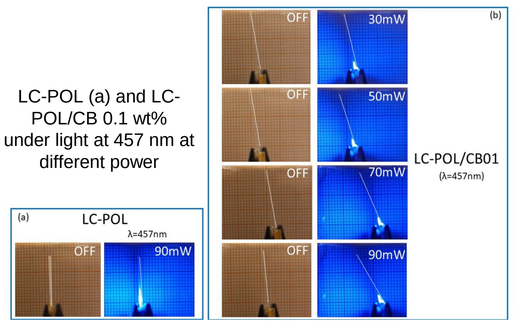


Azo-based-POL films show the best perfomance in terms of bending and speed



Azo-LC-POL/CB 0.1wt% under light at λ =532nm P=40mw

LC-POL (a) and LC-POL/CB 0.1 wt% under light at 457 nm at different power

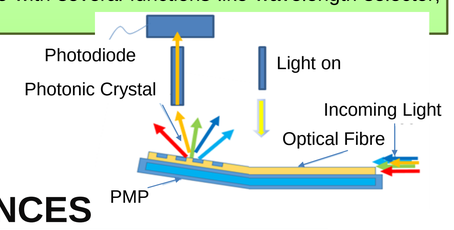


CONCLUSIONS

- ❑ Azo-LC- POL and LC-POL composites with CB were prepared and characterized.
- ❑ The results show that by introducing low amounts of CB is possible to induce photoresponsivity at wavelengths in the visible range where the corresponding pristine polymers do not present photomobile behaviour. The best performance is observed for Azo-LC-POL with 0.1 wt% CB

These results open new perspectives through the employment of carbon-based materials in PMP films to exploit the entire solar spectrum. This could be useful to move small solar cells and orientated them, as the conventional tracker, with the solar source during the entire day.

Furthermore, the possibility that the PMP can be bent or twisted by means of a light source allows to obtain innovative optical reconfigurable networks that can be used in various fields including those related to the telecommunications fields. In particular, realizing a photonic crystal on top of a fiber fabricated on the PMP we could be able to tune the wavelength coupled into another fiber realizing a sort of photonic device with several functions like wavelength selector, de-multiplexer or even a spectrometer.



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