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NiO nano particles doped PS-PVDF nanocomposite films: By Solution caste method, structural, morphology and Mechanical studies

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Abstract

Solution cast polymerization scheme was used to create PS-PVDF/Nickel oxide (NiO) hybrid nanostructures (NSs) utilizing Nickel nitrate as a metal precursor, PS-PVDF as a polymerizing agent, and Aloe-Vera (A.V.) gel as an organic fuel. In contrast to the unadulterated segments, PS-PVDF and NiO nanoparticles (NPs), due to communication among the PS-PVDF and the NiO NPs, the electrical investigations of PS-PVDF/ NiO hybrid NCs are rather distinct. From XRD structural information taken, SEM gives the surface morphology of the prepare samples. Mechanical properties of PS-PVDF/NiO NCs sample Based on the results of the measurements and data collected, the synthesized hybrid NCs might be employed in optoelectronic device applications and it's a semiconducting material.

Keywords: Polymer; Nickel oxide (NiO); Nano composites (NCs); XRD and mechanical parameters

1. Introduction

The composites are made of usual foremost polymers such as PS-PVDF [2], and poly-thiophene (PTh). PS-PVDF, amongst the aforementioned polymers, has gotten a lot of attention because of its unique characteristics in comparison to others [1, 2]. Because of their prospective uses and logical interests, Inorganic oxide materials in the nano domain have been thoroughly investigated. These materials have good physical and chemical characteristics due to the influence of their size [7, 8]. NCs made up of PS-PVDF and NiO are being studied more and more because their characteristics differ significantly from those of PS-PVDF and NiO NPs, which can be ascribed to interfacial interactions between the PS-PVDF and NiO NPs [3-14]. Several papers may be reviewed to learn more about an electrochemical characteristic of PS-PVDF and its NCs [5-6]. The current study focuses on dispersing NiO nanoparticles in a PS-PVDFmatrix to create hybrid NCs.

Many researchers have established that the PS-PVDF base nano composites can be broadly used as sensors to detect a variety of gases [8]. Srivastava et al. [7] reported multiwall carbon nanotube (MWCNT) doped PS-PVDF(PS-PVDF) composite thin films for hydrogen gas sensing applications. Their results reveal that the MWCNT/PS-PVDF composite film shows a higher sensitivity in comparison to pure PS-PVDF and it decreases with increasing hydrogen gas pressure. Zhang et al. [9].

The control of the morphology on the gas sensing perfor- mance is another important factor, and therefore, should be considered. The literature survey of polymer NCs concerning that the sensors composition is a main factor that affects the surface morphology of sensing materials which depend primarily on the nature of the components and the processing conditions [10]. In the present work, structural, morphology, and H2S sensing properties of PS-PVDF functionalized NiO NCs prepared by Solution cast polymerization were systematically investigated.

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The inorganic oxide NiO NPs were produced using a solution combustion method and then embedded in a PS-PVDF matrix NCs. various characterization techniques were used to examine the produced NCs.

1.1. Experimental

All of the chemicals were purchased from commercial foundations and were used exactly as they were.

2. Materials

Sigma Aldrich provided analar grade chemicals such as cobalt nitrate hexahydrate [$Ni(NO_3)_2 6H_2O$],Polystyrene (PS) [C_6H_8]n , Polyvinyl Floride (PVDF) (C2H2F2)n, ammonium per sulphate [$(NH_4)_2S_2O_8$], hydrochloric acid [HCl; purity 37 percent], and acetone [CH_3COCH_3]. Fresh aloe-vera gel was extracted from the plant.

