MATERIALS RESEARCH CENTRE
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Novel Highly Stable Conductive Polymer Composite PEDOT:DBSA for Bioelectronic Applications

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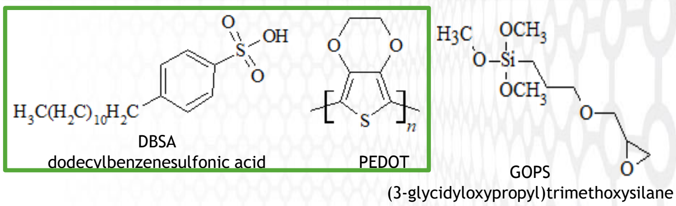
Introduction

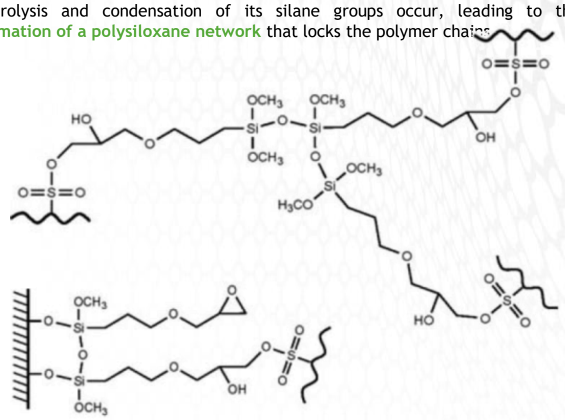
Organic bioelectronics utilizing conducting polymers presents a potential revolution in medicine. The material of choice for various bioelectronic devices is PEDOT:PSS thanks to its superior properties. However, recent studies have shown only limited biocompatibility of this material.

The aim of this work was to propose a novel material with enhanced properties compared to PEDOT:PSS. To reach this, **PEDOT doped with DBSA molecule was studied and optimized**. To obtain a material with excellent long-term stability, a cross-link of the material utilizing cross-linker GOPS was performed. In addition, sulphuric acid post-treatment was applied to improve material conductivity.

PEDOT:DBSA cross-link using GOPS

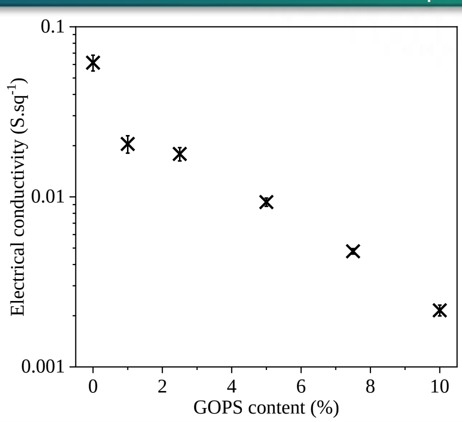


When GOPS is added to the dispersion of the polymer and induced by heat, the hydrolysis and condensation of its silane groups occur, leading to the **formation of a polysiloxane network** that locks the polymer chains.



- Cross-link **positively affects material's biocompatibility and long-term stability**, see a poster of Romana Malečková
- Cross-linking activity of GOPS was induced when heated at 60 or 140 °C, respectively, but also when standing at room temperature for 72 h.

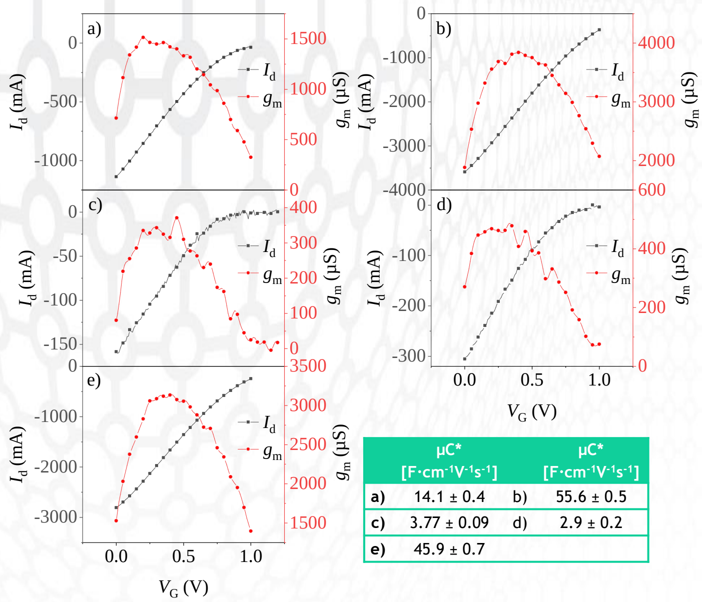
Effect of GOPS on material's electrical properties



- **Conductivity of pristine PEDOT:DBSA 0.06 S.sq^{-1}** (x pristine PEDOT:PSS 0.1 S.sq^{-1})
- Addition of 10 v/v % of GOPS resulted in conductivity drop of 97 %
- Application of H_2SO_4 post-treatment to overcome GOPS's negative impact

OECT characterization

- Preparation of OECT
  - Au interdigitated electrode system; L = 50 µm; W = 1 mm; d = 100 nm
  - Au gate electrode; electrolyte solution NaCl with conductivity of 200 mS
- Active material made of
  - a) pristine PEDOT:DBSA;
  - b) H_2SO_4 post-treated PEDOT:DBSA;
  - c) PEDOT:DBSA/GOPS, laboratory temperature-induced cross-link;
  - d) PEDOT:DBSA/GOPS, cross-link induction temperature 140 °C;
  - e) H_2SO_4 post-treated PEDOT:DBSA/GOPS, induction temperature 140 °C



	µC* [F·cm^{-1}V^{-1}s^{-1}]		µC* [F·cm^{-1}V^{-1}s^{-1}]
a)	14.1 ± 0.4	b)	55.6 ± 0.5
c)	3.77 ± 0.09	d)	2.9 ± 0.2
e)	45.9 ± 0.7		

- Transfer characteristics and transconductance
- Typical behaviour of p-channel transistor working in depletion mode
- Significantly positive effect of acid post-treatment
- µC* drop to ~20 % after cross-link induction
- **µC* of cross-linked material increased to 1 600 % after acid post-treatment**
- Electrical properties of pristine and modified PEDOT:DBSA comparable with materials commonly used for bioelectronics:
  - PEDOT:PSS/EG µC* ~ 47 F·cm^{-1}V^{-1}s^{-1}
  - PEDOT:dextran sulphate/EG µC* ~ 2.2 F·cm^{-1}V^{-1}s^{-1}
  - PTHS/EG µC* ~ 5.5 F·cm^{-1}V^{-1}s^{-1}

Conclusion

The aim of this study was to propose novel material suitable for bioelectronic applications. To reach this, PEDOT doped with DBSA molecule was studied and optimized. Pristine PEDOT:DBSA showed sufficient electrical properties since its electrical conductivity is of the same order as PEDOT:PSS. Moreover, OECT based on this material exhibited typical behaviour with µC* value convenient for bioelectronics. Such value was improved significantly after the application of H_2SO_4 post-treatment, **exceeding most of the commonly used materials**.

The cross-link of the polymer PEDOT:DBSA using cross-linking agent GOPS was performed to improve its long-term stability, and its effect on the material's electrical properties was studied. Such modification led to the considerable deterioration of conductivity, which was further improved after the application of H_2SO_4 post-treatment. **All these results indicate that PEDOT:DBSA, modified or not, possess the potential for bioelectronic applications.**

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