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Solvent Displacement Approach for Morphological Analysis of Low-Density Polyethylene and Polyethylene Glycol in Equal Proportion

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Abstract

Effect of polyethylene glycol(PEG) on the morphological characteristics of Low density polyethylene (LDPE) structure was investigated using the solvent displacement method.An equal weight ratio 1:1 of PEG and LDPE was employed to enhance the materials dispersion ,hydrophilicity,and biodegradability .The structural and morphological properties were analyzed using X-ray diffraction,Fourier-Transform infrared spectroscopy(FTIR) ,and scanning electron microscopy(SEM) .The results revealed a reduction in crystallinity ,while FTIR confirms the successful incorporation of PEG in LDPE ,improved spherical shape and less agglomeration , with potential applications in packaging and environmental fields.

Keywords: Solvent Displacement Methods, PEG LDPE, XRD, FTIR, SEM

1. Introduction

Polyethylene (PE),particularly Low Density Polyethylene is the most utilized petroleum-based synthetic polymer, due to its magnificent mechanical attributes, water holding capacity, lightness, cheapness and high energy effectiveness.LDPE owes its outstanding mechanical properties to its long and strong polymer chains or matrix.[1]

In fact, PE materials have low surface reactivity and hydrophobic nature due to the lack of functional groups and low proportion of polar regions on their surfaces, and therefore incomplete adhesion with other materials .Recently, many studies focused on the development of the surface modification of hydrophobic polymers via graft polymerization with PEGs. However, evident changes in surface characteristics of LDPE specimens after PEG/PEO grafting were demonstrated using several analysis techniques. These include surface hydrophilicity or wettability, chemical compositions of the surface, as well as surface roughness and morphology[2]

Polyethylene glycol (PEG) is a versatile hy-drophilic polyether that is immobilized onto the polymer surfaces using various techniques as physical adsorption, graft polymerization, covalent grafting, blending, etc. [3-6] In most instances, PEG is used because it exhibits the interesting property of being highly compatible with water (i.e., highly water soluble) while exhibiting strong incompatibility with a wide variety of other water-soluble substances.[7]

Several manufacturing techniques, including salting-out, emulsion evaporation, emulsification diffusion, and solvent displacement are used to produce biodegradable nanoparticles from preformed, well-defined polymers (Vauthier and Bouchemal, 2009). The solvent displacement method is a convenient, reproducible, fast, and economic one-step manufacturing process for the preparation of monodisperse, polymeric nanoparticles in a size range of approximately 50–300 nm (Fessi et al., 1989)[8]

The present study aims to fabricate LDPE- PEG composites using the solvent displacement method and investigate the effects of PEG incorporation on structural and morphological properties of LDPE.The composites were analyzed using X-ray diffraction(XRD),Fourier-Transform infrared spectroscopy(FTIR),and Scanning Electron Microscopy(SEM).

2. Materials and Methods

A. Materials

Low density Polyethylene (LDPE),Polyethylene Glycol (PEG ,moleculr weight 6000 g/mol),Xylene (analytical grade) was used as the organic solvent ,water was used throughout experiments.All chemicals were used as received without further purification.

B. Methods

Equal masses (3 gm each) of Low Density Polyethylene-Polyethylene Glycol (LDPE-PEG) was dissolved in 100 ml of xylene by using magnetic stirrer at constant temperature 110° C for 2 hour .Homogeneous solution was obtained then rapidly injected dropwise this solution into 300 ml of water using syringe then filtrate and dried.[9]

3. Results and Discussion

X-ray Diffraction of LDPE- PEG

The crystalline structure of 3 gm LDPE and LDPE- PEG (3gm each) was characterized byXRD in order to confirm the structure and the presence of PEG within the LDPE. The XRD patterns for pure 3gm LDPE and LDPE- PEG (3gm each) are represented in Figures1.1(a), 1.1(b) respectively

Figure 1 shows XRD of LDPE-PEG

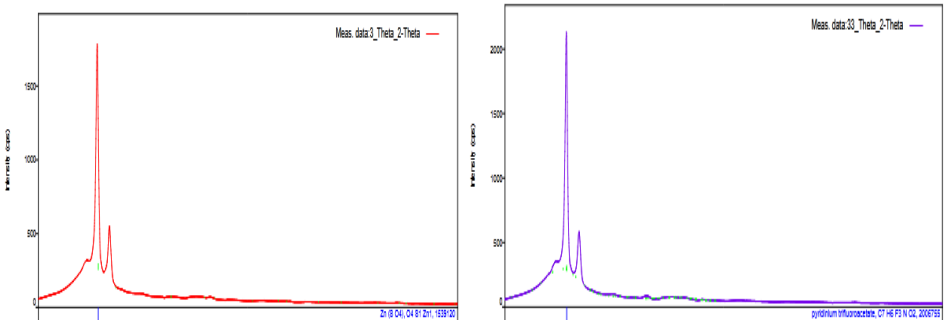

Fig.1.1(a) XRD of pure LDPE Fig.1.1(b) XRD of LDPE-PEG (1:1)

The XRD pattern in Figures 1.1(a) show a dominant fairly sharp peak at 21.19^0 and a weak broad peak at 23.55^0 correspond to (110) and (200) reflections from the orthorhombic polyethylene crystals[10] .These peaks confirm the semicrystlline nature of LDPE arising from its short chain branching and low crystalinity.

Figures 1.1(b) show a dominant fairly sharp peak at 21.19^0 and a weak broad peak at $23.52^{0.}$ Suggesting partial disruption of LDPE crystalline phase due to PEG integration.