2.1. The Polymer Synthesis

In order to make PS-PVDF an aqueous solution of aniline is combined with ammonium per sulphate ($(NH_4)_2S_2O_8$). A greenish black precipitate was produced, which was filtered out and treated with acetone as a cleaning agent. PS-PVDF powder was formed and then dried for 24 hours in a hot air oven at around 80 °C the chemical structure and resonance structure of PS-PVDF **Green fabrication of NiO nanoparticles**

Using Aloe-Vera (A.V.) gel as an organic fuel, a low-temperature Solution combustion method was used to produce NiO NPs. In a ceramic crucible, 2.90 grammes of Nickel nitrate hexahydrate was placed, and 15 ml of A.V. gel was put into the crucible and place on the magnetic stirrer for uniform mixture. The response combination was then placed in a pre-heated muffle furnace at a temperature of 500 degrees Celsius. The metallic nitrates and the fuel undergo a combustion process shown in Fig.1. resulting in nano powders of NiO.

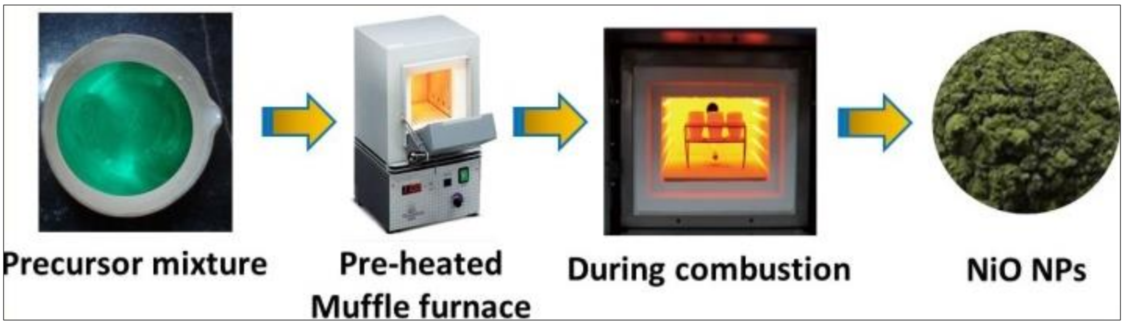

Figure 1 Schematic representation of the combustion synthesis of Nickel Oxide nanoparticles

2.2. Synthesis of PS-PVDF/NiO hybrid nanostructures

Solution cast polymerization method was used to combine PS-PVDF with NiO NCs. To achieve homogeneity, 0.1 M aniline was combined with 1M hydrochloric acid (HCl) and agitated for 15 minutes. Nickel oxide (NiO) NPs were added to the aforementioned mixture at the appropriate weight percentage to homogeneously distribute the NiO NPs. The oxidizing agent, 0.2M ammonium per-sulphate, was added to the polymer mixture drop-by-drop with constant stirring and kept at ice temperature for 4 hours to complete polymerization. The precipitate was filtered before being washed in acetone and de-ionized water. To get an uniform mass, it was calcined for 24 hours at 80°C in a hot air oven. This method was used to make PS-PVDF/ NiO NCs with different percentages of NiO (i.e., 10, 20, 30, 40, and 50wt percent).

3. Result and discussion

3.1. PXRD anaylsis

Figure.2. shows the X-ray diffraction patterns of PS-PVDF, NiO NPs, and PS-PVDF/NiO(10-50wt%) NCs (a). PS-PVDF nanoparticles show a broad diffraction peak at 24^{o}Bragg's angle (2Θ) [11-13]. In the current matrix, doping with the filler NiO NPs weakens the broad peak of PS-PVDF. In line with the standard ICDD card No. 73-1519 [14], the XRD patterns of Nickel oxide (NiO) demonstrate a simple cubic structure with lattice parameters a = b = c = 4.1678. Using established relations, the lattice parameters for the (200) X ray diffraction of cubic structured NiO in PS-PVDF/NiO(10-50 mol percent) polymer NCs were determined to be a = b = c = 4.183 Å.

