College of Engineering / The Ohio State University / Materials Science Engineering

2D Bending Analysis of PANI-CA Chemoactuator

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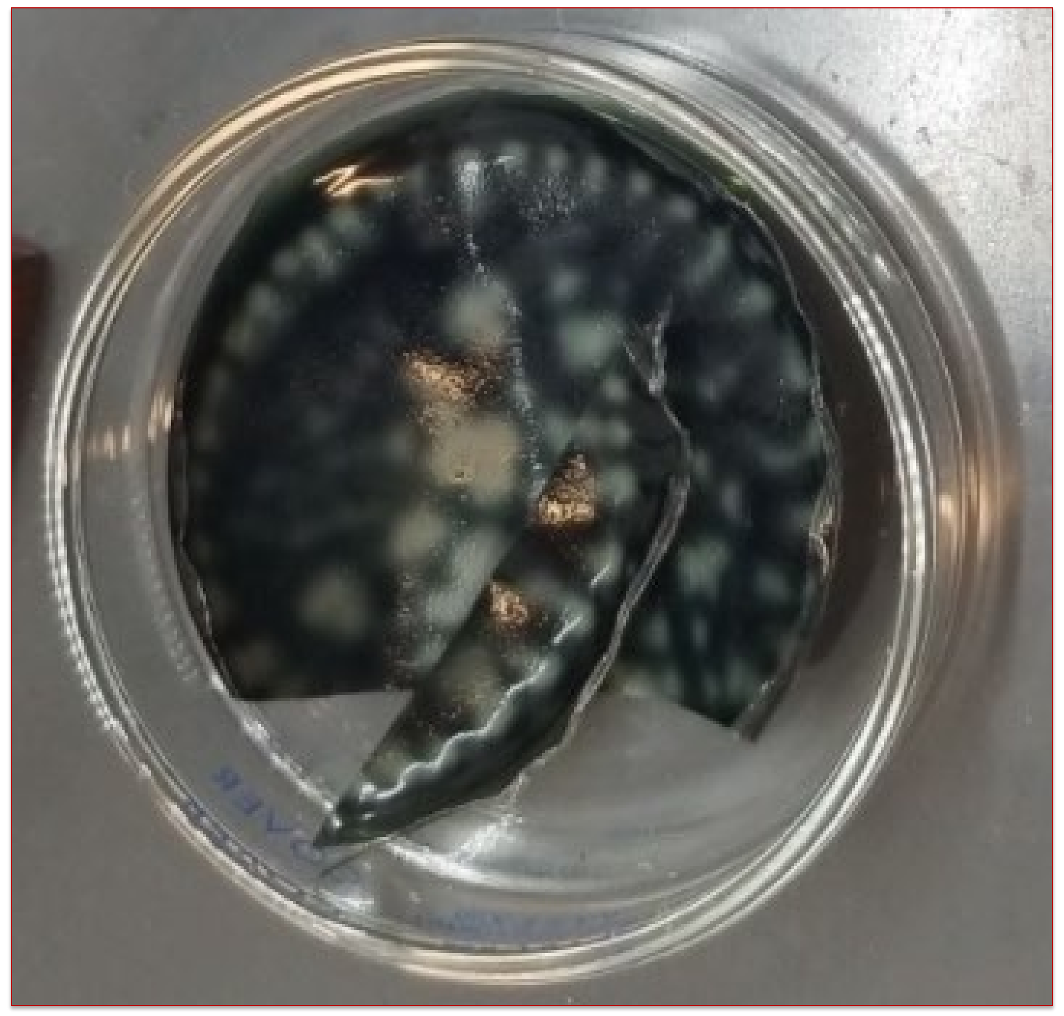
INTRODUCTION

Conducting polymers exhibit ductility, flexibility, and ease of synthesis, while offering metal-like conductivity. Polyaniline (PANI) is one example of these intrinsically conducting polymers which allow for tailored electrical properties. Leucoemeraldine polyaniline is the material chosen for this study as blending it with cellulose acetate gives a unique chemo-mechanical response. The chemoactuation of such composite films is explored in skin gas sensing applications.

