3D printed smart sensors for biomedical applications

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Introduction

Smart materials have one or more properties that can be changed in response to an external stimulus, such as magnetic or electric fields, pressure, stress, temperature or humidity [1,2,3]. Among smart materials, piezoelectric ones are most widely used in so many applications [4,5,6]. In this work, a smart polymer, Polyvinylidene fluoride (PVDF) was used to fabricate pressure, humidity and temperature sensors via 3D printing. Pyroelectric and piezoelectric properties were investigated using an astable multivibrator circuit as changes in PVDF permittivity were observed according to these stimuli [8]. Experimental results show an almost linear and inversely proportional behavior between these stimuli and the frequency response.

Methods

An ear, a thimble and a rectangular prism were designed in a 3D CAD software, then, they were manufactured in Polyvinylidene fluoride (PVDF) with a 3D printer from bits from bytes. PVDF is a smart material that exhibits piezoelectric properties. This way, PVDF 3D printed pieces were characterized as temperature, pressure and humidity sensors. Temperature and pressure were characterized using an astable multivibrator circuit as changes in PVDF permittivity were observed according to these stimuli. Humidity was characterized by mesasuring capacitive impedance with a LCR bridge (HM818- Rohde & Schwarz) at 1 Khz. 3D printed pieces were placed inside an insulation chamber of volume 0.018472 m^3 and humidity varied beteween 35% and 90% in concentration RH. Also, 4 commercial DHT11 humidity sensors (Aosong, Guangzhou, China) were introduced in the insulated chamber to establish the homogeneity of humidity inside the chamber.

