Bio-inspired materials are obtained from natural molecules or macromolecules. They are environmentally friendly and can be considered as good as synthetic ones, when used as biopolymers. The main advantage of natural macromolecules is that they are abundant in nature and extracted not only from fast growing plants, but also from agricultural or fish industry waste, such as sugar cane bagasse, shrimp carapace, fruit skins, etc. The other advantages is that they are biocompatible, biodegradable, renewable, which is very important to preserve our environment. The most important natural macromolecules are polysaccharides, proteins, deoxyribonucleic acid (DNA) and natural rubber. DNA, extracted from fish industry waste, is a promising material that can be used in different applications, such as optoelectronics.

The purpose of BIOMOLEC (Functionalized biopolymers for application in molecular electronics and in photonics) project was to render biopolymers such as DNA and collagen stable and applicable in photonics and in molecular electronics by appropriate functionalizations. This project between the partners with different, although complementary expertise, allowed a multidisciplinary approach at the interface of organic chemistry, physics, materials science, molecular and material engineering for environment friendly technologies with sustainable, renewable resources.

Natural macromolecules are mostly water soluble, and this could be a problem for some applications. However, it is possible to improve their physicochemical properties through chemical or physical derivatizations. As an example, substitution of DNA sodium counter ions, from salmon sperm extraction, by hexadecyltrimethylammonium chloride (CTMA) cations results in changing DNA solubility from water to low polar organic solvents such as butanol (Fig. 1).

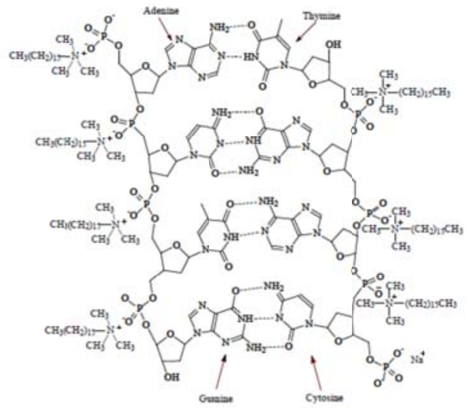

Fig.1: DNA-CTMA complex

The DNA–CTMA complex , which is processable into good optical quality thin films has been shown to be a promising matrix for several applications. The most relevant results obtained during these 4 years are summarized in the following :

- In the field of photonics, DNA was shown to represent an improved environnement for enhanced luminescence properties: due to the specific double strand helical structure offering a possibility of intercalation and /or a protective role, which minimise aggregation for small molecules, push-pull fluorescent chromophores have been shown to present a significant larger luminescence quantum yield in DNA–CTMA, compared to that observed in a synthetic polymer such as polymethyl methacrylate (PMMA). This represents a promising results for bio-imaging applications.
- Nonlinear optical (NLO) DNA based materials were also designed for applications in photonics.

First, the Third Harmonic Generation (THG) of thin films of DNA–CTMA complex doped with Disperse Red1 chromophore has been investigated. The variations of the THG susceptibility was analyzed as a function of dye concentration in terms of intercalation and/or aggregation.

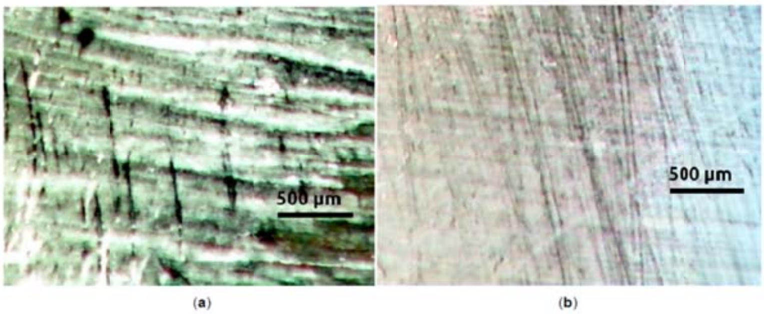

Fig.2: 532 nm laser-induced gratings within LC doped by C_{70} (a) and DNA (b)

More importantly, the NLO photorefractive effect, which leads to a refractive index alteration under irradiation for applications in the field of display panels, was studied, using an holographic technique, in several organic matrices, such as nematic liquid crystals, doped with nano or bio-objects. The Figure 2 displays laser induced gratings within LC doped by C_{70} and DNA.

- DNA has been shown to be promising material for ionically conducting membranes to be used in electrochemical devices such as electrochromic or dye sensitized solar cells (DSCC). Electrochromic devices have been shown to be attractive for the development windows in cars buildings, aircrafts or sunglasses.

DNA and modified DNA were doped with different dyes, and the colored or colorless membranes (Fig. 3) were applied in electrochromic devices with a color modulation under applied potential.

Fig.3: DNA-based membranes

For applications in DSCC, membranes were investigated as either hole carrier material (HTM) or polymer electrolyte, since some membranes present interesting ionic conductivity. The DNA-based samples as HTM in small DSSCs revealed a solar efficiency of 0.56%, while polymer electrolyte exhibited a solar efficiency of 0.66%.

In conclusion, this European project allows to obtained promising results, using natural macromolecules, which are not only environmentally friendly but could be also promising as materials for several applications devices in molecular electronics, photonics.