

# Morphological Study of PVDF-TiO<sub>2</sub> Composites Based Humidity Sensors

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## Abstract:

This study is conducted to enhance the sensitivity of nanocomposite films in applications such as humidity sensing. For this purpose, polyvinylidene fluoride (PVDF) and titanium dioxide (TiO<sub>2</sub>) nanocomposites based capacitive humidity sensors are fabricated via spin coating technique. The concentration of PVDF has been varied to investigate its effect on the properties of the films. The synthesized PVDF-TiO<sub>2</sub> composites are characterized by X-ray diffraction (XRD), Raman spectroscopy, Differential scanning calorimetry (DSC), Scanning electron microscopy (SEM), Atomic force microscopy (AFM) and Contact angle measurements. These characterization techniques are employed to study the structure, morphology, thermal stability and hydrophilicity of the deposited nanocomposite films. The 2.5wt% PVDF based capacitive humidity sensors demonstrate increased linearity and sensitivity as compared to the 5wt% sensors. Also, results show that the addition of TiO<sub>2</sub> nanoparticles enhances the hydrophilicity of composite film as compared to standalone PVDF films.

**Key words:** Nanocomposite, hydrophilicity, piezoelectric, sensitivity, capacitance.

## Introduction

In recent decades, polymer nanocomposites have gained much attraction in device fabrication and sensor applications [1]. The key advantages of polymers that have garnered this attraction are their lightweight and low cost of both materials and fabrication. PVDF is a piezoelectric polymer, which has high dielectric constant and mechanically and thermally stable. In capacitive based humidity sensors, the most important parameters that are directly linked to the device sensitivity are its hydrophilicity and hydrophobicity [2]. To improve these characteristics, we need to enhance the surface roughness and porosity of a sensing layer. Different methods are employed to enhance the surface morphology, which include copolymerization, synthesis of composites and blending techniques. However, the addition of nanoparticles to the polymer matrix is widely used to improve the optical, electrical and mechanical properties of nanocomposites [3]. In inorganic nanoparticles, TiO<sub>2</sub> nanoparticles are instrumental owing to their good stability, UV resistance, and high refractive index. In this work, TiO<sub>2</sub> nanoparticles

were synthesized with different concentrations of PVDF and the sensing layer properties such as porosity and roughness at different concentrations of PVDF were compared. We have employed spin coating to deposit sensing layers on ITO/glass substrates. The crystallinity of the PVDF-TiO<sub>2</sub> composite was analyzed by XRD while the thermal properties were investigated by DSC. The morphology of PVDF-TiO<sub>2</sub> nanocomposite were characterized by AFM and SEM. AFM analysis was done on the PVDF-TiO<sub>2</sub> composite films with 2.5wt% and 5wt% concentration of PVDF (Figure 1). The AFM analysis of PVDF-TiO<sub>2</sub> reveals that acetone etched 2.5wt% of PVDF-TiO<sub>2</sub> composite shows more absorbent structure as compared to the 5wt% of PVDF-TiO<sub>2</sub> composite film. We studied the hydrophilic property of the composite film by the contact angle measurement method. The measured contact angles for the PVDF film, unetched and etched PVDF-TiO<sub>2</sub> composite films were 91.1°, 82° and 57.6°, respectively (Table 1). This decrease in contact angle shows that roughness and voids that developed on the film surface had made it hydrophilic, which is essential for water

absorption characteristics. Results of the electrical efficiency in terms of change in capacitance as a function of relative humidity, showed that the 2.5wt% PVDF-TiO<sub>2</sub> based

capacitive humidity sensors are more linear and more sensitive in contrast to the 5wt% of PVDF-TiO<sub>2</sub>(Figure2).

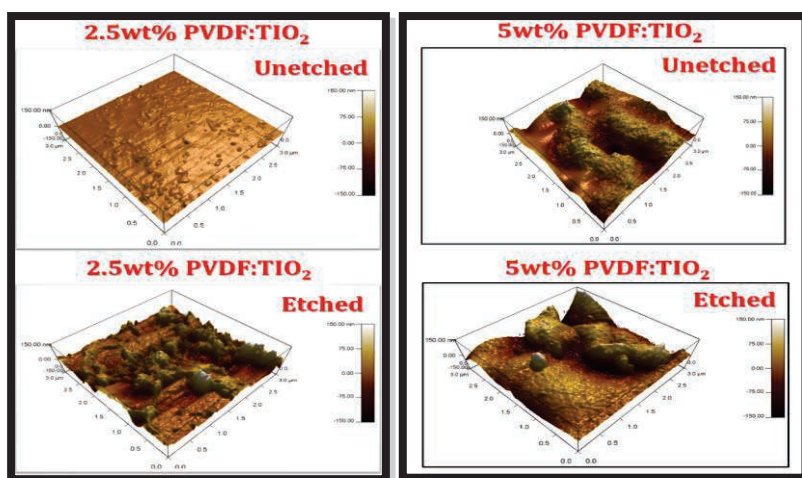


Fig. 1. AFM analysis of acetone etched and unetched 2.5 wt% and 5wt% PVDF-TiO<sub>2</sub> composite film

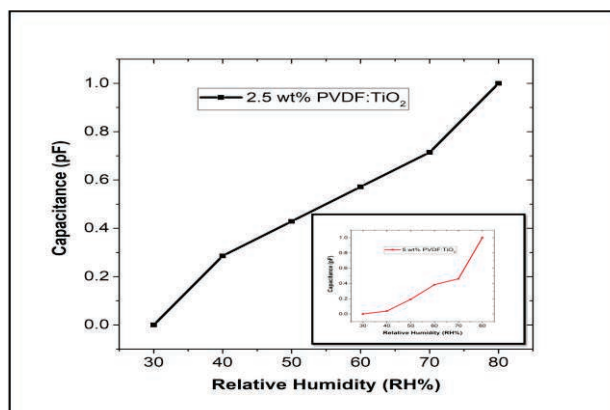


Fig. 2. Capacitance vs Relative humidity level of 2.5wt% and 5wt% of PVDF-TiO<sub>2</sub> composite

| Sample Type         | PVDF film | PVDF-TiO <sub>2</sub> composite film | Acetone etched PVDF-TiO <sub>2</sub> (2min) |
|---------------------|-----------|--------------------------------------|---|
| Contact Angle Image |           |                                      |   |
| Contact Angle       | 91.16°    | 82°                                  | 57.6°                                       |

Table. 1. Contact angle measurement of PVDF film, PVDF-TiO<sub>2</sub> film and acetone etched PVDF-TiO<sub>2</sub> film.

## References

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