The PS-PVDF/NiO hybrid NCs showed a significant increase in the lattice parameters of NiO..[14-15] the adsorption of PS-PVDF atomic chains on the surface of NiO results in a small extension of the fundamental building block (unit cell) of the crystalline NiO material. The change in crystallite size of the most prominent peaks (200) planes in X-ray diffraction patterns of PS-PVDF/NiOhybrid NCs can also be ascribed to the presence of such interactions. Scherrer's formula (shown below) is used to compute the usual crystallite sizes of NiO and PS-PVDF/NiO hybrid NCs for the (200) visible peaks.

$$D = \frac{0.9\lambda}{\beta cos\theta} \ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where D denotes the average crystallite size and β is the peak's full width at half-maxima (FWHM). In PS-PVDF/NiO NCs, the crystallite size of Nickel oxide (NiO) along the (200) plane increases from 22 nm to 37 nm. The fact that the crystallinity of NiO is enlarged by the absorption of PS-PVDF subatomic chains on the surface of NiO in PS-PVDF/NiO NCs demonstrates that the crystallinity of NiO is expanded. [16-17].

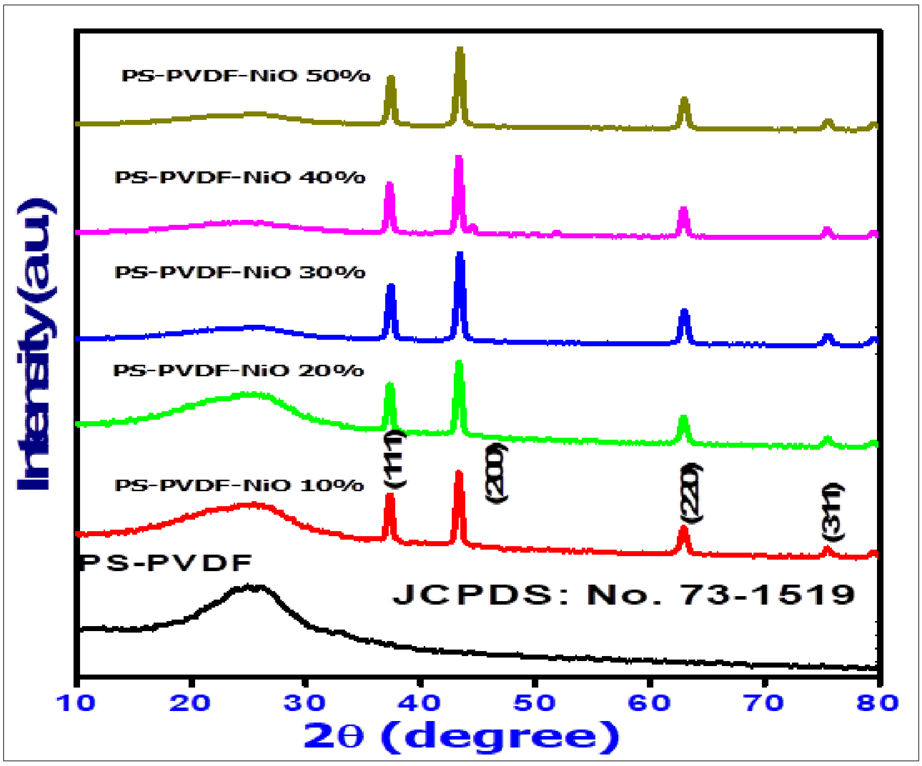

Figure 2 PXRD patterns PS-PVDF/NiO NCs (10- 50 wt %)

Table 1 The estimated average crystallite size, PS-PVDF/Co3O4 (10-50 wt%) NCs

Co3O4 (wt %)	Crystallite size (nm) by Scherer's method
10	23
20	29
30	30
40	33
50	34

3.2. Organizational and morphological studies

Figure.3. depicts surface morphological investigations of the current polymer/Metal oxide nano composites. [18-19] Surface morphology of pure PS-PVDF shows granular morphology with holes in the centre of spectrograms (Fig. 4a), and nano-crystalline morphology of NiO NPs (Fig. 3b). The morphology of prepared NCs PS-PVDF/NiO (10–50 wt percent) is shown in Figure 3.c-e. The morphology shows congested groups when the NiO content in the PS-PVDF matrix is increased 50% (Fig.3c). Further incorporation of NiO (50 wt%) NCs into the PS-PVDF matrix (Fig.3c) results in permeable linked nanospheres [20-23]. Fig 3(a-g) SEM EDX spectra show the presence of NiO content in the PS-PVDF matrix.

