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Synthesis of PVA/PAA/$SrTiO_3$ Nanostructures for Pressure Sensors

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In this work, new types of nanocomposites are fabricated from $SrTiO_3$-doped PVA–PAA blend for a high-sensitivity, flexible, high corrosion-resistance, and low-cost pressure sensor. The microscopy images, FT-IR studies and pressure-sensor application of PVA/PAA/$SrTiO_3$ nanocomposites are examined. The PVA/PAA/$SrTiO_3$ nanocomposites are tested for pressure sensor with range from 80 bar to 160 bar. The results indicate that the PVA/PAA/$SrTiO_3$ nanocomposites have high sensitivity for pressure.

У цій роботі нові типи нанокомпозитів виготовлено із суміші полівініловий спирт (ПВС)–поліакриламід (ПАА), леґованої $SrTiO_3$, для дешевого давача тиску високої чутливости, гнучкого, високого опору корозії. Перевірено зображення мікроскопії, дослідження інфрачервоною спектроскопією на основі перетвору Фур'є (FT-IR) і застосування для давача тиску нанокомпозитів ПВС/ПАА/$SrTiO_3$. Нанокомпозити ПВС/ПАА/$SrTiO_3$ випробувано для давача тиску з діяпазоном від 80 бар до 160 бар. Результати вказують на те, що нанокомпозити ПВС/ПАА/$SrTiO_3$ мають високу чутливість щодо тиску.

Key words: polymer blend, PVA, $SrTiO_3$, nanocomposites, pressure sensor.

Ключові слова: полімерна суміш, полівініловий спирт, $SrTiO_3$, нанокомпозити, сенсор тиску.

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1. INTRODUCTION

Nanotechnology is promising as a fast growing area with its technological application for the reason of developed new substance in nanosize. It can be proved a boon, because it has a large possibility to get benefits in fields as information and communication technology, drug improvement, water decontamination [1]. In the class of new materials, polymer nanocomposites have grabbed more attention due to their enhanced electrical, optical and magnetic properties. These materials possess increased modulus and flame resistance, and are capable to preclude oxidation and agglomeration. These enhancements in properties are due to interaction between nanoparticles and polymer matrix. Addition of nanoparticles in polymer matrix improves lifetime of nanoparticles, modifies the surface of nanoparticles by passivation defect states, provide low cost, ease of device fabrication and tuneable optical and electronic properties [2]. Polymers have stability after chemical and physical doping with high mechanical properties [3]. Integration of macro- and nanocomposites has led to the development of a new class of nanocomposite materials, which find vital approach in medicine, biology, industry and defence. Polymers and organic materials have been receiving a great deal of attention for their unique features offering to realize lightweight, environmental friendly, flexible and cost effective electronic devices [4]. Polyvinyl alcohol (PVA) is a polymer with carbon chain backbone attached with hydroxyl groups. These OH groups can be a source of hydrogen bonding and hence assist in the formation of polymer blends. PVA is non-toxic, water-soluble synthetic polymer, which is widely used in the polymer blends due to its good physical and chemical properties, excellent film forming characteristics, emulsifying capability, non-carcinogenic, biodegradable and biocompatible qualities. These unique characteristics enable it for its applicability in pharmaceutical fields, as drug coating agents, material for surgical structures and cosmetic industries [5]. This work aims to prepare of PVA/PAA/$SrTiO_3$ nanocomposites for low-cost pressure sensors.

2. MATERIALS AND METHODS

In this work, the materials used are PVA (88 wt.%) and polyacrylamide (PAA) (12 wt.%) in a polymer blend and the $SrTiO_3$ nanoparticles as additive. To get a homogeneous solution PVA–PAA blend, magnetic stirrer is used in mixing process when each of the PVA and PAA polymers are dissolved in distilled water. $SrTiO_3$ nanoparticles are added to solution with concentrations of 0, 1.8, 3.6, 5.4 and 7.2 wt.%. To prepare the PVA/PAA/$SrTiO_3$ nanocompo-

sites, the casting method is used. Films of PVA–PAA/$SrTiO_3$ nanocomposites are prepared by dissolving 1 g of PVA and PAA with 88:12 ratio in 30 ml of distilled water. The sample is placed between copper plate, and load is applied on two plates where sample between them. The capacitance for different applied load in a range 80–160 bar is measured by using LCR meter type HIOKI 3532-50 LCR HI TESTER at 100 Hz, which locally manufactured.

