Publishable summary

The NEMEDES project (Figure 1) concerns the production of novel electrochromic (EC) materials based on monomers having Donor-Acceptor-Donor (D-A-D) structures for application in multicolored electrochromic devices (ECDs) that have exceptional operating characteristics and enhanced stability. In face of the contemporary state of the art, the aim of the project is that the produced copolymers have proper absorption spectra through the entire visible region, given that most of the EC polymers are limited with one or two colours. Even though there are some multichromic polymers, they do not cover the entire visible spectrum and they have several important disadvantages, such as low stability and poor processability. As a first step, novel monomers were designed and synthesized (Figure 2). For the production of the polymers, two different polymerization techniques were used, namely chemical polymerization and electropolymerization. In the case of electropolymerization, bis-3,4-ethylenedioxythiophene- (EDOT) and bis-thiophene- derivatives with an acceptor unit between were used as electron donors; this way, the side reactions were suppressed. The approach to design the monomers and their polymerization procedures (in order to produce polymers with strictly defined structures) is expected to lead in ECDs with exceptional operating characteristics and enhanced stability. The polymers produced were investigated with many techniques and they were applied to ECDs, both single- and dual- layer. The operational characteristic of the devices, as well as their stability was studied.

The technology that was developed for the novel multicolored polymer ECDs, starting from monomer synthesis to copolymerization to device manufacture, is designed bearing in mind that it should not be limited for laboratory bench-scale experiments, but in way that permits its straightforward scaling up. The results that were derived from the NEMEDES project concerning the EC polymers and their ECDs are remarkable and important and they are summarized below.

EC polymers

- Novel monomers based on D-A-D structures were designed, synthesized and characterized.
- Polymer films were obtained by electropolymerization of the corresponding monomers. The novel EC films were deposited directly on indium tin oxide (ITO) electrodes.
- It was found that the optical, electrochemical, nanomechanical properties, as well as the morphology of the polymers, depend strongly on the electron acceptor or donor used.
- The films are well adhered onto ITO electrodes and they are stable during the potential switching.
- The spectroelectrochemical properties of EC films were studied by in-situ UV-Vis method, in order to measure the dependence of the spectra in relation to the applied potential. ***The polymers exhibited multicoloured electrochromic behaviour, are stable and they switched their colours depending on the potential. It was important that we managed to obtain the three basic colours (green, blue and red/indigo) in both neutral and oxidized states (Figure 3).***

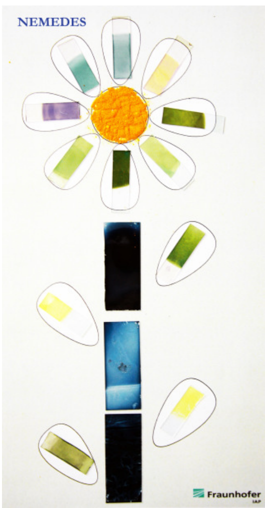
EC devices

✓ The EC polymer films were used for manufacturing single- and dual- layer ECD.
✓ By optimizing the construction procedure for the ECDs, the necessary know- how was developed.
✓ ***The single layer devices exhibited one colour change during their doping-dedoping cycles.***
✓ ***The dual devices had better respond time and were true multi-coloured (i.e. they exhibited more than one colour change).***
✓ ***The devices show a promising performance, switching time, stability and they can be the applied for manufacturing improved ECDs at commercial scale.***

The web page of the NEMEDES is active since August 2013, http://www.iap.fraunhofer.de/de/Forschungsbereiche/Funktionale_Polymersysteme/polymere_und_elektronik/elektroaktive_polymere1.html

Contact Details:
Despoina Triantou, Dr.Chemical Engineer/Marie Curie Fellow
Fraunhofer Institute for Applied Polymer Research, Department 'Polymer and Electronics'
Geiselbergstraße 69, 14476 Potsdam-Golm
Email: dstrian@gmail.com