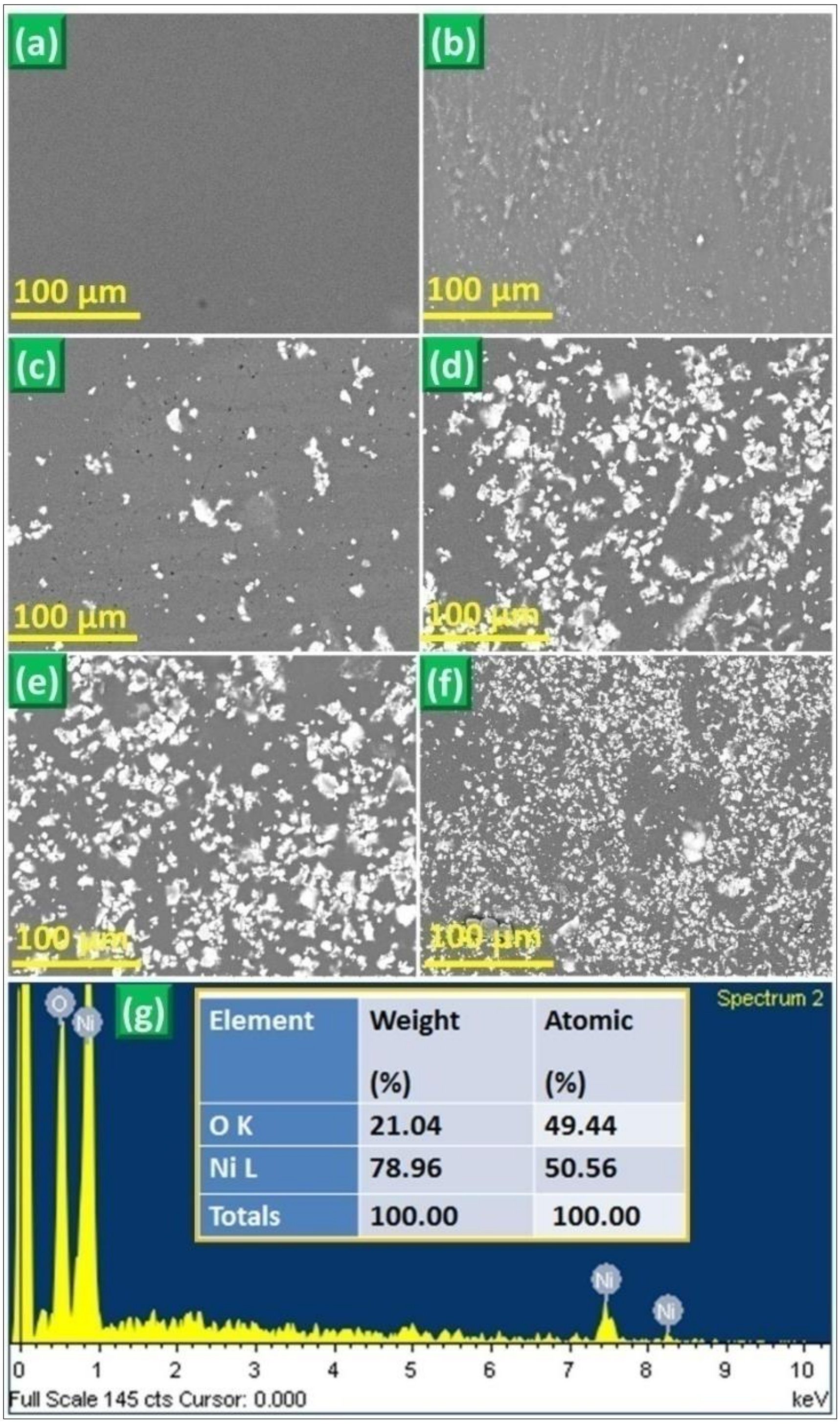

Figure 3 SEM micrographs of (a) pure PS-PVDF, (b) NiO NPs (c) PS-PVDF/NiO NSs and (d-e) EDAX Spectra of PS-PVDF/NiO NSs