When blending leucoemeraldine PANI with cellulose acetate in the proper ratio and size, the films provide a mechanical and electrical response to acetone (headspace analysis)

This technology has potential use in wearable sensors due to skin-gas vapors leading to the actuation of the films. 2D image analysis techniques are being employed to track and replicate the motion of the sensing membranes. It was found that the response is reproducible and scales with the gas concentration.

PANI-CA films created on glass dishes



The final films are produced in discs and cut into thin strips. The films have a plastic-like top and a black, matte bottom that is composed of polyaniline. The bottom conducts an electrical charge while the top does not.

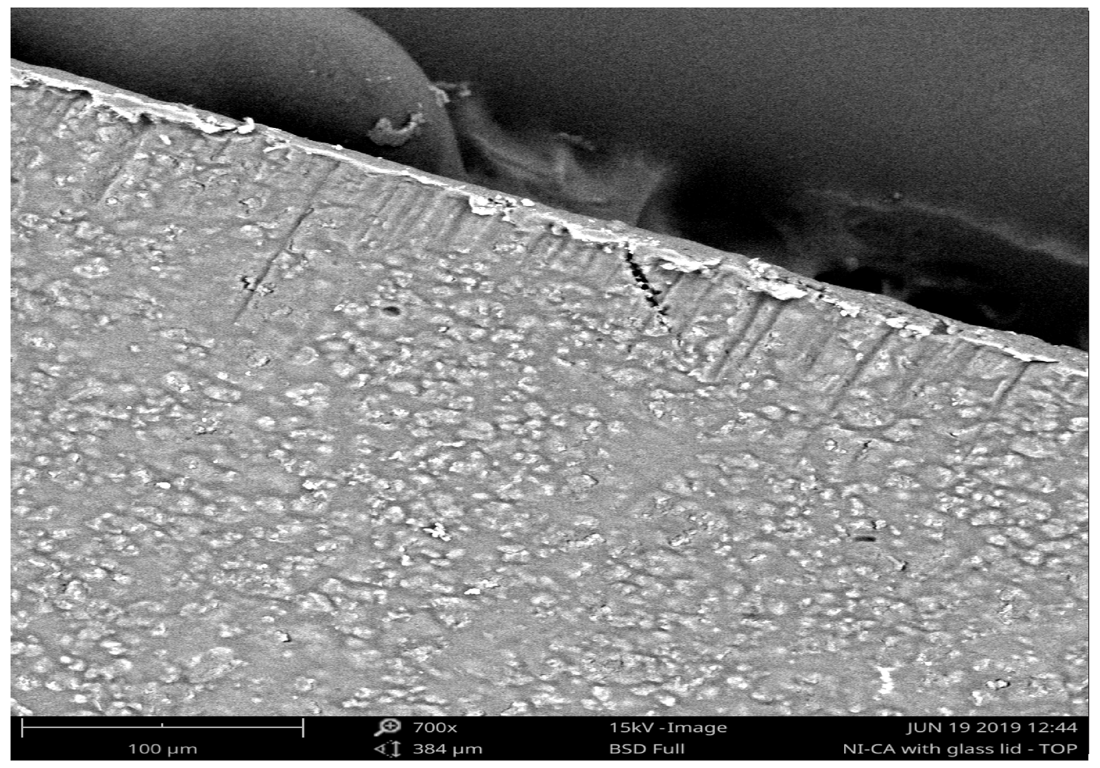
ANALYSIS

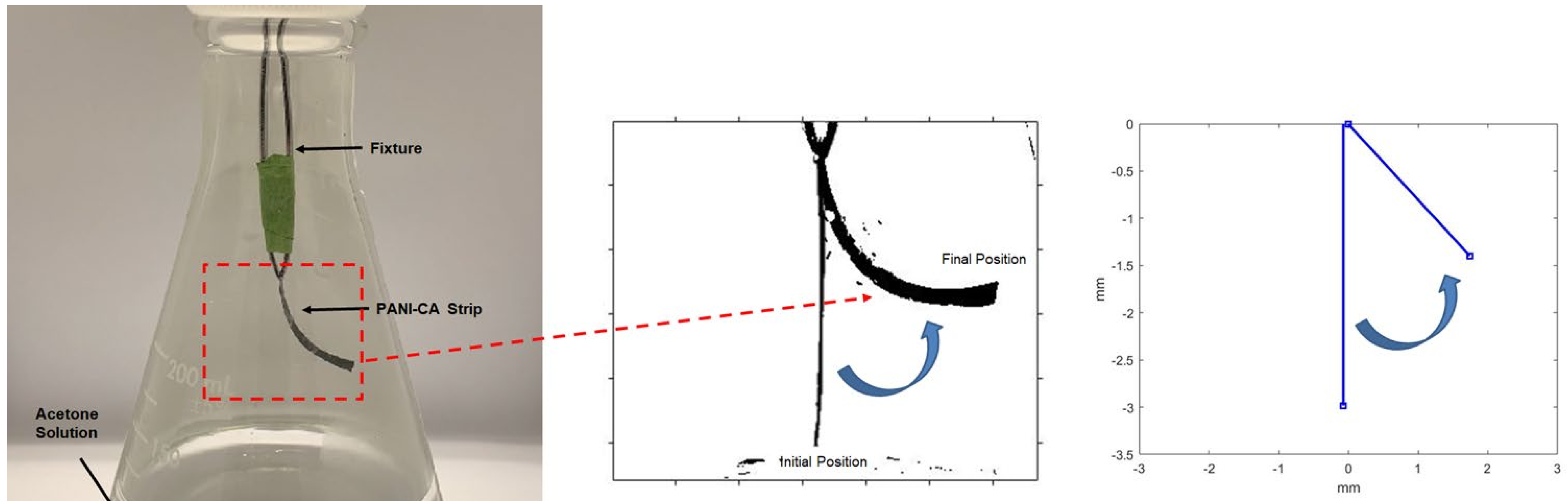
Image processing tools provide the ability to extract information from the captured images and characterize the data according to predefined algorithms. Bending of such thin film actuators reported by other researchers fail to address the nature of bending and focuses on measuring the displacement of the thin films.

Using 2D modelling approach in MATLAB, we are able extract frames from recorded video which are used to quantify the bending of films by processing the image attributes which involves rasterizing, filtering and digitizing the data that can be mapped onto a 2D cartesian plane.

This approach uses the end-point analysis to monitor the bending of PANI-CA films. The obtained data were used to analyze the transient stages, nature of bending and reproducibility of the bending process.

SEM 700x magnification photo of film's top side





Digitization (Binary Image)

2D Mapping on Cartesian Plane

NEXT STEPS

