Optical performance of highly oriented nanofibers of very efficient organic nonlinear materials

E. de Matos Gomes[*], D. Isakov[*], M. S. Belsley[*], M. M. M. Raposo[#], R. M. F. Baptista[#], S. P.G. Costa[#], M. Margarida R. Costa[%], B. Almeida[*], S. Fernandes[*], P. Sá[*]

[*]Departamento de Física, Universidade do Minho, Braga, Portugal
[#] Departamento de Química, Universidade do Minho, Braga, Portugal
[%] Departamento de Física, Universidade de Coimbra, Coimbra, Portugal

emg@fisica.uminho.pt

The intense interest in organic chromophores having strong second harmonic generation (SHG) performances is related to their possible use in low cost electro-optic devices such as high-speed photonic switching and electro-optic modulators.

The basic scheme for obtaining organic second-order nonlinear optical (NLO) materials involves placing chromophores that exhibit large first hyperpolarizabilities, β, within a macroscopic organization of microscopic molecular building blocks to produce a noncentrosymmetric crystal packing. In general, dipolar second-order NLO chromophores consist of a π-conjugated bridge end-capped with strong electron donor and acceptor substituents (D−π−A).[1]

We report on a simple and generic technique to achieve a macroscopic departure from centrosymmetry, based on the preparation of nanofibers of stable organic nanocrystals using the electrospinning technique,[2]. This is capable of producing highly efficient organic electrooptic and nonlinear optical materials. We demonstrate that electrospinning is a very effective tool for producing uniaxially aligned nanofibers of (D−π−A) organic chromophores with anisotropic properties and discuss their nonlinear optical performance. Highly aligned nanofibers of both well established organic NLO materials like 2-methyl-4-nitroaniline and new arylthienyl- and bithienylbenzothiazoles[3-4] have been produced using a rotating drum collector. They consist of organic NLO functional nanocrystals embedded within a polymeric matrix.

X-Ray diffraction studies show that the chromophores exhibit highly uniform orientations within the nanofibers having their dipole moment directed along the fibers axis behaving like a “single-crystal”-like layer.

Optical second harmonic generation polarimetry reveals a high degree of molecular alignment within the fibers and demonstrates the effectiveness of the nanofibers in generating second harmonic light. Benzothiazole heterocycles are also used for several optical applications in materials chemistry (eg OLEDs) due to their fluorescence.[5] Fluorescence studies of the fiber containing arylthienyl- and bithienylbenzothiazoles were also performed showing that these novel materials exhibit also fluorescence properties. Moreover the λ_{em} of the fiber compared to the λ_{em} of the benzothiazole solution showed a bathochromic shift of 34 nm.

A discussion about the influence of fiber morphology and structure on the propagation of light will be undertaken in view of the potential technological applications.

References

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