Results

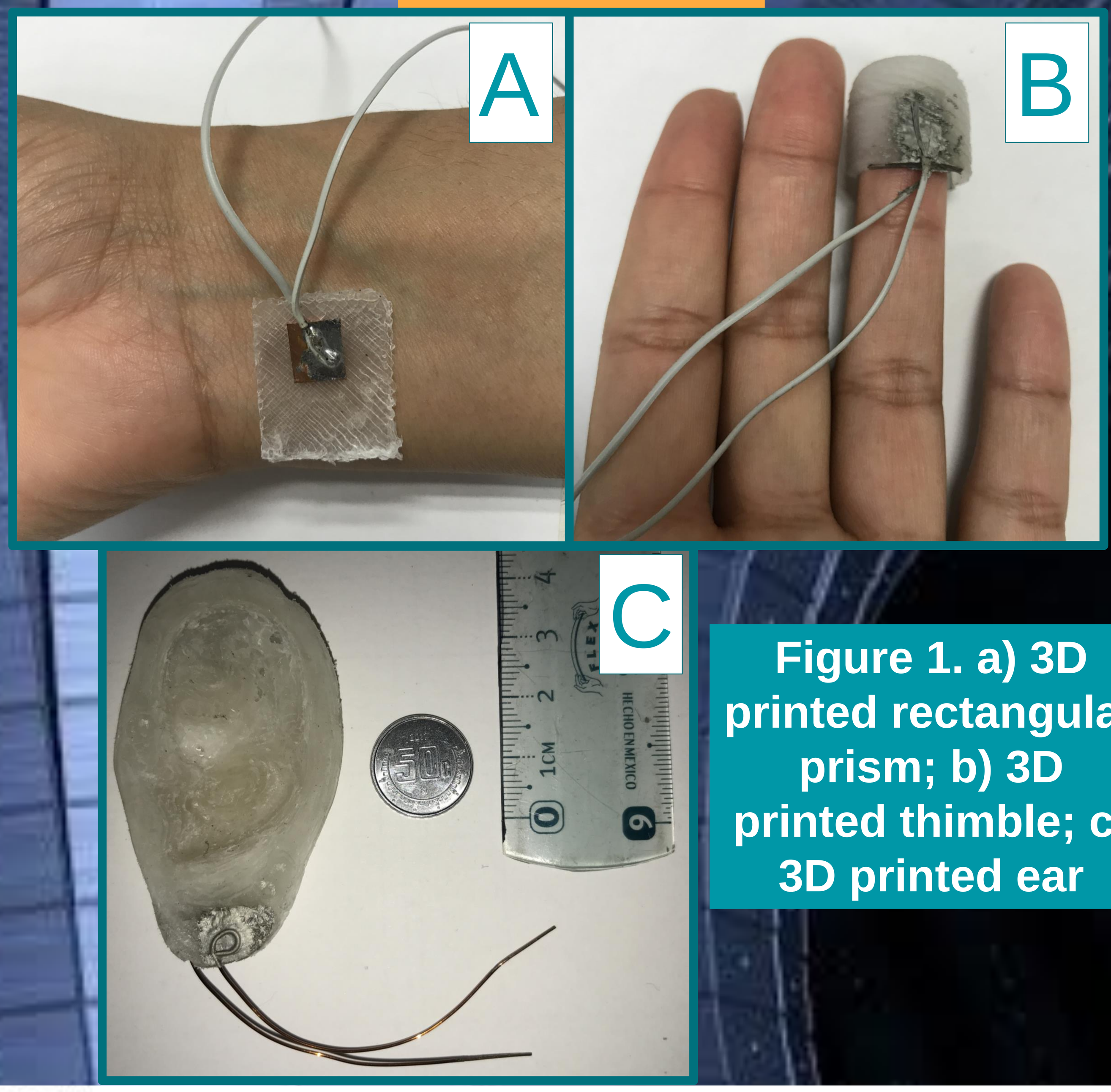

Figure 1. a) 3D printed rectangular prism; b) 3D printed thimble; c) 3D printed ear

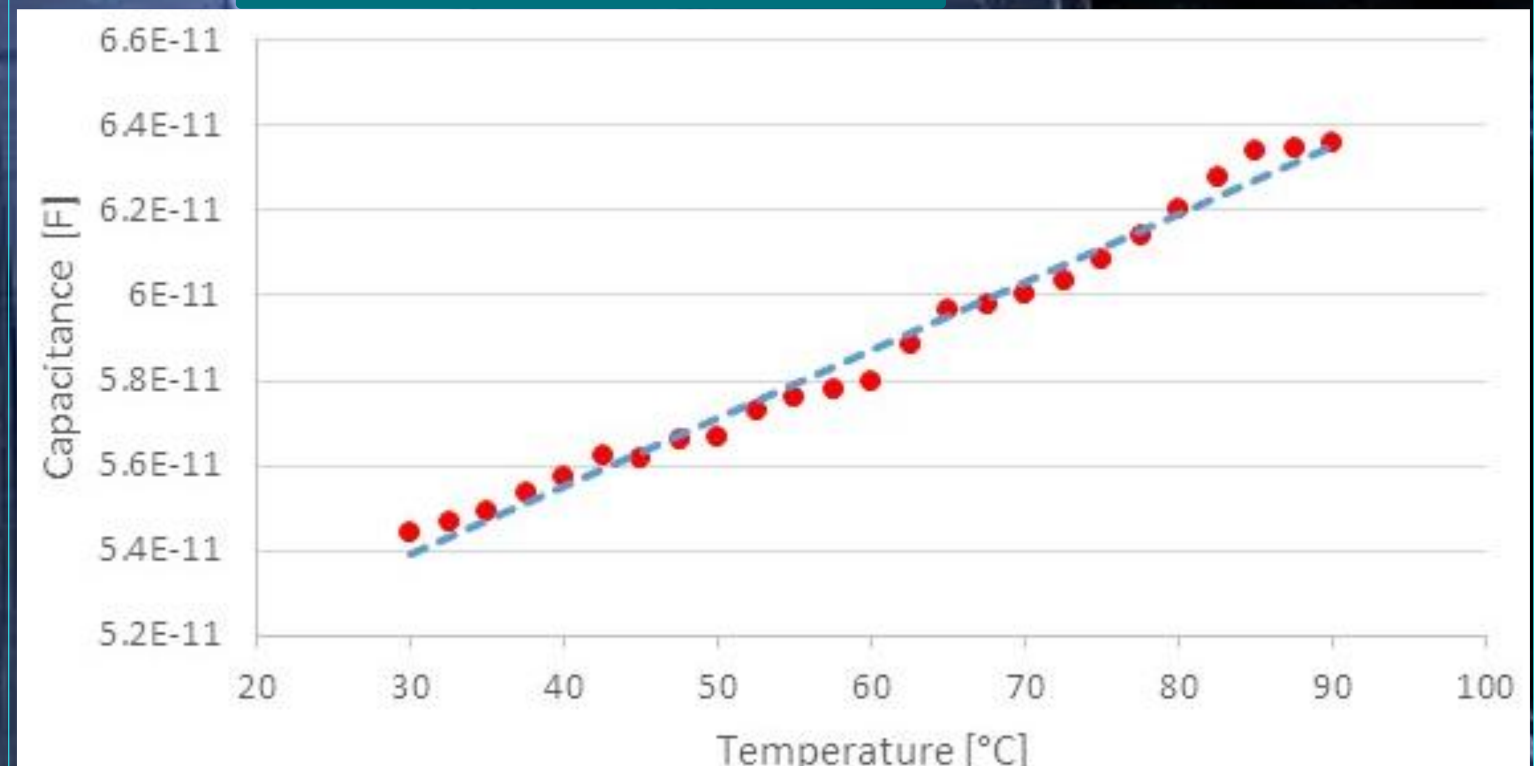

Figure 2. Thermal response of the 3D printed rectangular prism from 30 °C to 90 °C