These peaks may broaden or reduce in intensity,indicating a loss of crystallinity or dispersion into the LDPE matrix .overall ,the XRD results confirm the coexistence of PEG and LDPE crystalline phases within the composite and suggest that solvent displacement method leads to a moderately altered crystalline structure.

4. FTIR Analysis of LDPE-PEG

FTIR spectra of the samples 3gm LDPE and 3gm each of LDPE-PEG was analysed in the wave number range of 4000-500 cm^{-1}

Figure 2 shows FTIR spectra of LDPE-PEG

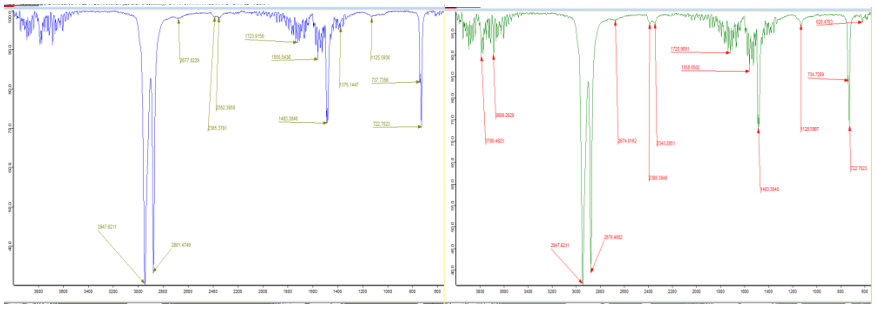

Fig.2.1(a)FTIR spectra of pure LDPE Fig.2.1(b) FTIR spectra of LDPE-PEG (1:1)

FTIR spectra of 3gm of pure LDPE exhibited characteristics absorption bands at approximately at 2947.62cm^{-1} and 2881.47 cm^{-1}corresponding to asymmetric and symmetric stretching vibrations of -CH_2- groups.The peak of 1483.38 cm^{-1} attributed to –CH_2- bending vibrations.The peak at 722.70 cm^{-1}is due to C-H rocking (Asymmetric C-H bending).The peak of 1125.59 cm^{-1}is occur due to CH_2 rocking.

FTIR spectra of 3gm of each LDPE-PEG exhibited characteristics absorption bands at approximately at 2947.62 cm^{-1} and 2878.46 cm^{-1}corresponding to asymmetric and symmetric stretching vibrations of -CH_2- groups.The peak of 1483.38 cm^{-1} attributed to –CH_2- bending vibrations. The peak at 722.70 cm^{-1} is due to C-H rocking (Asymmetric C-H bending) The peak of 1128.59 cm^{-1} is occur due to presence of -C-O bond of PEG.

The presence of all major functional group peaks indicates successful incorporation of PEG and LDPE No significant shifts in peaks Minor peak shifts or broadening could indicate partial miscibility or hydrogen bonding between PEG and LDPE.

5. Scanning Electron Microscopy(SEM)

Scanning Electron Microscopy (SEM) was used to examine the surface morphology and microstructural characteristics of the pure LDPE and LDPE-PEG composite samples**.**

Figure 3 shows SEM analysis of LDPE-PEG

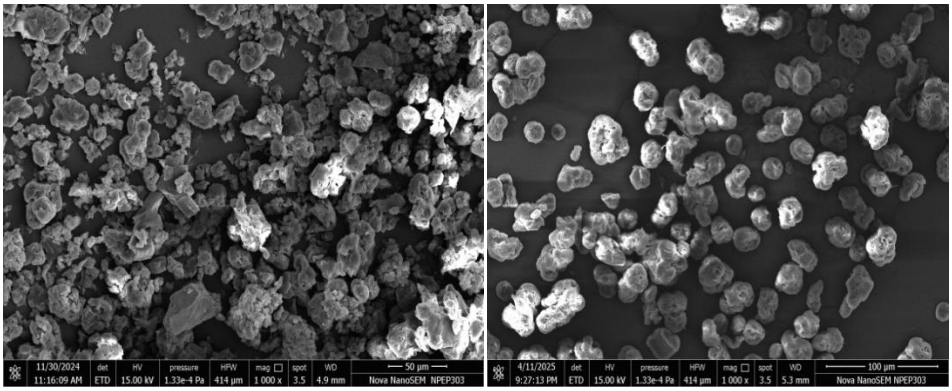

Fig.3.1(a) SEM images of pure LDPE Fig. 3.1(b) SEM images of LDPE-PEG(1:1)

Pure LDPE showed irregular shape, with agglomeration ,typical of its semicrystalline structure The morphology was characterized by the absence of pores.

In LDPE-PEG composite,significant morphological changes were observed mostly spherical in shape,less agglomeration with few irregularities.

The surface appeared rougher and more granular indicting successful incorporation of PEG in LDPE.

6. Conclusion

From the present study the effect of polyethylene glycol on structural properties of low density polyethylene was synthesise by solvent displacement methods at equal proportion. X-Rays Diffraction (XRD) technique was applied to investigate the morphology of the polymer; the results obtained confirmed a partial crystalline character of LDPE. The XRD results shows that after addition of equal ratio PEG and LDPE reduce the crystal size. Fourier Transform Infra Red (FT-IR) Spectroscopy was also used to investigate the functional characteristics of the polymer. Effect of PEG added in LDPE there is slightly changes in peak position. Scanning Electron Microscopy(SEM) was used to investigate surface morphology.Addition of PEG in LDPE improved spherical shape and less agglomeration.

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