

## **$\gamma$ -Irradiated Poly(Ethylene Oxide): Spectroscopic and Thermal Analysis**

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Polymer modification by high energy radiation has many advantages: no catalyst or additives are needed to initiate the reaction and it can be performed at various temperatures. The initiation is homogeneous throughout the system resulting in higher reaction extents and the reaction rate is easily controlled by varying the dose rate. The products are sterile what is important for medical applications. Chemical properties of a particular polymer determine its radiation response: generally crosslinking is the main effect in unsaturated chain polymers while degradation dominates in the polymers with saturated carbon chain,

Poly(ethylene oxide), PEO, is a semicrystalline polymer that is widely used particularly for preparation of polyelectrolytes and hydrogels. PEO mostly degrades if irradiated in air while crosslinks in the inert atmosphere, but numerous factors can influence the outcome, so its radiation chemistry has to be investigated in detail. Infrared spectroscopy combined with thermal analysis is a powerful tool to study corresponding changes, while other experimental techniques can provide additional information.

Ionizing radiation usually reduces the degree of crystallinity of polymers, both because of crosslinking and degradation, but in some cases shorter polymer chains formed on degradation of more radiation-sensitive amorphous part easily crystallize resulting in an increased degree of crystallinity. The changes in the degree of crystallinity are easily and quickly assessed by differential scanning calorimetry (DSC), the shapes of thermograms and heats of phase transformations being very sensitive.

The purpose of this study is to assess the changes brought into PEO by  $^{60}\text{Co}$   $\gamma$ -radiation to selected doses, taking into consideration its properties (molecular mass) whether it was irradiated as powder, pellet or in solution, in air or nitrogen, its postirradiation changes. Thermal analysis showed that the heats of crystallization generally increased at lower doses but then decreased with the dose, the changes being more pronounced at higher dose rate. The peak widths increased and crystallization temperatures decreased reflecting lower quality of crystallites that further decreased during postirradiation period. The molecular mass and sample form had minor effects on thermal properties of irradiated PEO samples. The greatest changes occurred in PEO irradiated as aqueous solution. Thermal analysis cannot offer information on underlying chemical change since both crosslinking and degradation may result in the same type of thermal changes.

To record infrared spectrum each PEO sample type had to be approached differently and appropriate spectral range to be chosen carefully. The most prominent changes in FTIR spectra of PEO on irradiation in solid state are the absorption increases at about  $3500\text{ cm}^{-1}$  and  $1100\text{ cm}^{-1}$  while some absorptions at  $960\text{ cm}^{-1}$  and  $842\text{ cm}^{-1}$  somewhat decreased in number of others samples. Carbonyl absorptions appeared in the samples where oxidative degradation occurred due to the irradiation in air while in those irradiated in the inert atmosphere vinyl absorptions appeared. Such changes are mostly due to degradation. The spectra of hydrogels recorded in the NIR region showed significant increases at  $7000\text{ cm}^{-1}$  and  $5250\text{ cm}^{-1}$  and shifts of those maxima to higher wavenumbers indicating changes in hydrogen bonding implying both crosslinking and structural changes in those samples.