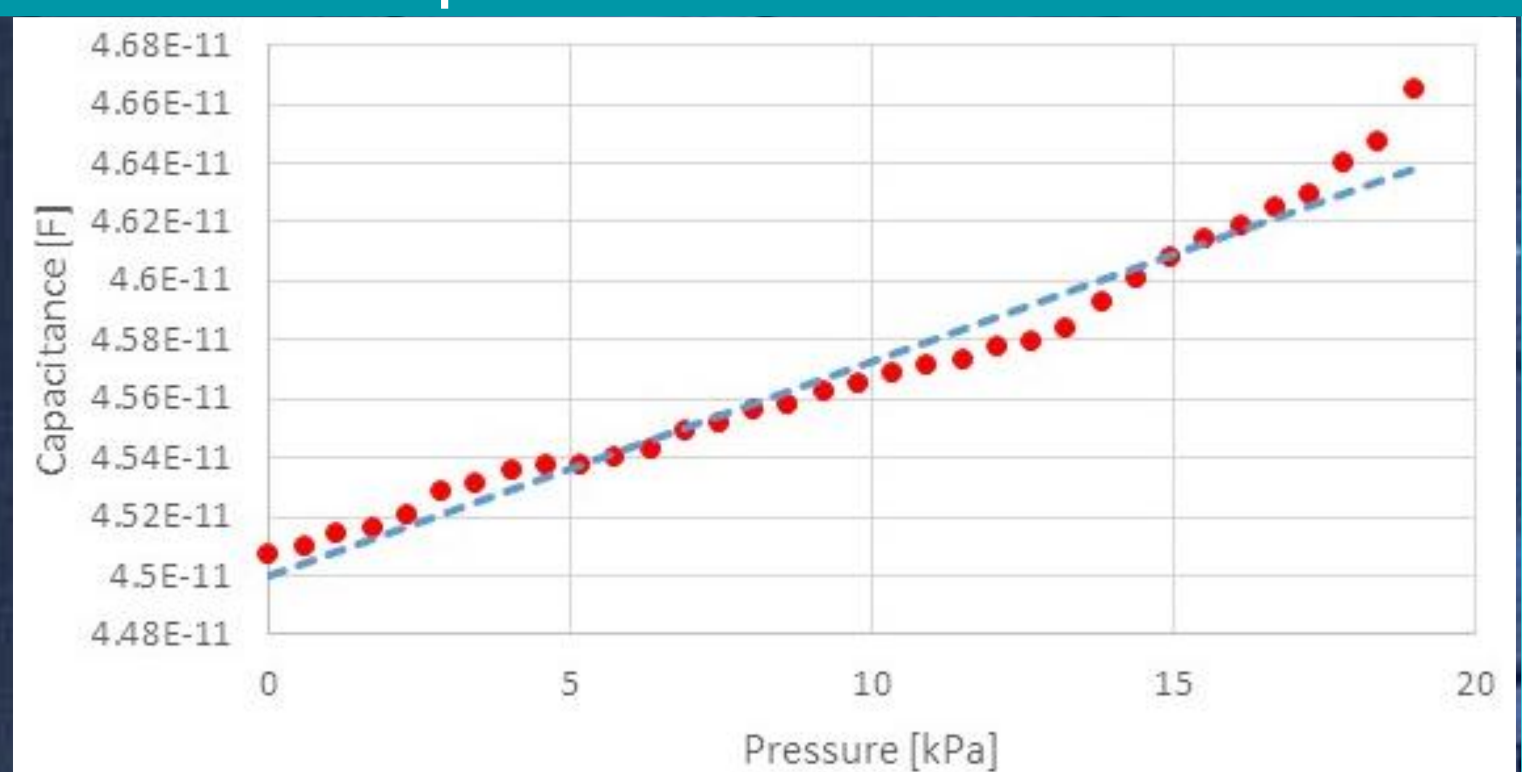

Figure 3. Response of the 3D printed thimble as pressure sensor from 0 KPa to 19.6 KPa

