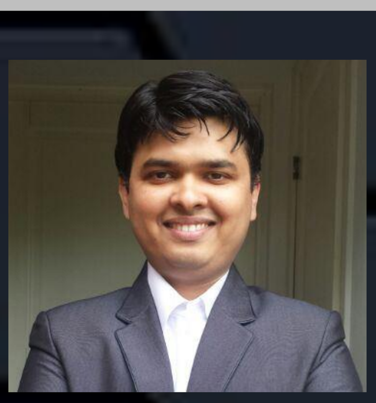


An Electrostatically Stable Polyviologen-Reduced Graphene Oxide Composite Films for Future Electrochromic Displays

Bhushan Gadgil*, Pia Damlin and Carita Kvarnström

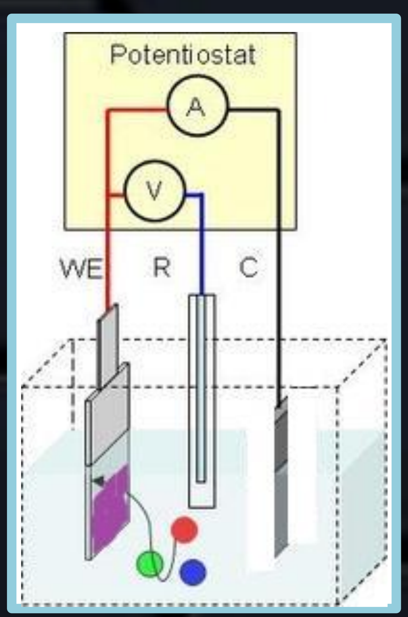
E-mail: bhushan.gadgil@utu.fi

Turun yliopisto University of Turku

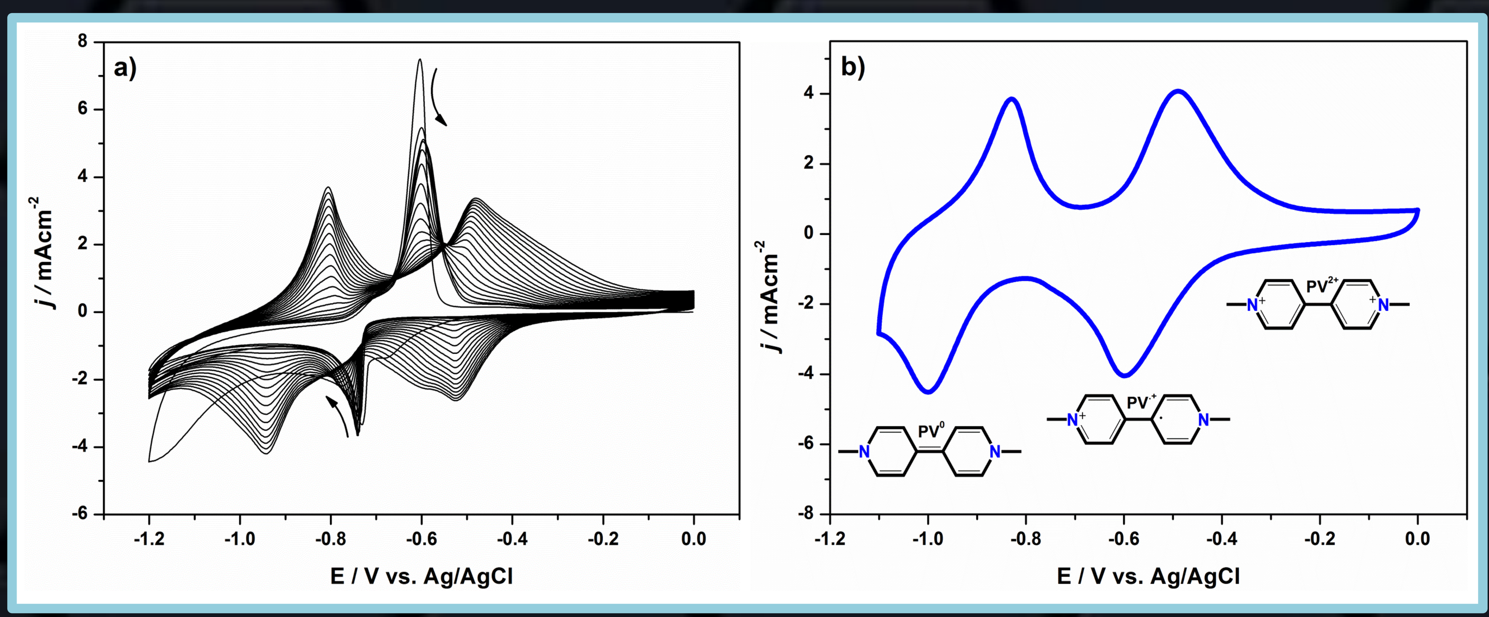
Background & Motivation

- Electrochromism (EC) involves electroactive materials that show a reversible color change by virtue of redox reaction when a small DC voltage is applied.
- The importance of viologens in the field of electrochromic materials is well known due to their intensely colored radical cation formation. Recently, graphene emerge as a transparent conducting material useful in display device applications.
- In this work, polyviologen (PV)-reduced graphene oxide (rGO) nanocomposite films were fabricated by one-step reductive electropolymerization of cyanopyridinium based monomer (CNP) in an aqueous dispersion of GO.
- Comparative studies between PV and PV-rGO films on FTO were performed to check the EC performance of films.
- Applications: EC windows and mirrors used in airplanes & automobiles, displays, solar control windows, mirrors etc.

