

# NOTE

## IR Spectroscopic Study of Fibers Made of Polypropylene with Grafted Copolymer of Styrene and Divinyl Benzene

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### INTRODUCTION

Strong base and strong acid polyolefin fibers with grafted styrene may be obtained in different textile forms, such as cut fiber, staple fiber, filaments, non-woven materials, and ion-exchange paper.<sup>1–4</sup> Available and virtual applications of strong base and strong acid fibers include air purification from gases, vapors, aerosols of acidic and basic character, and mutagenous components of a tobacco smoke in pure rooms, respirators, filters for ventilation air and industrial exhaust gas purification from ions of heavy metals, and in electro dialysis and ion-exchange apparatuses for preparing high-resistance water as acid-base catalysts for syntheses of valuable organic substances and components of artificial soils for plants.<sup>5–7</sup>

In view of such a wide application area, it is important to have maximum full information about structural details and behavior of these polymeric materials under their working conditions. This work concerns the compatibility of components of fibers of series FIBAN made on the basis of polypropylene (PP) fibers with grafted copolymer of styrene and divinyl benzene (DVB).

### SAMPLES AND EQUIPMENT

The samples were prepared in a laboratory. After  $\gamma$ -irradiation of the PP fibers in 15–50% solutions of the

monomers in methanol, the residual homopolymer was separated from the grafted fibers by washing in Soxhlet extractor; then the fibers were dried at 60°C to a constant mass. The samples for investigation were in a staple form with the content of grafted polymer 18–305% mass to the initial PP. The fibers were 50 mm in length and from 35 to 53  $\mu\text{m}$  in diameter in dependence on the mass of grafted copolymer. The copolymer contained 98 wt % styrene (S) and 2 wt % DVB. The latter additive was introduced to reduce the monomer loss during the procedure of washing the samples with benzene.<sup>8</sup>

The infrared (IR) spectra were recorded on the DS 403G grating spectrophotometer.

