Polymer Nanocomposite-Based Moisture Sensors for Monitoring of Water Contents in Natural Gas Pipelines

Graduate Student, Science and Engineering

S. Mallick[a]*, Z. Ahmad[b] and F. Touati [a]

[a] Department of Electrical Engineering, Qatar University, Doha, Qatar University

[b] Center for Advanced Materials (CAM), Qatar University (CAM), Doha, Qatar

* Email: sm1404760@qu.edu.qa

PLA-TiO2 nanocomposite humidity sensor

In this work, we investigated polymer nanocomposite-based humidity sensors to achieve higher sensitivity, shorter response and recovery time and smaller hysteresis loss.

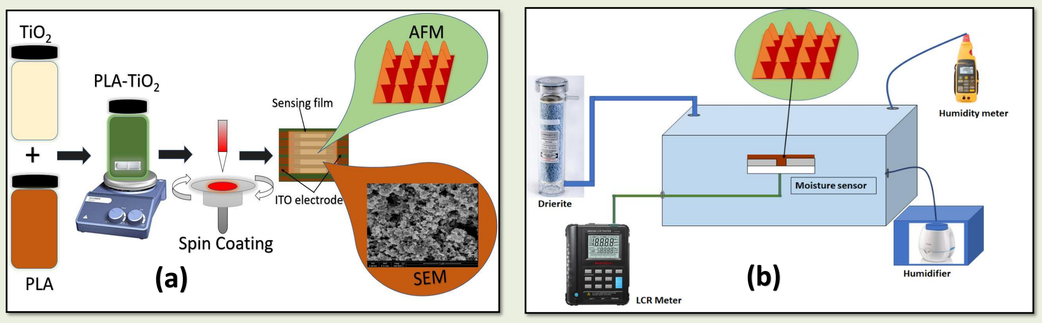


Figure 1: (a) Schematic diagram of the moisture sensors fabrication steps. (b) Electrical setup to test the humidity sensor

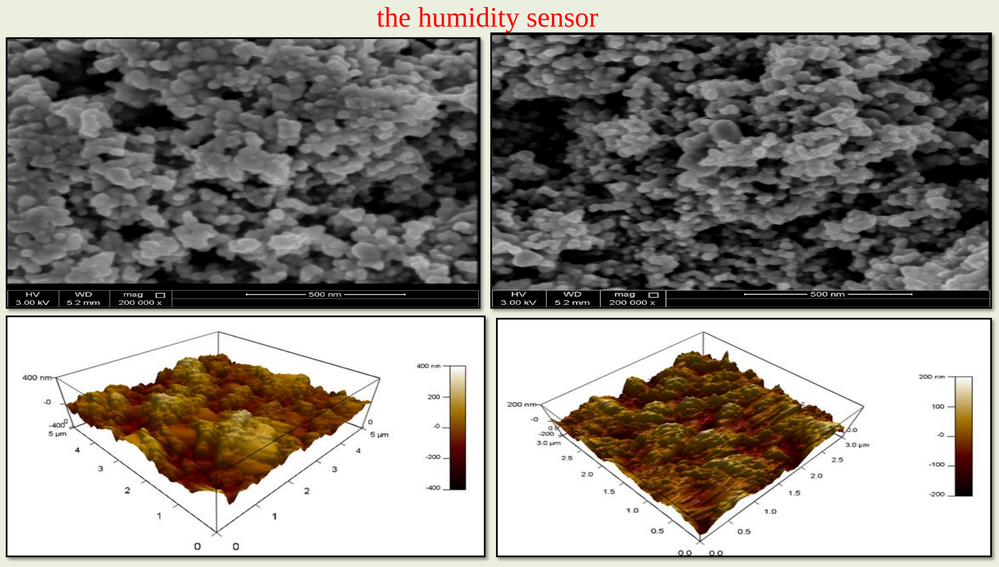


Figure 2: FESEM and AFM analysis of PLA-TiO_2 sensing film with and without acetone etching.