Figure 1. A flower constructed by ITO electrodes with differently EC films, all of them deposited by electropolymerization (logo of the NEMEDES).
Figure 2. Flow sheet for the implementation of the project
Figure 3. Colour pallet of the polymers synthesized (at different oxidation states)



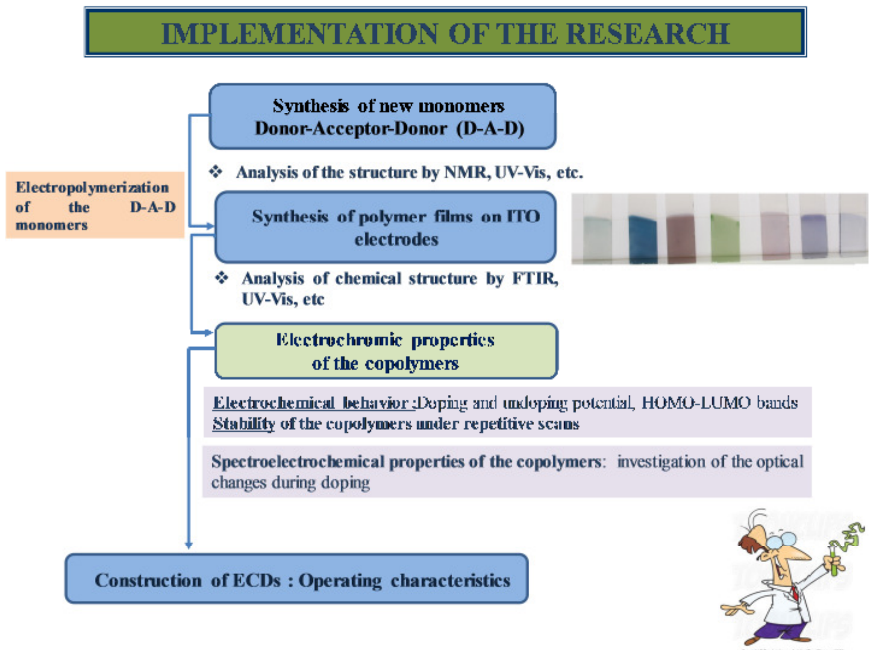


Figure 1. A flower constructed by ITO electrodes with differently EC films, all of them deposited by electropolymerization (logo of the NEMEDES).

Figure 2. Flow sheet for the implementation of the project

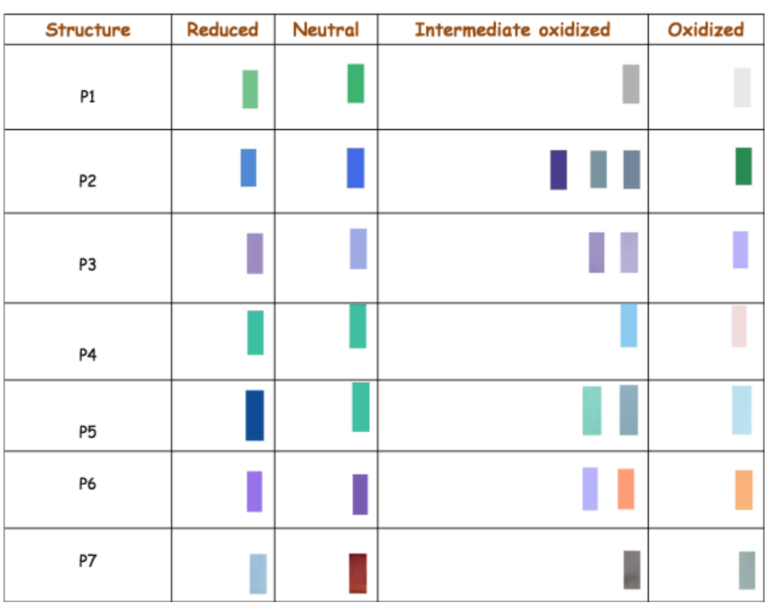


Figure 3. Colour pallet of the polymers synthesized (at different oxidation states)