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Portable triboelectric microfluidic system for self-powered sensors towards *in-situ* detection

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ABSTRACT

Point-of-care testing for health and environmental monitoring sometimes requires the detection of specific molecules in liquid media to provide a diagnosis in a resource-limited or outdoor environment. Thus, it is significant to develop portable and self-powered sensor systems to enable *in-situ* detection of analytes in liquids. Triboelectric nanogenerator (TENG) and microfluidic devices are two nascent technologies that can be used for point-of-care testing. Furthermore, the combination of these technologies is proposed as an attractive research strategy to achieve portable sensors by using the electrical signals generated during the mechanical interactions between the test solution and the device. Herein, a portable TENG-based microfluidic self-powered sensor system is demonstrated. The system consists of a triboelectric microfluidic (TEMF) device, which generates a voltage in response to the target analyte solution flowing through the microchannel. The viability and versatility of this device are illustrated for ionic concentration measurements, as well as *in-situ* monitoring for the catalytic reduction of an industrial pollutant, 4-nitrophenol (4-NP). The results verify that the proposed sensor system has the potential for application in the field of self-powered chemical sensors for environmental monitoring and analytical chemistry.

1. Introduction

Point-of-care testing is showing great potential in health care [1], environmental monitoring [2,3], food safety [4], national defense [5], and other fields. However, for testing in outdoor and other resource-limited environments, providing a suitable power supply to the system is still difficult. Currently, self-powered sensor systems without external power sources are playing an irreplaceable role in environmental and health monitoring fields, due to their small size, stable performance, fast response, and low energy consumption [6]. Therefore, self-powered sensor systems based on solar cells [7], biofuel cells [8], or enzymatic biofuel cells [9] have been developed. However, compared with solar or biomass energy, there is a wider range of mechanical energy sources in the environment. Thus, as a new mechanical energy harvesting technology, triboelectric nanogenerators (TENGs) have emerged with great promise for applications in self-powered systems. TENGs can provide two different functions for chemical sensors: (1) as the power source for the chemical sensor [10]; and (2) directly using the TENG as an active chemical sensor. The latter can be accomplished by monitoring the changes in the electronegativity of the functional TENG material when it absorbs or reacts with the target chemical. The changes in the triboelectric output can be used as sensing signals. Based on this mechanism, self-powered TENG-based humidity sensors [11], gas sensors [12–14], and chemical or biochemical sensors [15–17] have been demonstrated.

In contrast, considering that target molecules such as some environmental pollutants often exist in solution, it is significant to develop a portable system that can realize rapid *in-situ* detection of analytes in liquid. Recently, microfluidic devices have been widely used in such chemical sensors owing to their high efficiency, activity, and sensitivity

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