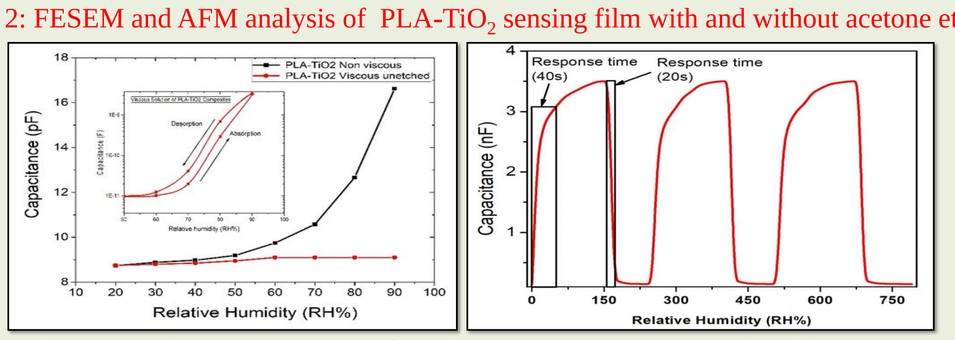


Figure 3: Electrical response of the PLA-TiO_2 nanocomposite humidity sensor.

- PLA-TiO_2 nanocomposite-based humidity sensors after treatment with acetone shows higher sensitivity as compared to unetched PLA-TiO2 nanocomposite sensor.

PVDF-TiO_2 nanocomposite humidity sensor (FM/FESEM photos)

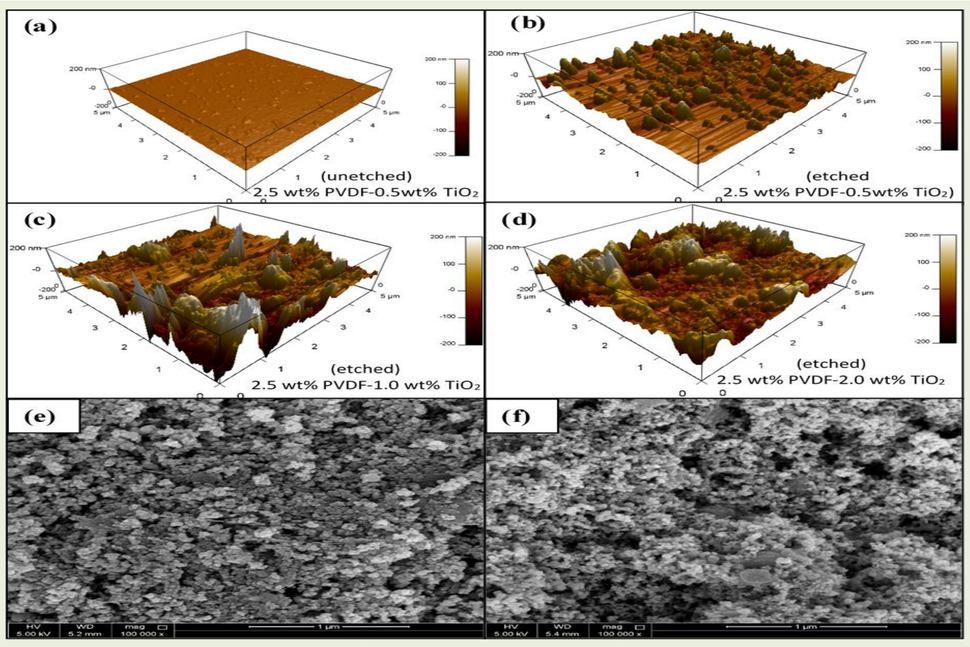
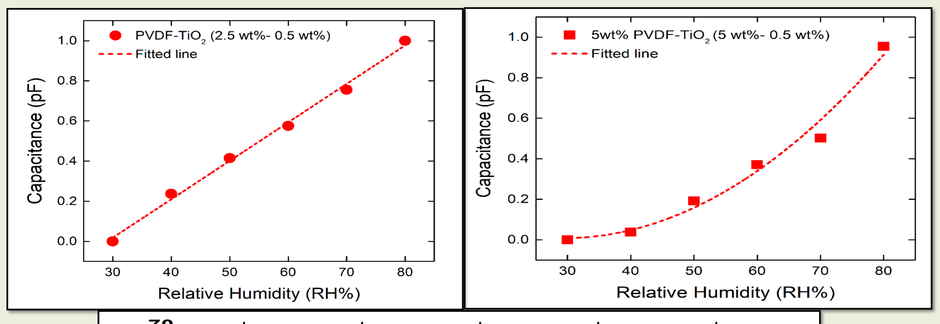


Figure 4: Morphological analysis of PVDF-TiO_2 sensing film with and without acetone etching.