Experimental

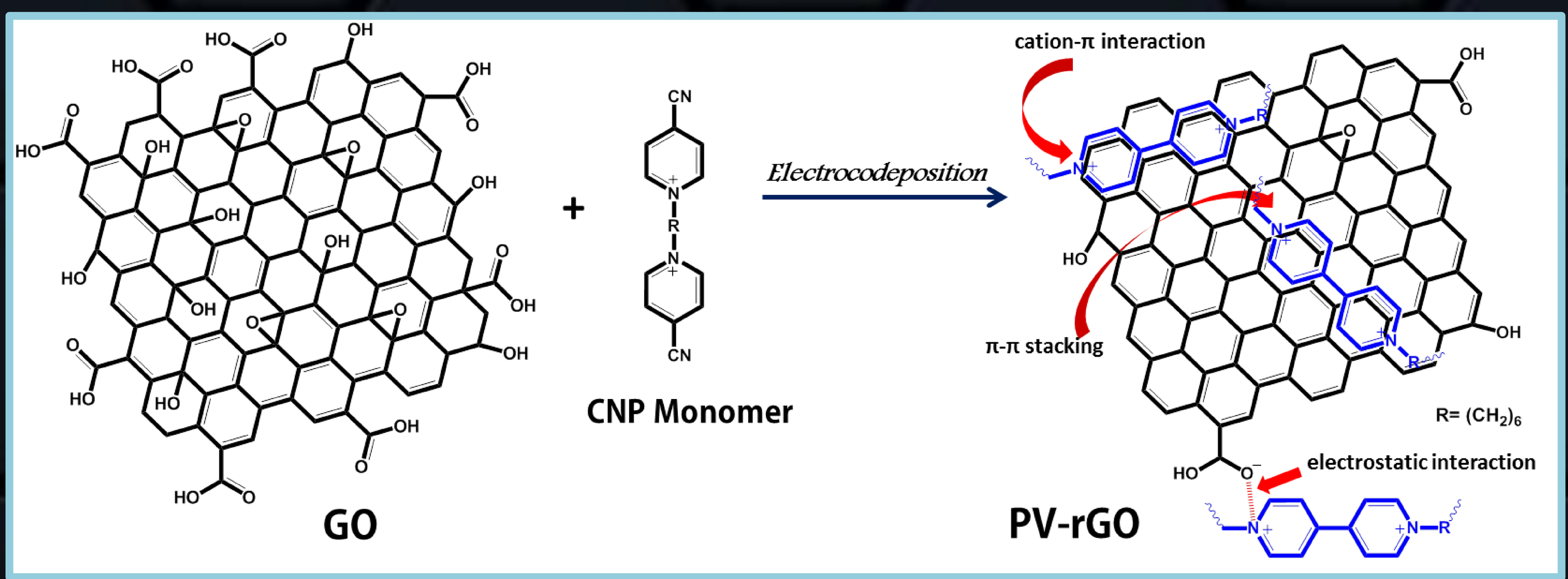


Electrochemical setup for thin film deposition



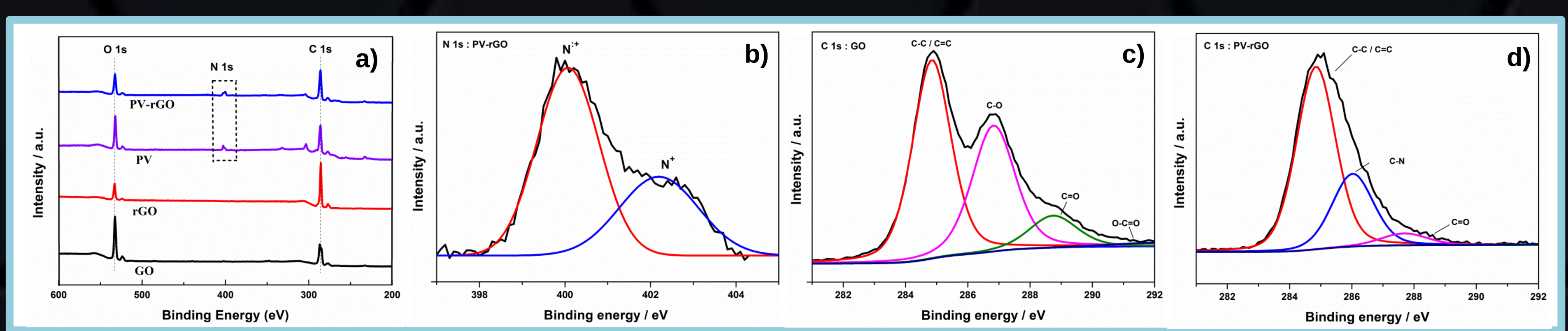
a) CVs of the electrocodeposition of CNP-GO dispersion on FTO substrate in 0.1 M KCl aqueous solution. b) Corresponding CV of PV-rGO film.

- Electropolymerization of CNP to PV & electroreduction of GO to rGO occurred in one step & within the same potential window (0 to -1.2 V).