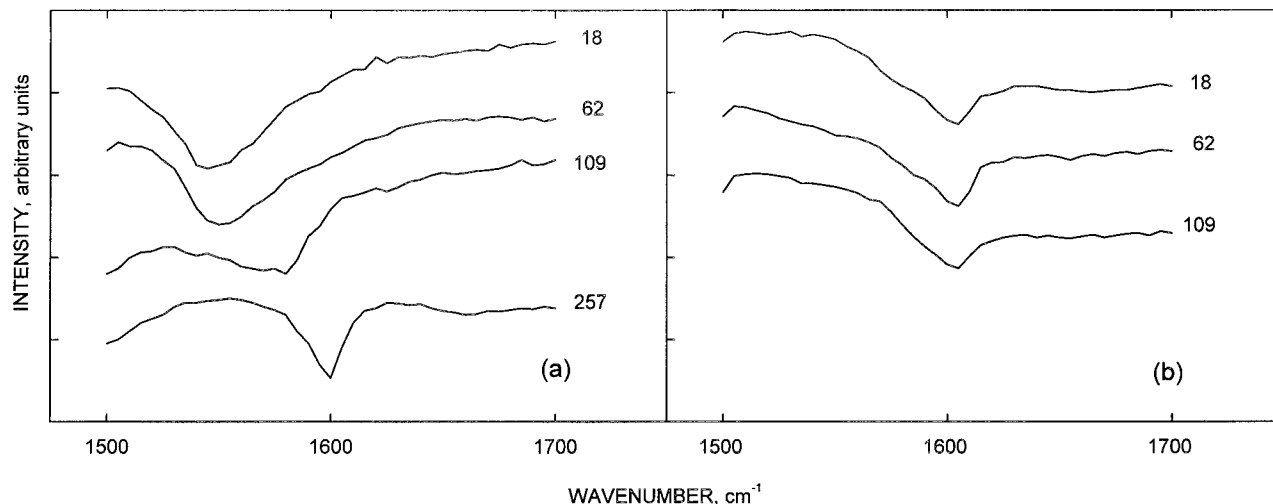
### RESULTS AND DISCUSSION

The IR spectra in the frequency region of interest for a few samples with various contents of the grafted polystyrene (PS) are presented in Figure 1. The band of CH groups vibrations in benzene cycles should be situated at 1603  $\text{cm}^{-1}$ . In reality, in the spectra of the samples with moderate content of PS, it was found to be shifted to the low-frequency side up to 1545  $\text{cm}^{-1}$ . With the increase of the PS concentration, the band gradually returns to the position specific for benzene cycles vibrations. At a PS content of 257 wt %, the band maximum is situated at its normal frequency of 1603  $\text{cm}^{-1}$ . In Figure 2, one can see a dependence of position of the band under consideration for a series of samples.

We believe the band shift was caused from the interaction between the polymer components. To deter-

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**Figure 1** IR transmission spectra of the PP-grafted PS-DVB system in the region of the band of CH groups in benzene cycles with normal position at  $1603\text{ cm}^{-1}$  at various contents of grafted polymer: (a) as-prepared and (b) annealed samples. The percentage of PS in the samples is indicated near the curves. The effective thickness of every sample was chosen to provide approximately equal intensity of the transmission bands.

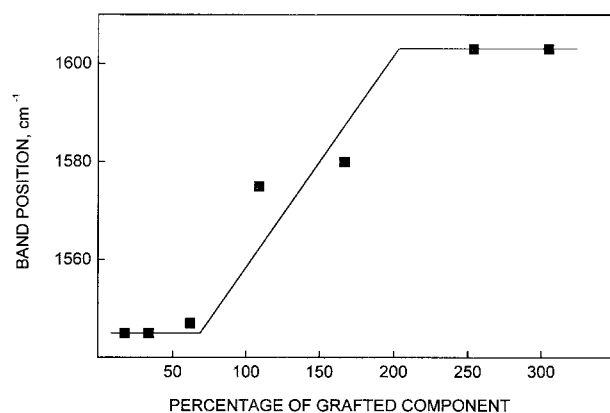
mine the thermal stability of newly formed interpolymer aggregates that affect the benzene cycles vibrations, the fiber were annealed at various temperatures. It was found that after heating the samples at  $90^\circ\text{C}$  during 1 h, the band shift disappears in the spectra of all the samples [Fig. 1(b)], thus indicating the presence of the isolated PS component.

In Nizovtseva et al.,<sup>9</sup> the small-angle X-ray scattering evidenced a restricted compatibility of the PS polymer with polyethylene, while the equatorial diffuse scattering, characteristic for microheterogeneous system in this case was absent. In the present study, the perturbation of the IR spectra of as-prepared samples

with moderate ( $<100\text{ wt } \%$ ) concentration of grafted polymer evidences the strong interchain coupling at the level of macromolecular segments. This could refer to the similarity of their solubility parameters<sup>10</sup> and, in general, is inherent to compatible systems. As a result, the characteristic band of the benzene cycles occurred at  $1545\text{ cm}^{-1}$ . The heat treatment of the samples rises the molecular mobility, thus destroying the metastable state and stimulating the phase segregation (in view of thermodynamic incompatibility of PP and PS).

In fibers with high content of the grafted polymer ( $>200\%$ ), the latter forms its own domains in the host bulk. In this case,  $1603\text{ cm}^{-1}$  occurred at its normal position. In the intermediate case, part of the PS chains interact with the PP, while other PS chains interact between themselves. The band maximum shifts from  $1545$  to  $1603\text{ cm}^{-1}$  as the grafted copolymer percentage grows.

To conclude, the thermodynamically incompatible polymers PP and PS form a metastable mixture at a  $\gamma$ -induced grafting process. A heat treatment destroys the unstable state with nucleation of isolated PS and PP phases.



**Figure 2** Real position of the  $1603\text{-cm}^{-1}$  band versus the concentration of grafted PS. The line serves as a guide for the eyes.

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