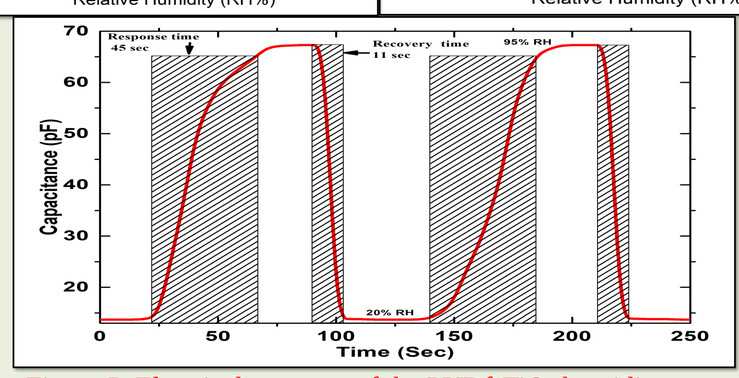


Figure 5: Electrical response of the PVDf-TiO_2 humidity sensor

- PVDF-TiO2(2.5 wt%- 0.5 wt%) nanocomposite sensor shows linear and stable response over whole RH range. Sensor also shows shorter response and recovery time.

PVDF-$BaTiO_3$ nanocomposite humidity sensor

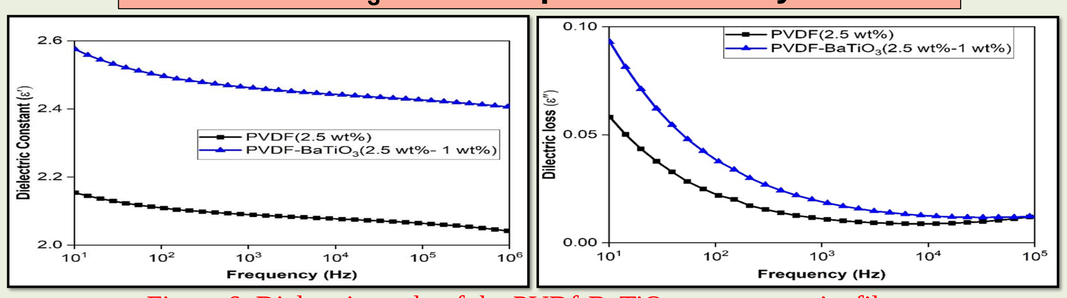


Figure 6: Dielectric study of the PVDf-$BaTiO_3$ nanocomposite film.

Sample Type	PVDF Film	PVDF-$BaTiO_3$ composite film	Acetone-etched PVDF-$BaTiO_3$
Contact angle image			
Contact angle	92.25°	80.95°	50.6°

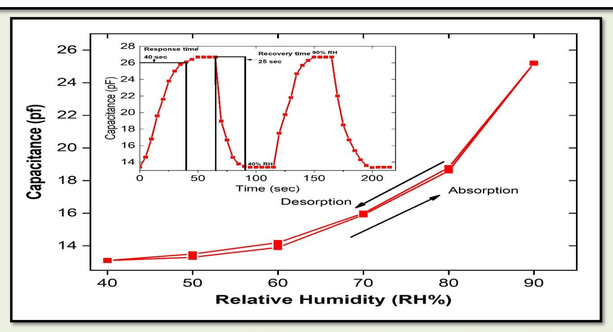


Figure 7: Capacitive response of the PVDf-$BaTiO_3$ based humidity sensor

- $BaTiO_3$ improved the dielectric property of the PVDF-$BaTiO_3$ nanocomposite film and sensors exhibit a stable capacitive response with reduced hysteresis loss.

