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PU/PVA Nanomesh-based Breathable, Stretchable, Anti-friction On-skin Electrodes

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MSc Seminar

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Wearable bioelectronics has emerged as a transformative technology for continuous health monitoring, yet conventional electrodes face critical challenges in long-term wearing comfort, mechanical durability, and signal fidelity. Here, we present a novel breathable nanomesh electrode fabricated via electrospinning of polyurethane (PU)/polyvinyl alcohol (PVA) composite nanofibers, followed by thermal evaporation of gold (Au) to create conductive pathways.

The PU/PVA nanomesh substrate features a hierarchical porous architecture with dual fiber populations, achieving exceptional breathability demonstrated by superior water vapor permeability compared to commercial gel electrodes and PDMS substrates. The nanomesh electrode exhibits remarkable mechanical compliance, sustaining up to 180% strain with stable electrical performance under 50% strain and maintaining signal integrity over 1,000 stretching-releasing cycles at 30% strain. Notably, the electrode demonstrates outstanding abrasion resistance, surviving 2,500 friction cycles under 45 g load with minimal baseline drift.

For practical applications, the nanomesh electrode achieves low skin-electrode impedance comparable to commercial gel electrodes across a broad frequency range (1–10^6 Hz), enabling high-quality electromyography (EMG) and electrocardiography (ECG) recordings. EMG signal-to-noise ratio (SNR) exceeds 28 dB under 10 kg force and remains stable after 12 hours of continuous wear. Long-term continuous ECG monitoring over 7 hours maintains consistent SNR (~30–35 dB), with clear P-QRS-T waveforms preserved during various daily activities including PC work, laboratory experiments, and rest periods. Heart rate variability tracking further validates the clinical utility for cardiovascular assessment.

This work establishes a promising strategy for next-generation imperceptible wearable sensors, bridging the gap between comfort, durability, and high-fidelity biosignal acquisition for continuous healthcare monitoring.