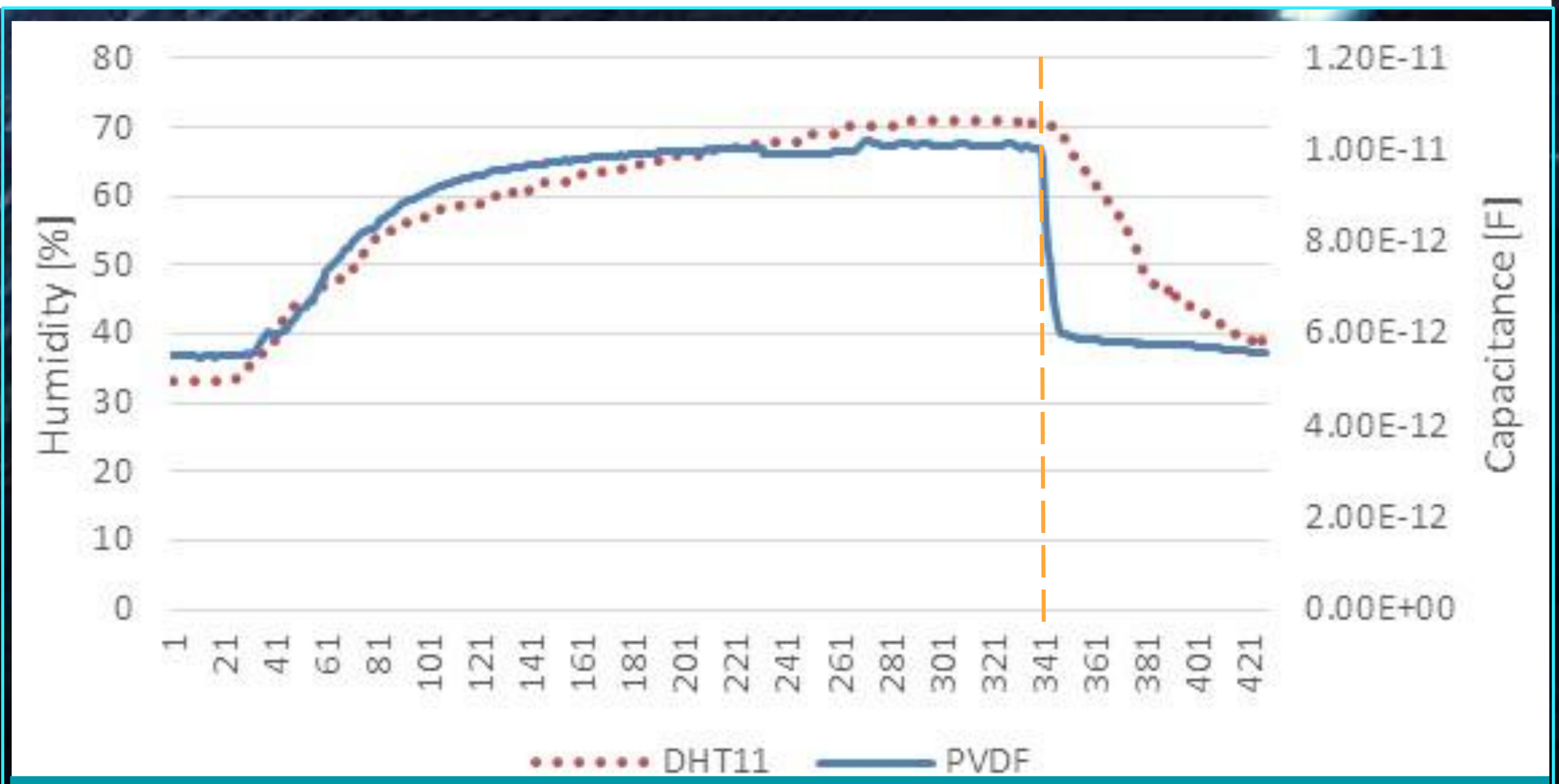

Figure 4. Humidity response of the 3D printed ear from 30% to 70%. Dotted orange line shows the instant time the chamber was opened.

Conclusions

In this work, sensors made of a smart material, PVDF were manufactured satisfactorily with a 3D printer. They were tested as pressure, humidity and temperature sensors. The characterization could be achieved satisfactorily. As shown in Figures (2), (3) and (4), it was found that the typical response of the PVDF pressure, humidity and temperature sensors was very reliable and also showed a high sensitivity to the variations of these stimuli.This kind of smart sensors are a promising tool in biomedical field due to its piezoelectricity and pyroelectricity, allowing people to monitor environmental parameters.

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