PVDF-SPEEK blend resistive humidity sensor

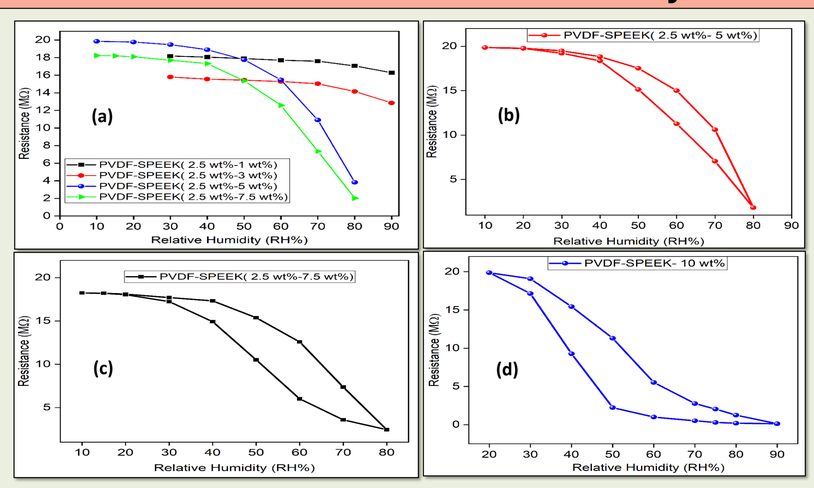


Figure 8 Resistive response of the PVDF-SPEEK blend humidity sensor

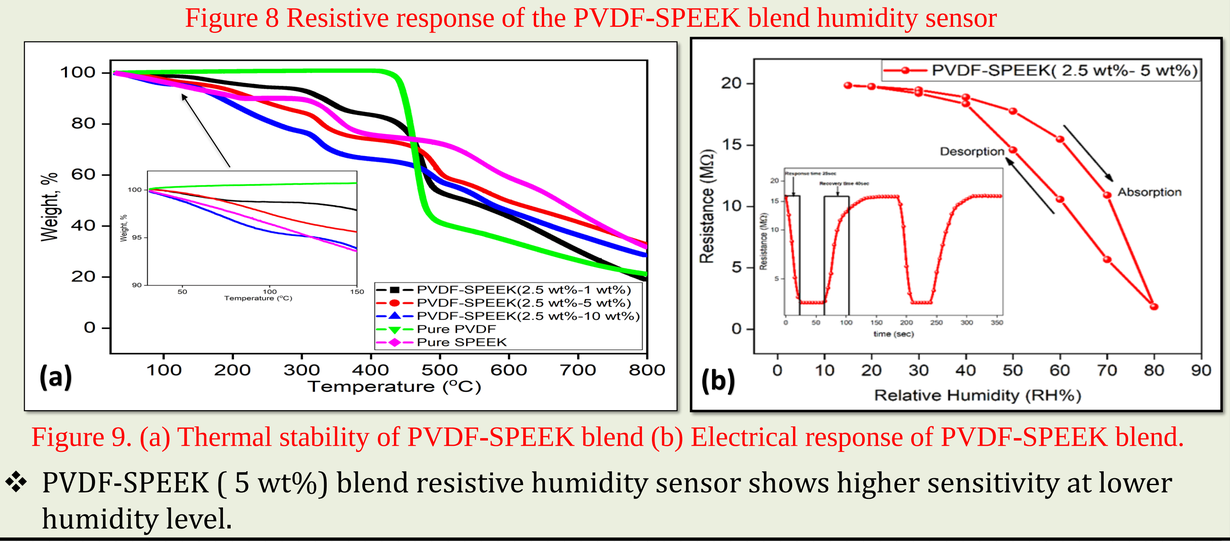


Figure 9. (a) Thermal stability of PVDF-SPEEK blend (b) Electrical response of PVDF-SPEEK blend.

- PVDF-SPEEK (5 wt%) blend resistive humidity sensor shows higher sensitivity at lower humidity level.

Concluding remarks:

We have investigated different polymer nanocomposites for the development of improved humidity sensors. In the first phase, we studied the potential of PLA-TiO_2 nanocomposite for humidity sensing applications. We optimized the concentration of TiO_2 in the PLA-TiO_2 nanocomposite and etch the surface of the sensing film with acetone. In the second phase, we studied the PVDF-TiO_2 nanocomposite-based humidity sensor and achieved a linear and stable capacitive response by optimizing the concentration of PVDF. In the third phase, we incorporated the $BaTiO_3$ nanoparticles within optimized PVDF and studied the dielectric property of the nanocomposite film. PVDF-$BaTiO_3$ sensors show stable capacitive response with reduced hysteresis loss. In the fourth phase, we blended the PVDF with SPEEK polymer and optimized the concentration of SPEEK which has improved a great deal the sensitivity of the humidity sensors at lower humidity levels.

Acknowledgement:

This work was made possible by GSRA3-1-1116-14016 from the Qatar National Research Fund (a member of Qatar Foundation). The findings made herein are solely the responsibility of the authors. The author are also thankful to Centre of Advanced Materials (CAM), QU for the continuous support during this project.