3. RESULTS AND DISCUSSION

Figure 1 shows microscopy examination of PVA/PAA/$SrTiO_3$ nano-

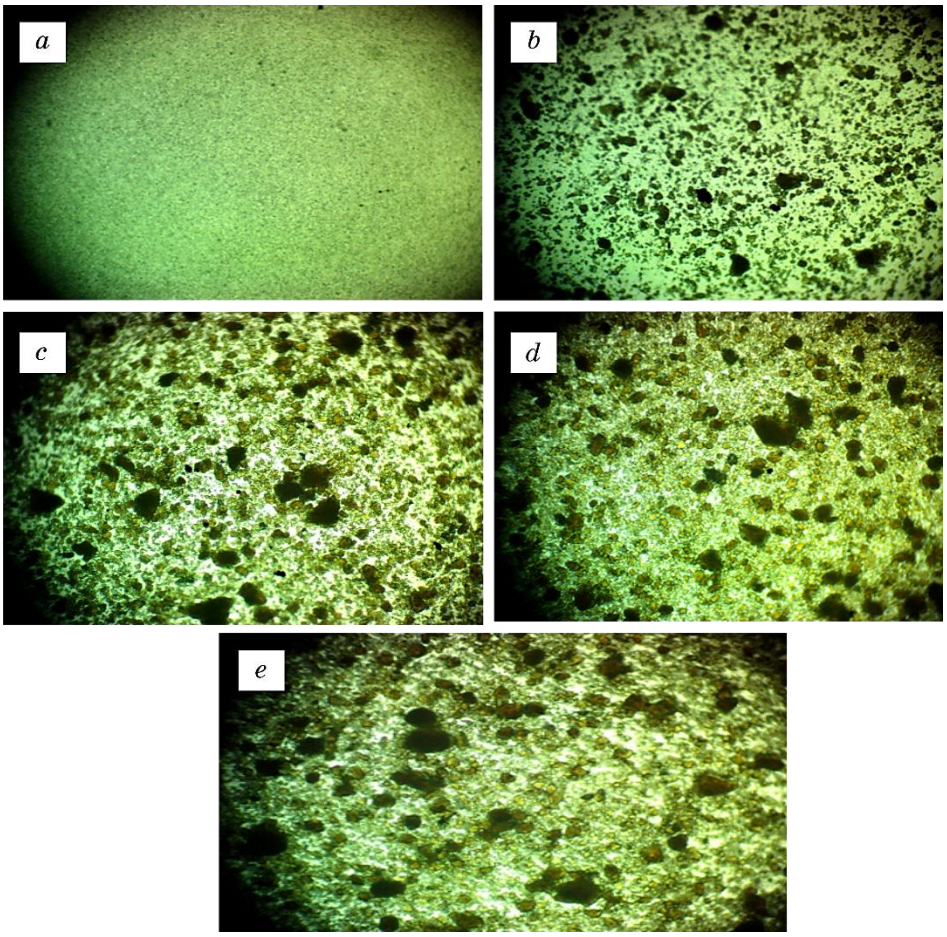

Fig. 1. Microscopy images (×10): (*a*) pure blend; (*b*) 1.8 wt.% $SrTiO_3$ nanoparticles; (*c*) 3.6 wt.% $SrTiO_3$ nanoparticles; (*d*) 5.4 wt.% $SrTiO_3$ nanoparticles; (*e*) 7.2 wt.% $SrTiO_3$ nanoparticles.

composites. The microscopy examination shows the distribution of the $SrTiO_3$ nanoparticles in the polymer PVA–PAA blend. When adding the $SrTiO_3$ nanoparticles to the polymer PVA–PAA blend, the concentrations of the charge carriers, which are absorbing the photons, will increase as shown in Fig. 1, *a*, *b*, *c*, *d* and *e*.

