

FTIR Analysis of Infrared Irradiated Polymers

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ABSTRACT

The modification of polymer properties under ionizing radiation¹ is a subject of great interest due to the increasing use of polymers in hard radiation environments encountered in space crafts, nuclear power plants, sterilization irradiators, high energy particle accelerators etc. The present work deals with the changes induced in CR-39 (Columbia Resin) and PET (polyethylene terephthalate) polymers by IR (Infrared radiation) irradiation. In order to obtain the fundamental information on the modification of polymers due to irradiation, FTIR (Fourier Transform Infrared Spectroscopy) analysis has been employed to both the polymers. The changes have been estimated from the relative increase or decrease in the band intensities of functional groups present in the polymeric chains. IR spectroscopy allows the identification of different absorption bands²⁻³. Overall increase in intensity of all the functional groups has been noticed with an exception at 36 hr exposure where the intensity has been found to decrease. A broader band has been observed at 1500-1000 cm^{-1} , which may be attributed to the thickness of the CR-39 polymer (230 μm).

Key Words: FTIR, CR-39, PET

INTRODUCTION

Irradiation of the polymers generally leads to a radiation damage, which modifies the properties of the surface and bulk of the polymers⁴⁻⁵. These modifications are the

consequence of irreversible reaction mechanisms in polymers owing to processes like main chain scission, intermolecular cross-linking, and creation of unsaturated bonds and emission of atoms, and molecules etc⁶.

The present work has been carried out to study the comparative influence of IR radiation on the intensity variation of CR-39 and PET polymer.

EXPERIMENTAL

Small pieces of PET and CR-39 have been cut from a sheet of average thickness of 100 μm and 230 μm , respectively. The samples were washed and cleaned with sodium hydroxide and then under running water to remove the adsorbed impurities. Irradiation was carried out in air at room temperature for time period varying from 1 to 72 h with the interval of 12 h using an IR lamp (Philips infra phil HL4311) of 150 W at 210 V, at a distance of 6cm from the source output. The chemical changes have been investigated using the reliable analytical techniques of Fourier Transform Infrared Spectrophotometer (FTIR-8400S, SHIMADZU) in the range of 4000-500 cm^{-1} .

RESULTS AND DISCUSSION

The infrared spectra have been obtained for unirradiated and irradiated samples (Fig.1).