3.3. Mechanical Studies

Figure.4. polymer films is Initially, PS-PVDF exhibits a lower tensile strength and a higher elongation at break that reflects its flexibility due the hydrophilic nature of the PS-PVDF, which is related to the existence of the hydroxyl groups in the polymer backbone, which contribute to water absorption competent to raise the open volume among the polymeric chains [18-19]. In doing so, the relieve of progress of polymeric chains with admiration to each other is spectacularly enhanced. In packaging, a plasticizer is a substance further to materials to impart flexibility, workability, and elongation. The plasticizer to the film is to overcome the film brittleness caused by extensive intermolecular force and 50 wt % shows the more stronger then remaining films.The prepared new ductile materials, The below graphs shows Strain –Strain relation of PS-PVDF/NiO NCs with different ratios (10-50) NCs. [20-21].

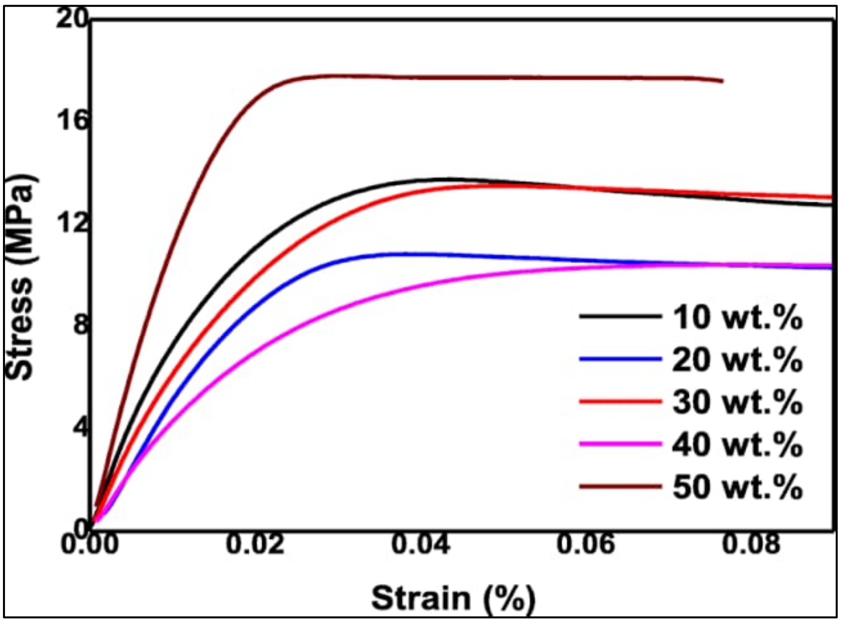

Figure 4 Mechanical studies of PS-PVDF/NiO NCs

4. Conclusion

In conclusion, the PS-PVDF/NiO NCs were successfully produced using a Solution caste polymerization method. The amorphous nature of pure PS-PVDF and the cubic phase of NiO NPs are confirmed by PXRD patters and also the morphology of pure PS-PVDF and blends was investigated in depth with TEM micrographs. SEM Surface morphology of pure PS-PVDF shows granular morphology with holes in the centre of spectrograms and EDX spectra confirms the presence of PS-PVDF/NiO NCs. PS-PVDF exhibits a lower tensile strength and a higher elongation at break that reflects its flexibility due the hydrophilic nature of the PS-PVDF, which is related to the existence of the hydroxyl groups in the polymer backbone. To summaries, the current PS-P.VDF/NiO hybrids NCs are promising materials for fabricating for semiconducting as well as Mechanical properties of the material shows the ductile nature.

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