Figure 1 shows that the $SrTiO_3$ nanoparticles are aggregated as clusters at lower content. When increasing the ratio of $SrTiO_3$ nanoparticles, they form paths network inside the PVA/PAA blend.

Figure 2 shows the FT-IR spectra of PVA/PAA/$SrTiO_3$ nanocom-

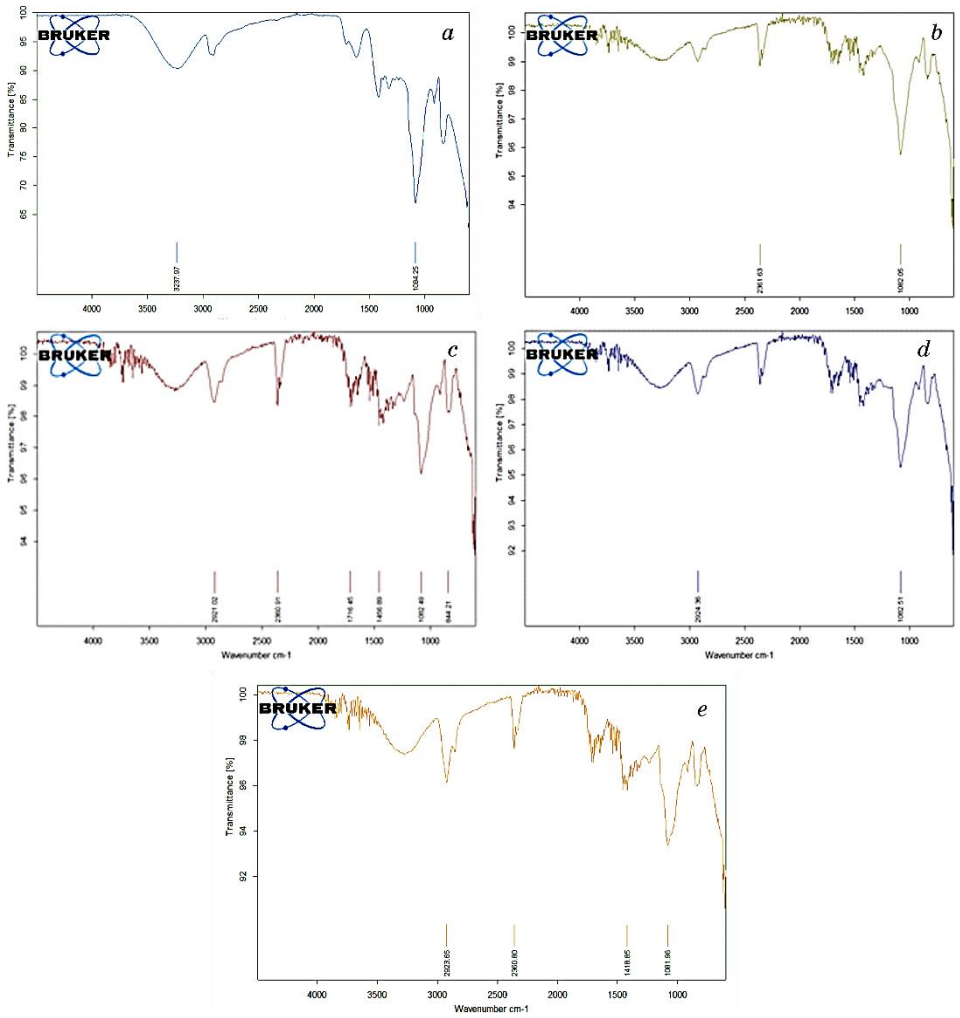

Fig. 2. FT-IR spectra of PVA/PAA/$SrTiO_3$ nanocomposites: (*a*) pure blend; (*b*) 1.8 wt.% $SrTiO_3$ nanoparticles; (*c*) 3.6 wt.% $SrTiO_3$ nanoparticles; (*d*) 5.4 wt.% $SrTiO_3$ nanoparticles; (*e*) 7.2 wt.% $SrTiO_3$ nanoparticles.

posites.