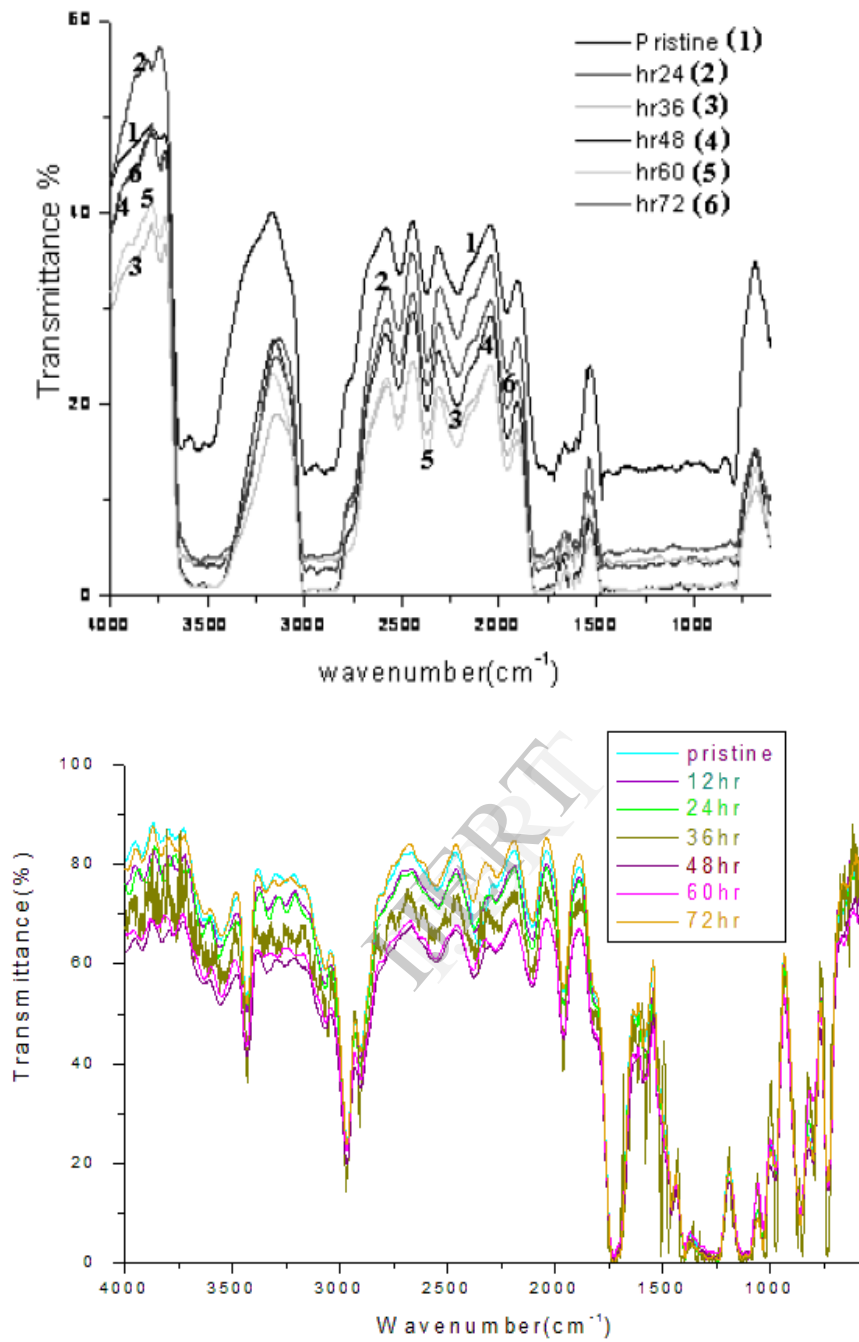


Fig.1: FTIR spectra for Pristine and IR exposed CR-39 and PET polymer

Overall increase in intensity of all the functional groups has been noticed in CR-39 with an exception at 36 hr exposure where the intensity has been found to decrease. A broader band has been observed at 1500-1000 cm^{-1} which may be attributed to the thickness of the CR-39 polymer (230 μm). While in case of PET an overall decrease in the intensity has been observed with an exception at 72 hr, where the intensity has been found to increase, this may be due to the bond breaking in polymer.

For the better interpretation of the results, normalization of some peaks has been considered with respect to H_2O of the pristine samples as reference.

Normalization w.r.t. H_2O

From the Fig.2, the water content of the CR-39 has been found to increase up to 12 hr exposure which corresponds to decrease in the intensity of O-H bond, it may be concluded that O-H capture H atom from the backbone to produce water and become free from polymeric chain.

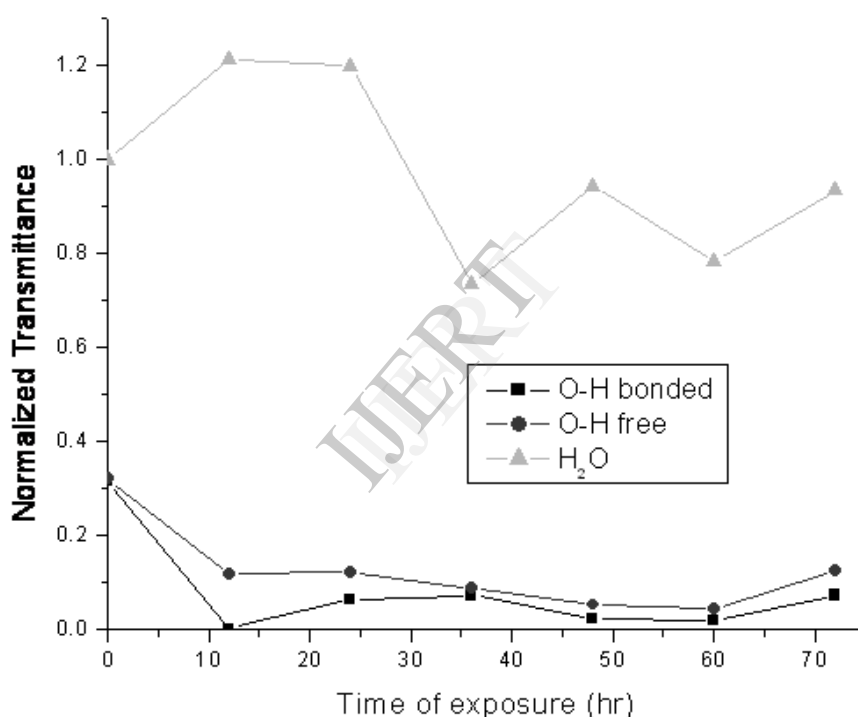
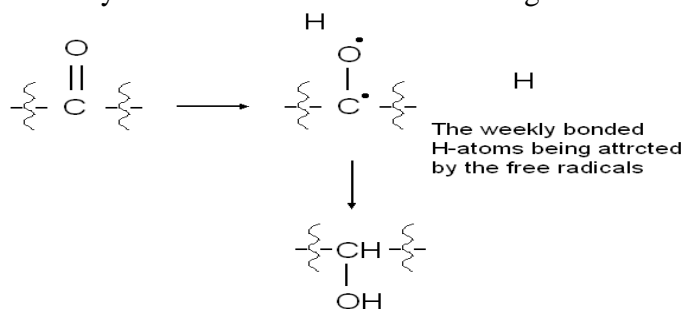