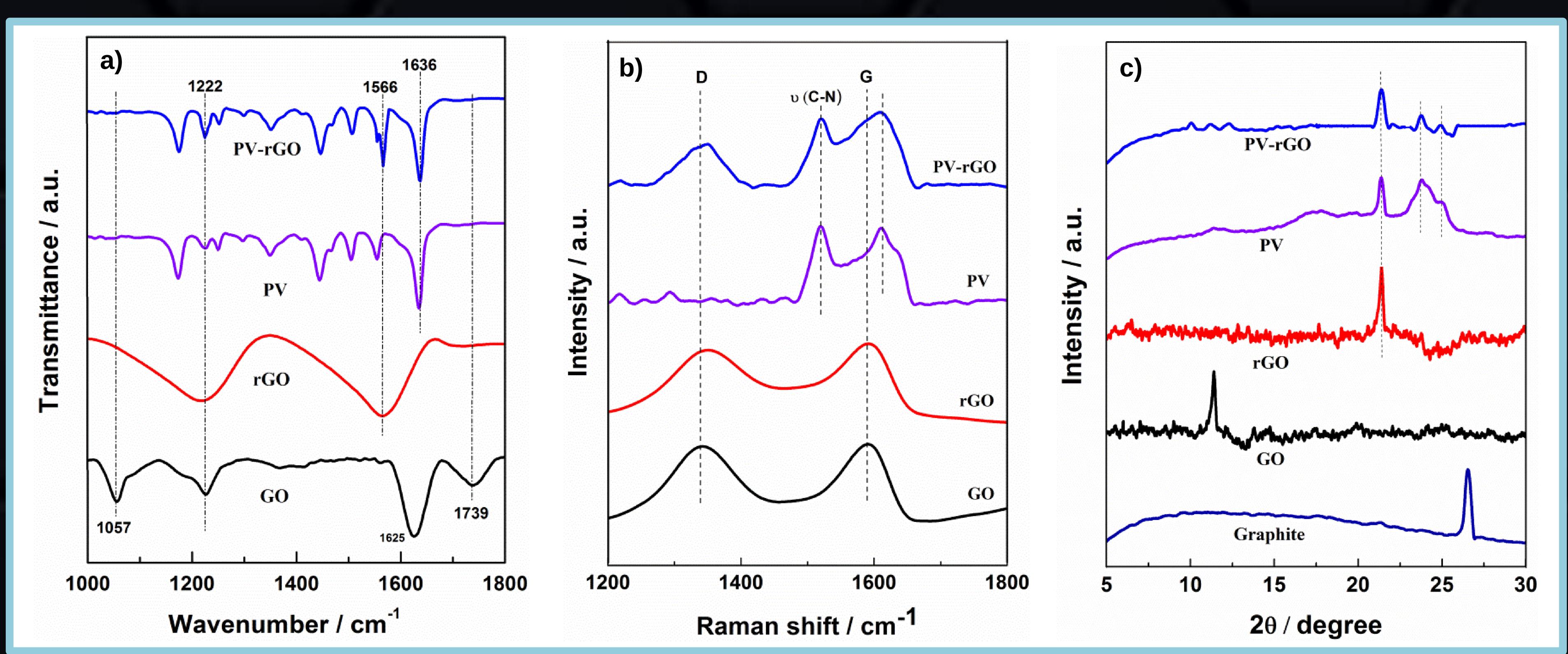


Schematic of GO and its electrocodeposition with CNP monomer to yield PV-rGO nanocomposite and illustration of possible non-covalent interactions in PV-rGO structure.