The FT-IR studies of nanocomposites manifest the interactions in nanocomposites. They show broad bands at 3237.97 cm^{-1}. The large bands observed between 3550 and 3200 cm^{-1} are linked to the stretching O–H from the intermolecular and intramolecular hydrogen bonds. The vibrational band observed between 2840 and 3000 cm^{-1} refers to the stretching C–H from alkyl groups. This correlation was calculated through the ratio of the intensities associated with vibrational bands of C–O (1710 cm^{-1}) and bending vibrations related to CH_2 groups at $\delta = 1460$ cm^{-1} that remains almost constant [6]. The peaks at 1418–1424 cm^{-1} were assigned to the C–O groups of polymers matrix. The band observed at 2920 cm^{-1} is characteristic of an asymmetry-stretching mode of CH_2 group. The strong band around 1086–1090 cm^{-1} for all samples of nanocomposites is attributed to the stretching mode of C–O group. The two strong bands observed at around 1420 cm^{-1} and 841 cm^{-1} are attributed to the bending and stretching modes of CH_2 group, respectively [7].

As noted from the FT-IR studies, there are no interactions between PVA–PAA blend and $SrTiO_3$ nanoparticles.

Figure 3 shows a variation of the electrical capacitance for PVA/PAA/$SrTiO_3$ nanocomposites with the pressure for different concentrations of $SrTiO_3$ nanoparticles.

As shown, the electrical capacitance of PVA–PAA blend increases as the pressure increases. There is an explanation of this behaviour: the $SrTiO_3$ nanoparticles are aggregated as clusters in the

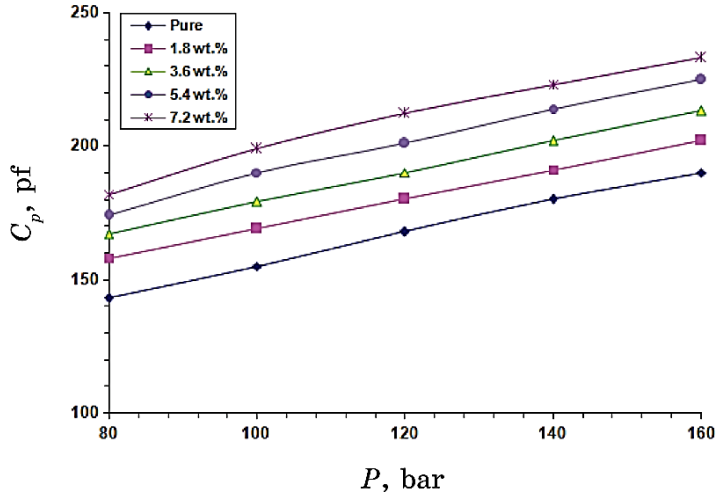

Fig. 3. Variation of the electrical capacitance for PVA/PAA/$SrTiO_3$ nanocomposites with the pressure for different concentrations of $SrTiO_3$ nanoparticles.

PVA/PAA blend and, hence, the electrical resistance is high. Applying the pressure causes a decrease in the distance between filler particles inside the matrix and an increase in the number of conductive paths that leads to decrease in the resistance of composites. Hence, the resistance is low, and the electrical capacitance of PVA/PAA/$SrTiO_3$ nanocomposites will increase [8–14].

4. CONCLUSIONS

In the present work, synthesis of PVA/PAA/$SrTiO_3$ nanocomposites has been investigated.

The microscopy images, FT-IR analysis and pressure sensor application were examined.

Finally, the results show that the electrical capacitance of PVA/PAA/$SrTiO_3$ nanocomposites increases with the rise in pressure that makes the PVA/PAA/$SrTiO_3$ nanocomposites useful for pressure sensors' applications with low cost, lightweight and high sensitivity.

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