STRUCTURAL STUDY OF PVA COMPOSITES WITH INORGANIC SALTS BY X-RAY DIFFRACTION

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Abstract
Polymer composites are among the most rapidly growing research fields in material science. Polymer composites are adding a great deal of material that is more durable and useful as compared to the conventional material. Properties of composite materials greatly depend on the nature, proportion and compatibility of the components of the composite materials. In this paper we have conducted an analysis of the XRD study of polymer composites of Poly (vinyl alcohol) with inorganic salts such as sodium sulphate and lithium sulphate.

Key Words; PVA, XRD, Sodium sulphate, Lithium sulphate,

Introduction
Composite materials are the materials made up of two or more components forming two or more phases. These materials are heterogeneous at least on a microscopic scale [1]. During the past decades, there has been a rapidly increasing search for new materials that can replace conventional materials. Ideal structural materials should have low densities, high tensile strength, high stiffness, resistance to abrasion and corrosion. Obviously, this is a rather formidable combination of characteristics that is hard to be found in any of the conventional material. Polymers composites are up to greater extend fulfilling the demand for such material. Properties of blends and composite materials greatly depend on the nature of the matrix and the filler, their compatibility, nature of the size combining units and their relative properties.

More recently, considerable research effort in polymer blends and composites has led to a mushrooming growth of the patent and scientific literature. A great deal of book reviews and conferences proceedings covering different aspects of the preparation, phase behaviour and applications of different types of blends and composites have been established [2]. In this study, we have aimed at taking into account structural analysis of the polymer composites of PVA with inorganic salts. This work is an attempt to introduce such a material that can be used both in aqueous and non-aqueous media as a bio-material and as a high performance material respectively. Along with other improvements features; such a material can prove itself advantageous for bio, medical and industrial applications.

Experimental
Chemicals used:
The polymer Poly (vinyl alcohol) (BDH chemical Ltd England) with molecular weight of approximately 125,000 g/mol, sodium sulphate (BDH Chemical Limited England) and lithium sulphate (Merck, Germany) was used while distilled water was used as a solvent.
Preparation of Stock solutions:
Stock solutions of sodium sulphate and lithium sulphate were prepared and later used to prepare different concentrations (2%, 4%, 6%, 8% and 10%) of the salt in polymer to make composites of different compositions. Weighing of all chemicals and polymer was done on AND HR200 type top loading balance.

Preparation of Polymer Composite films:
The stock solution was used to make different compositions of solutions using the dilution formula. In these solutions of different concentrations, solid PVA 5% (w/w) was added and dissolved using magnetic stirrer with hot plate. Solutions of composites transferred to Petri dishes of 14 cm diameter, kept on a smooth and level surface, covered with lids and annealed at room temperature. Solvent evaporation method was used to obtain uniform smooth films of polymer composites.

Characterization:
After the composite films were prepared and dried, they were cut into the appropriate sized and shapes and then subjected to characterization analysis. The X-Ray diffraction (XRD) analysis has been a very useful tool used to determine the structure and crystallization of different materials. It has been used to determine the structure of the polymeric composites successfully [3-4]. XRD analysis of various compositions of three polymer-composite systems was carried out.

Results and Discussion
X-Ray Analysis of PVA /Sodium Sulphate Composite
XRD pattern of pure PVA film (Figure 1) was recorded and used as a reference for other compositions of different composite systems [5]. The observation of the maximum intensity diffraction peak at $2\theta = 19.8^\circ$ corresponding to $d$ spacing 4.480Å, indicated the presence of a typical semi-crystalline structure, consistent with earlier studies [6]. X ray diffraction patterns PVA/Na$_2$SO$_4$ (2%, 4%, 6%, 8% and 10%) composite system are shown in Figure 2. The XRD pattern of the pure PVA has indicated the presence of crystalline behaviour, in agreement with the results reported earlier [7]. Addition of sodium sulphate to various compositions in PVA to form different compositions of the composite; demonstrated the amorphous nature of composite system and the amorphous nature was observed to increase with increase in the concentration of the added salt, because the crystalline structure of the Polymer vanishes by increasing the concentration of salt.

![Figure 1: XRD Pattern of pure PVA film.](image)

In other words it can be said that semi-crystalline nature of PVA is shattered by the addition of sodium sulphate [8]. The same behaviour has been observed in the combination of all patterns along with PVA film pattern for comparison with respective control PVA film pattern. These results are complying with early reported results of...
similar studies \[9\]. The changes in the XRD patterns clearly indicated coordination between the components of the composites; i.e. polymer and the salt \[10\].

![X-Ray Diffraction Pattern](image)

**Figure 2:** X-Ray Diffraction Pattern of, a) Pure PVA, b) PVA/Sodium sulphate (0.2%), c) PVA/Sodium sulphate (0.4%), d) PVA/Sodium sulphate (0.6%), e) PVA/Sodium sulphate (0.8w%) and f) PVA/Sodium sulphate (1.0%).

**XRD Analysis of PVA/Lithium Sulphate Composite**

Results obtained from the PVA/lithium sulphate composites of various compositions of lithium sulphate showed more or less similar behaviour as compared to the PVA/sodium sulphate composites.

The observed intensity of XRD peaks from these samples was significantly higher than that for PVA/sodium sulphate composites which showed the greater impact of lithium sulphate on the crystallinity of the composite formed by increasing lithium sulphate in PVA as a polymer matrix. This phenomenon is obvious from Figures 3, showing the behavior of the composites with different concentrations of lithium sulphate.

![X-Ray Diffraction Pattern](image)

**Figure 3:** X-Ray Diffraction patterns from, a) Pure PVA, b) PVA/lithium sulphate (0.2%), c) PVA/lithium sulphate (0.4%), d) PVA/lithium sulphate (0.6%), e) PVA/lithium sulphate (0.8%) and f) PVA/lithium sulphate (1.0%).
It is noted that the diffraction peaks in case of PVA / lithium sulphate composites move to the higher value of $2\theta$ as the concentration of Lithium sulphate increases in the composite; which is an evidence for higher degree of crystallinity in the composite. This fact has shown in the Figure 3 which shows a comparison among various concentrations of lithium sulphate in the PVA / lithium sulphate composite.

Conclusions
X-Ray diffraction analysis of PVA / sodium sulphate composite and PVA / lithium sulphate composite revealed the major change in the structure and morphology of the composite by addition of the salts in the polymer. In each case, there is transition from more crystalline amorphous structure by addition of the salts.

References