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Corrosion in Ti-Cu electrodes for EMG and muscular rehabilitation

NANOTECHNOLOGIES
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PROBLEM AND PROPOSED SOLUTION

- The increasing prevalence of age-related motor disabilities leads to the need of innovative healthcare solutions.
- Traditional rehabilitation, burdened by accessibility limitations, leaves a significant portion of the population without access to essential electromyography (EMG) and electrostimulation therapy.
- Dry electrodes hold potential for home-based EMG recordings and muscle rehabilitation, yet challenges persist related to their performance in the presence of sweat.
- To comprehensively evaluate their durability, different electrochemical tests were performed.
- This study is centered on elucidating the impact of corrosion on Ti-Cu electrodes, with a primary objective of increasing their longevity and performance in the context of remote elderly care and rehabilitation applications.

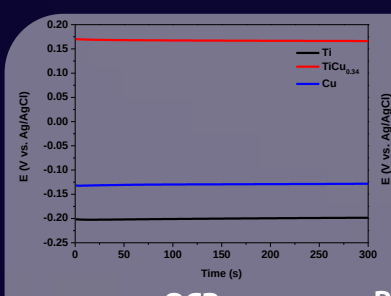
MATERIALS AND METHODS

- **Design:** Electrodes with 15 mm diameter and 3 mm thickness, with a detachable deposition holder
- **Materials:**
  - Substrate: PLA
  - Thin Films: Ti, $TiCu_{0.34}$ and Cu
- **Fabrication techniques:**
  - Substrate: 3-D printing
  - Thin Films: DC magnetron sputtering
- **Electrodes' properties studied**:
  - Tendency to corrosion: Open circuit potential (OCP) stabilized when ΔE < 60 mV/h
  - Corrosion resistance: Potentiodynamic polarization with a scanning rate of 0.5 mV/s in anodic direction from -0.25 V_{OCP} till 1.5 $V_{Ag/AgCl}$
- **Environment**: Artificial sweat (EN 1811:1998 standard) with pH = 4.70 ± 0.02 at room temperature
- **Electrodes' characterization:**
  - Morphology: SEM

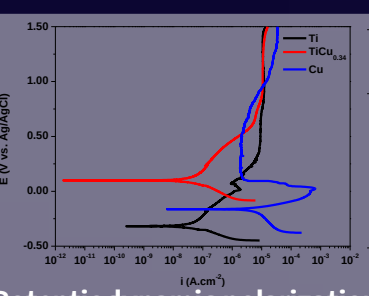
RESULTS

Electrodes of:

- Cu: Low i_{pass}, but fast film's dissolution.
- $TiCu_{0.34}$: Lower tendency to corrosion, high but precise i_{pass}, forming a homogeneous surface
- Ti: Less precise i_{pass} than $TiCu_{0.34}$ electrode, resulting in sweat bumps on the surface.



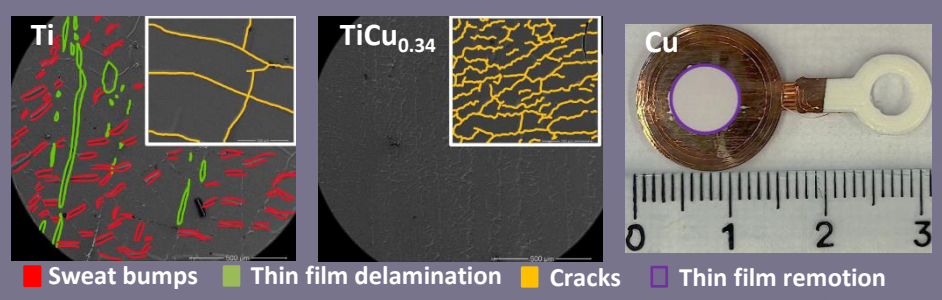
OCP



Potentiodynamic polarization

	E_{OCP} ($V_{Ag/AgCl}$)	i_{pass} ($\mu A\ cm^{-2}$)
Ti	-0.17 ± 0.03	7.8 ± 1.3
$TiCu_{0,34}$	0.15 ± 0.02	11.1 ± 0.3
Cu	-0.11 ± 0.02	4.4 ± 1.8

Corrosion parameters



Sweat bumps | Thin film delamination | Cracks | Thin film remotion

Corroded electrodes exposed to sweat

CONCLUSIONS

- Cu electrodes present the worst corrosion resistance, as they present a faster dissolution.
- $TiCu_{0.34}$ electrodes exhibit superior corrosion resistance compared to the Ti electrodes, as they present a more compact passive film, leading to a more homogeneous surface with no sweat bumps.

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