Surface & Spectral Analysis

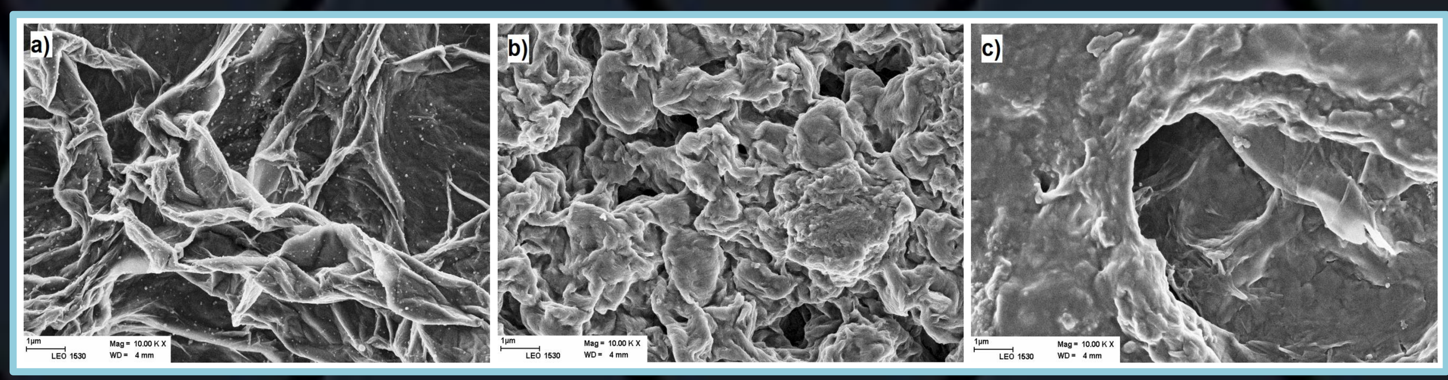


a) XPS survey spectra of the samples, b) N 1s XPS spectra of PV-rGO, and c, d) C 1s XPS spectra of GO and PV-rGO.



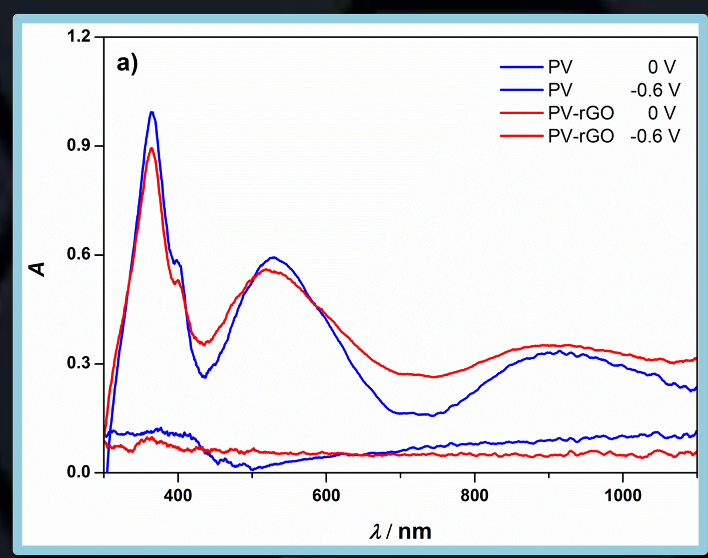
a) FTIR spectra, b) Raman spectra and c) XRD patterns of the samples.

Microscopy

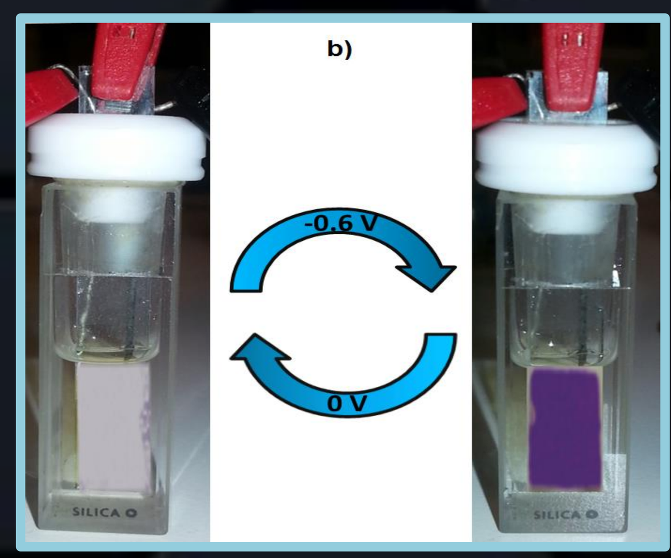


SEM images of a) GO, b) PV and c) PV-rGO films.

