BIOELECTRONIC CAPTURE AND RELEASE OF CANCER CELLS

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ABSTRACT

We present a novel copolymer made of thermo-responsive poly(*N*-isopropylacrylamide) and conducting poly(3,4-ethylene-dioxythiopene):poly(styrene sulfonate) for the generation of label-free and non-invasive detection of the capture and release of cells on bioelectronic devices. This platform could be applied to the sorting of cells obtained in clinic.

INTRODUCTION

Smart functional materials such as poly(*N*-isopropylacrylamide) (pNIPAAm) can undergo structural changes due to their inherent lower critical solution temperature (LCST) phase transition in water at 32 ºC.[1,2] On its side, poly(3,4-ethylenedioxythiopene):poly(styrene sulfonate) (PEDOT:PSS) is a conducting polymer that possess mixed ionic and electronic conduction properties.[3] This work presents a novel electroactive functional copolymer (PEDOT:PSS/pNIPAAm), which combines the conducting properties of the PEDOT:PSS and the thermo-actuation capabilities of pNIPAAm.[4] This material enables the label-free capture and release of cells with simultaneous EIS monitoring of the process (Figure 1).

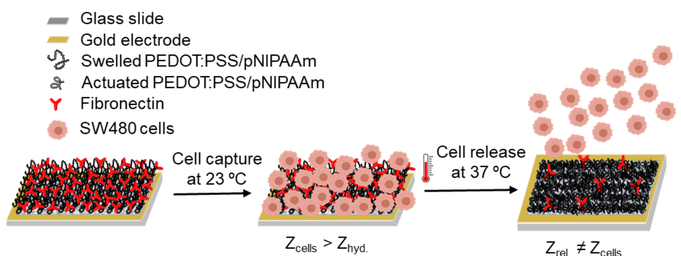

Figure 1: Schematics of the cell capture and release mechanism based on the hybrid functional PEDOT:PSS/pNIPAAm copolymer and electrical monitoring of the process.

EXPERIMENTAL

Gold-electrodes were fabricated by following this protocol (Figure 2A).[5] PEDOT:PSS/pNIPAAm was prepared by mixing the components in Figure 2B and spin coated.

Sw480 adenocarcinoma cancer cells were captured by embedding fibronectin protein into the copolymer for 2 h, following with three cell media washes. Then, 650.000 cells in 100 µL media were added to the PEDOT:PSS/pNIPAAm electrodes and left to attach for 3 h at rt. Cell release was triggered by applying 37 °C for 20 min on a hot plate, cells were collected and electrodes were washed with media.

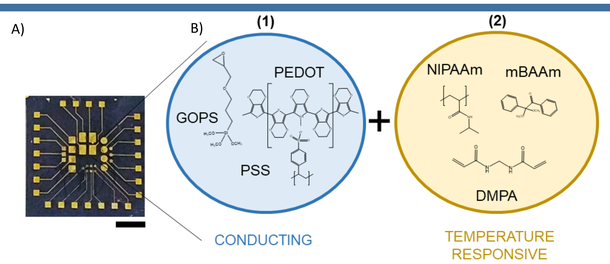

Figure 2: A) Photograph showing the photolithographically patterned device consisting of 24 gold-electrode arrays on glass. Scale bar: 5 mm. B) Chemical structure of the components of (1) the conducting polymer: PEDOT:PSS with GOPS and (2) the thermo-responsive polymer: NIPAAm, mBAAm, and DMPA.

RESULTS AND DISCUSSION

PEDOT:PSS vs PEDOT:PSS/pNIPAAm mechanical and EIS characterization

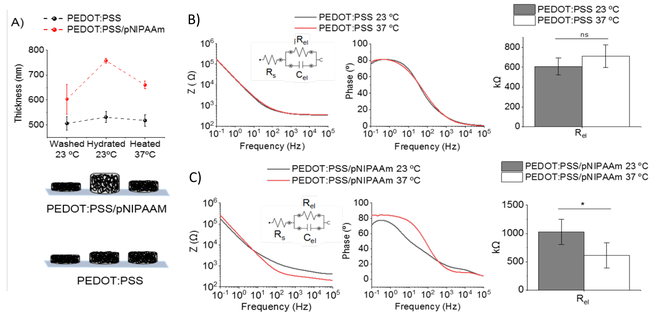

Figure 3: A) PEDOT:PSS and PEDOT:PSS/pNIPAAm thickness during a hydration/heating cycle (top), scheme of the thermo-actuation of PEDOT:PSS/pNIPAAm and PEDOT:PSS (bottom). B) Impedance vs frequency (left), phase angle vs frequency (middle) and a plot displaying Rel (right) obtained from EIS measurements of bare the PEDOT:PSS at 23 ºC and at 37 ºC for a R(RC) circuit. C) Impedance vs frequency (left), phase angle vs frequency (middle) and a plot displaying Rel (right) obtained from EIS measurements of PEDOT:PSS/pNIPAAm and actuated PEDOT:PSS/pNIPAAm at 37 ºC.

Cell capture and release

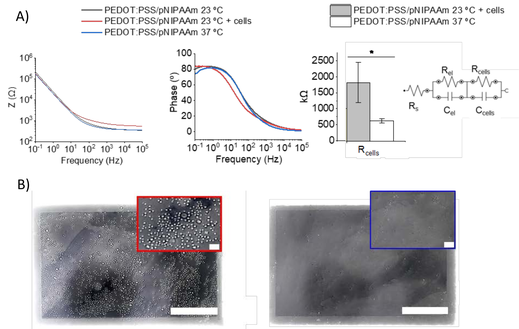

Figure 4: Cell capture and release data. A) Impedance vs frequency and phase vs frequency plots of the cell capture and release with PEDOT:PSS/pNIPAAm. A) Impedance vs frequency (left), phase angle vs frequency (middle) and a plot displaying Rel (right) obtained from EIS measurements of PEDOT:PSS/pNIPAAm for the capture and release of cells. B) Optical microscopy images of the captured cells (left) and after thermo-actuation (right) (4x) with a zoomed fraction of 400 x 200 µm area. Scale bars correspond to 400 µm.

CONCLUSIONS

The novel PEDOT:PSS/pNIPAAm is functional for temperature triggered release of captured cells, as well as for the simultaneous monitoring of the process by EIS. This opens the possibility of using organic bioelectronics as label-free devices, leading to an easy tracking of the process, minimizing user intervention, towards development of complex architectures for simultaneously sensing and actuating different targets.

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