Engineering a Self-Fitting Wearable Sleep Sensor Using Shape-Memory Polymer (SMP) Networks

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Sleep quality is fundamental to overall health, yet many existing sleep-monitoring devices suffer from signal distortion due to poor and inconsistent skin contact during overnight movement. Rigid or elastic wearable straps often fail to accommodate individuals anatomy, leading to discomfort and unreliable data. The aim of this study was to evaluate whether a self-fitting wearable film fabricated from acrylate shape-memory polymers (SMPs) could conform to curvature under physiologically relevant conditions. SMP networks were synthesized using tert-butyl acrylate (tBA) and poly(ethylene glycol) dimethacrylate (PEGDMA), with crosslink density varied from 10–40 wt% to tune thermomechanical behavior. Device performance was evaluated in an in vitro setting by measuring the time required for the material to conform to the inner wall of a 10 mm cylindrical tube at 40 C, simulating ear-like curvature at body temperature. Conformability was quantified through shape fixity (Rf) and shape recovery (Rr). The results showed that the SMP conformed to the cylindrical geometry within physiologically relevant time scales and maintained its programmed shape once cooled. In vivo signal acquisition was conducted using the SMP-based sleep sensor, enabling stable electrode contact and successful recording of physiological signals, which were used to generate brain activity graphs and data on alpha, beta, and theta bands. While this study does not assess long-term on-body performance, the ability to obtain clear in vivo signals suggests that SMP-based sleep sensor can provide a low-pressure, body-conforming interface. Overall, this work supports the potential of using shape-memory polymers to improve contact stability, signal quality, and comfort in wearable health-monitoring technologies.

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