Since these wearable sensors do not require sweat to detect gaseous biomarkers in skin, we will next evaluate them for skin acetone detection. Quantifying the bending of PANI-CA films/membranes in 3D domain will enable us to fine tune the sensitivity of these sensors. This technique can be used to continuously monitor the bending of such thin film actuators to determine the lifetime of the sensor.

APPLICATIONS

The PANI-CA film has several potential applications. Due to the mechanical response of the film, actuators such as strain gauges, photosensors, or infrared sensors among others may be used to display the sensor output which is the acetone concentration. This is useful for purposes relating to monitoring ketone-based function, such as metabolic rate changes after exercise or diabetes control. This can be done either with breath-based input, or by skin-gas measurements.

There is also potential for the film to be used in such a manner from an electrical perspective due to the change in resistance under exposure.

The image processing software to be used in other related projects.

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Abstract: 2D Analysis of PANI-CA Chemoactuator

As-cat polyaniline (PANI) films/membranes were made by doping Leucoemeraldine PANI in hydrochloric acid before being rinsed with water and dissolved into a composite solution with cellulose acetate. The films were cut into small strips of roughly 3x12 mm and exposed to acetone (headspace analysis). The chemo-actuating response of the composite films/membranes caused it to bend inwards. In order to quantify the bending process, we introduced image processing technique using MATLAB to capture frames from the recorded video, rasterizing, filtering and digitizing the data to obtain intermediate binary images that can be mapped onto a 2D cartesian plane. This process is repeatable and provides the ability to continuously monitor the bending of thin films especially during the transient stages of motion.