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Alert Patches Embedding Conjugated Polymeric Lamellar and Metal Nanoparticles Generating Optoelectronic Responses against Thermal Stresses

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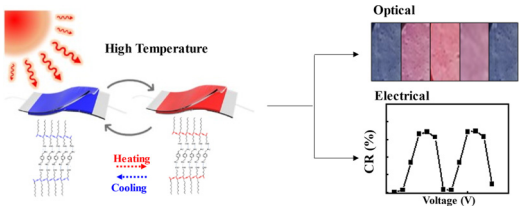
Abstract: In this study, we provide essential information of dangerous states in external environments such as extreme ambient temperature. This platform can determine external signals, such as thermal stress, and simultaneously convert them to a readable form. We fabricated alert patches with colorimetric materials, metal nanoparticles, and matrix polymers. Polydiacetylene (PDA), a family of conjugated polymers, has attracted attention in the field of sensors to read fluorescent, and optoelectrical properties. The highly ordered lamellar PDA architecture showed that the electrical current synchronizes with its color transition (blue-to-red) is reversible. The conductive nanoparticles provided current reversibility. The potential advantages of this alert patch include simple fabrication and continuous monitoring by thermal stresses. Furthermore, this system can find wide applicability in wearable patches on clothes, skin, and surfaces of materials.



Key words: alert patches, polydicaetylene, matrix polymers, metal nanoparticles.

1. Introduction

There is growing demand for the development of sensor technologies for real-time monitoring in various fields.[1-11] Typical sensors include those used in electronic skin (e-skin), touch interfaces, and environment indicators. Readout tools include electrical signals. Many studies have focused on electronic readout systems such as sweat components,[1,2] and micro-pressure.[3-7] Another measurement tool used is colorimetric readout, which can detect changes in sweat components change,[8,9] and pressure.[10,11] These tools focus on the conditions of the body and exhibit the following limitations. The electrochemical signals make it difficult for an individual to immediately monitor human state signals. The colorimetric sensors can detect this instantaneously, but most of them are irreversible in color transition. Most physical sensors have complicated fabrication processes. We intend to address the shortcomings of monitoring systems by developing competitive sensors. It is necessary to confirm the conditions of the surrounding environment for the sensor to be able to provide an accurate warning state. For example, even with the same exercises the risk of exhaustion or collapse would increase with exposure to ambient temperature.[12-14] Environment temperature can cause battery explosion, plant death, and overheating inside cars. Therefore, correct diagnosis of the external environment is necessary for warning signals regarding humans or the surroundings. We focused on the extreme ambient temperature. Solar radiation in the external environment can increase the ambient temperature and harm humans or other surroundings. Therefore, our sensing platform measured the ambient temperature by electrical or colorimetric detection. Real-time monitoring platforms are mainly composed of functional materials and flexible materials. We used polydiacetylene (PDA), which is an interesting π-conjugated polymer in terms of readout signals including optical (blue-to-red),[15,16] non-to-fluorescence,[16] and resistance (increased)[17] when exposed to various stimuli. External stress may consist of thermal stress,[18] pH,[19] ions,[20] mechanical stress, ligand-receptor interactions,[21] and optoelectronic stimuli.[22-26] When the blue phase of PDA becomes red, the resistance of PDA increases owing to the lower overlap of electron orbitals.[17] Therefore, PDA can be useful for double readout applications. Most of these optical and electrical transitions are irreversible after removing external stimuli. Irreversibility limits the design for applications, especially for ones in which continuous monitoring is necessary. The colorimetric reversibility of PDA is induced by covalent bond formation,[18,27,28] organic building block formation,[29,30] and the formation of organic/inorganic composites.[31-34] Among those methods, synthesis of using two organic building-block molecules has advantages in high-speed process, and high yield products. THE complex films were formed by acid-base interaction between two organic molecules, Diacetylene (DA) and para-xylyenediamine (pXDA).[30] The polymerized blue-phase complex films showed thermochromic reversibility. Hence, this material can be useful for continuous monitoring using color indicators.

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