Fig.2: Time of exposure (hr) versus Normalized transmittance with respect to water content of pristine CR-39

It remains constant for 24 hr and thereafter dehydration of the CR-39 has been observed which is also evident from increase in the extent of O-H bond. Free O-H has been found to remain constant. There is decrease in water content at 36 hr and it may be because of

vaporization which results from the heating effect of IR radiation. Water content at 48 hr again increases which leads to the molding of the samples due to rehydration of the sample. At 72 hr, carbonate linkage breakup and supposed reaction is given below.



Due to this breakup of carbonate linkage, intensities of all the three i.e. of H₂O, O-H free and O-H bonded have been increased at 72 hr.

The water content of PET has been found to decrease upto 12 hr which may be due to vaporisation caused by IR heating effect (Fig.3).

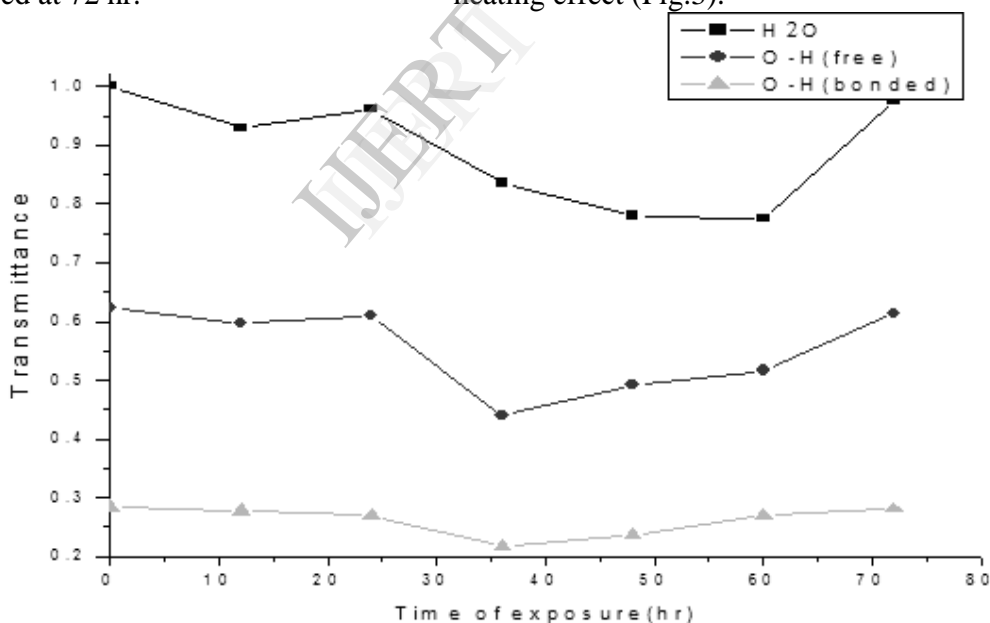
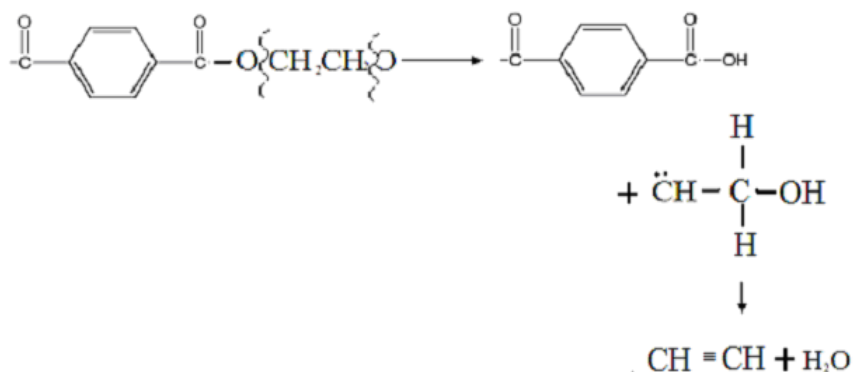


Fig.3: Time of exposure (hr) versus Normalized transmittance with respect to water content of pristine PET

The sharp decrease at 48h may be due to bond breaking in the polymer. The water content remains constant upto 60hr and the sharp increase is observed

at 72hr due to the formation of water from evolution of free O-H. At 72h, carbonate linkage break up and supposed reaction is given below.



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