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## Abstract

## Full Text

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*PHYSICAL CHEMISTRY*

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# STUDY OF ISOTACTIC POLYPROPYLENE BY THE METHOD OF INFRARED SPECTRA

*(Presented by Academician A. V. Topchiev, 13 II 1957)*

Samples of isotactic polypropylene obtained by various methods were studied in the form of films 0.2 mm thick. The films were prepared by melting the polymer and pressing the melt between two rock-salt plates. Infrared absorption spectra were measured on an IKS-11 spectrometer with NaCl and LiF prisms in the region 700–3000  $\text{cm}^{-1}$ . The spectra were measured point by point, and also with the aid of an ÉPP-09 recorder. For measurements at different temperatures (in the range 20–200°), electric heating was used.

Fig. 1. Infrared absorption spectrum of polypropylene: 1 –isotactic polypropylene at 20°, 2 –isotactic polypropylene at 170°, 3 –fraction extracted with ether

In the spectra of all samples of isotactic polypropylene the following absorption bands were found: 720, 730, 790, 810, 839, 894, 935, 969, 992,  $\sim$  1050, 1108, 1170, 1376, 1460,  $\sim$  2850, 2875, 2924, and 2957  $\text{cm}^{-1}$ . The spectrum is shown in Fig. 1. In the region 830–1000  $\text{cm}^{-1}$  the spectrum coincides with that obtained by Natta and co-workers<sup>(1)</sup> (these authors give the spectrum only in the indicated region), with the exception of a very weak band at 935  $\text{cm}^{-1}$ , which we did not observe in all samples. The presence of strong bands at 894  $\text{cm}^{-1}$  and 992  $\text{cm}^{-1}$  is characteristic of crystalline isotactic polymer: in the fraction extracted with ether these bands are very weak (see Fig. 1). We investigated the crystallinity of isotactic polypropylene by the method described in papers<sup>(2–4)</sup>. Upon heating the polymer to a temperature of 140–150°, changes arise in the spectrum, expressed in the weakening of the bands at 810, 839, 894, and 992  $\text{cm}^{-1}$ . These bands practically disappear at a temperature of  $\sim$  170°, at

Fig. 2. Temperature dependence of the transmission of the  $992\text{ cm}^{-1}$  band of isotactic polypropylene

Figure 2: Fig. 2. Temperature dependence of the transmission of the  $992\text{ cm}^{-1}$  band of isotactic polypropylene

which melting of the polymer is completed. Natta indicates that  $T_m$  of isotactic polypropylene is  $160\text{--}170^\circ$  <sup>(5)</sup>. Evidently, the named bands may be regarded as “crystallinity bands”; they are characteristic of the most stable rotational isomer realized in the crystal. The spectrum of the molten polymer is also shown in Fig. 1, and the curve of the dependence of transmission at the maximum of the  $992\text{ cm}^{-1}$  band on temperature is shown in Fig. 2. This curve has an S-shaped form, usual for the melting of crystalline polymers <sup>(2-4)</sup>. We see that from this curve the melting temperature of the polymer can be determined.

The degree of crystallinity was determined by studying the temperature dependence of the intensity of the  $790\text{ cm}^{-1}$  band. The intensity of this band increases sharply when the polymer melts. On the other hand, this band is present in the spectrum of the polypropylene fraction extracted with ether. The spectrum of this fraction practically coincides with the spectrum of molten isotactic polymer, with the exception of small differences in the region  $800\text{--}850\text{ cm}^{-1}$  (see Fig. 1). The  $790\text{ cm}^{-1}$  band may be assigned to the amorphous polymer. The content of the amorphous part of the polymer was determined by comparing the optical density at the maximum of the  $790\text{ cm}^{-1}$  band at room temperature with the optical density at a temperature above  $T_m$ . The degree of crystallinity was found from the difference <sup>(2)</sup>. For the three samples studied, the degrees of crystallinity were found to be  $\sim 75$ ,  $\sim 90$ , and  $\sim 100\%$ . It should be noted that these determinations do not claim great quantitative accuracy, since they were made from differential intensity. However, it may be asserted that the degree of crystallinity of the samples studied is very high.

**Fig. 2.** Temperature dependence of the transmission of the  $992\text{ cm}^{-1}$  band of isotactic polypropylene.

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