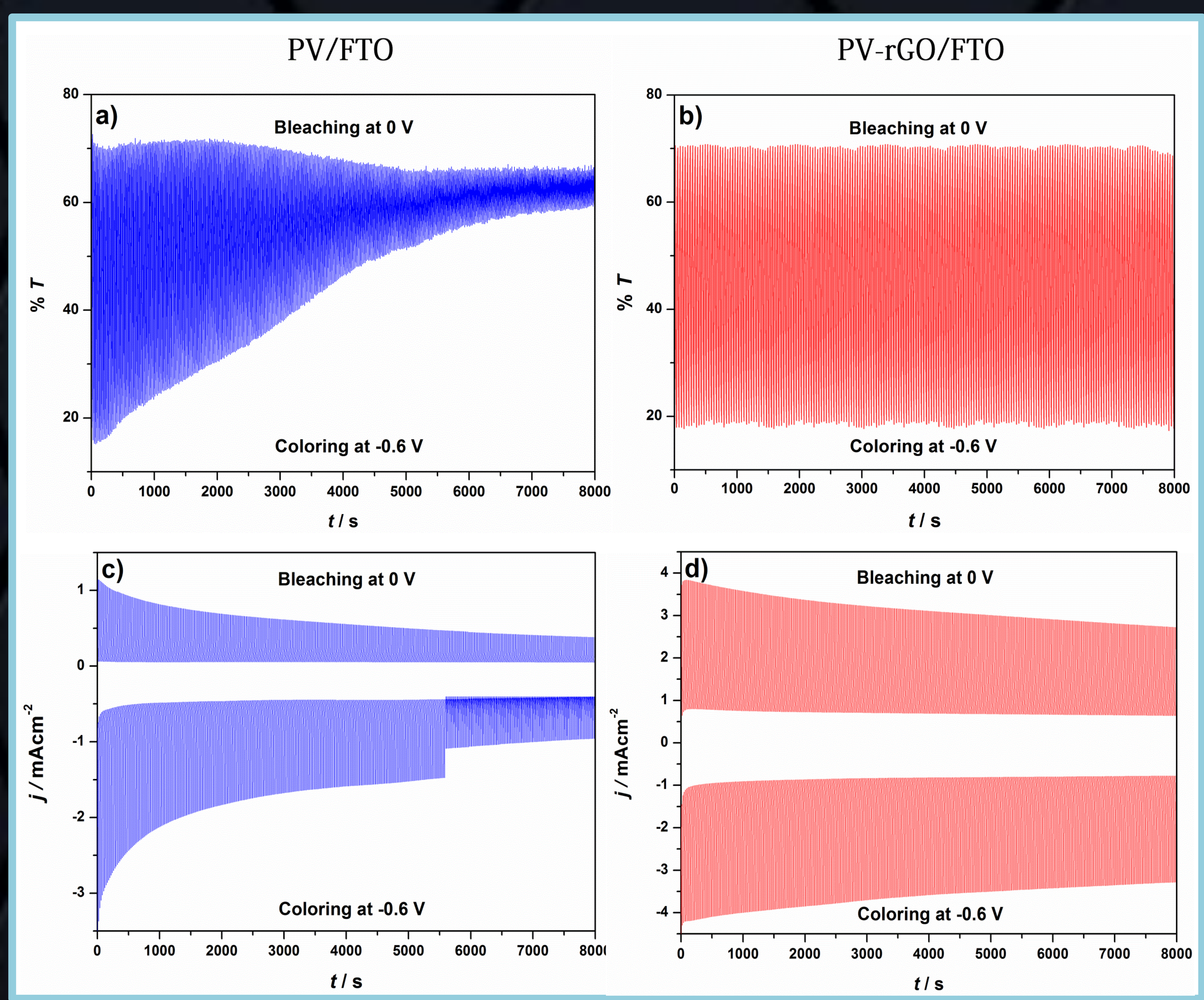
Electrochromic Properties



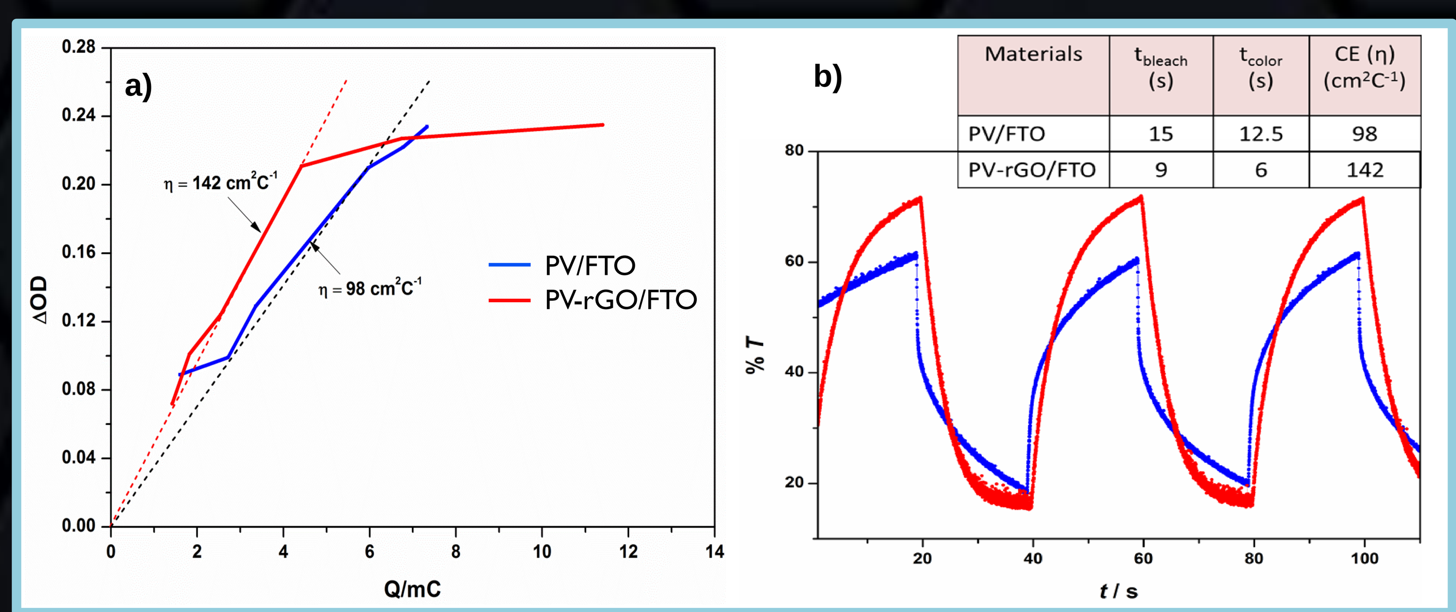
a) Absorption spectra of films at bleached (0 V) and colored (-0.6 V) states.



b) Photographs of the EC films in their bleached and colored state.



a, b) Voltage controlled %T changes & c, d) corresponding chronoamperometry response of PV/FTO and PV-rGO/FTO films at bleached (0 V) and colored (-0.6 V) state at 525 nm.



Materials	t_{bleach} (s)	t_{color} (s)	CE (η) (cm^2C^{-1})
PV/FTO	15	12.5	98
PV-rGO/FTO	9	6	142

a) Plot of ΔOD vs. charge (Q) for coloration efficiency (CE or η) calculation of films. b) EC switching times measurement. Inset: Table showing switching times & CE values.

Conclusions

- ✓ **Successful fabrication of PV-rGO nanocomposite film via a one-step electrocodeposition of CNP-GO solution.**
- ✓ **The structural characterizations proved the non-covalent wrapping of rGO sheets around the insulating PV matrix.**
- ✓ **Improved EC coloring efficiency of PV-rGO composites compared to PV demonstrates the role of reinforced rGO nanosheets in facilitating ion/charge transport in films.**
- ✓ **Low driving voltage, high optical contrast and low cost one step PV-rGO fabrication process makes it suitable for future optoelectronics and ECDs.**

Acknowledgement

Academy of Finland, UTUGS PCS Graduate School and Magnus Ehrnrooth foundation is gratefully acknowledged for financial support.