Radiation Effects on PP/PS Blends as a Model of Protection Effects by Aromatics

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Polypropylene (PP) is the most popular polymer for the application in construction of medical devices, due to the hardness and temperature resistance. Unfortunately, the virgin PP is of low resistance towards ionizing radiation, already to sterilization doses and cannot be applied without additives. Another option is a blend with a second polymer, especially aromatic, and therefore polystyrene (PS) was applied. The classic case of protection in the aliphatic/aromatic system (benzene/cyclohexane in liquid or solid state) shows that the surface area and structure of the interphase is crucial for the effectiveness of energy transfer. Our blends of PP (virgin, F401 from Orlen-Olefins) with PS were prepared in a variety of ways, from mechanical blending, to radiation induced grafting. Two linac accelerators (10 MeV, 6-9 kW) were applied, with different shapes of electron beam, formed according to particular methods used for the investigation of effects; doses were 10-600 kGy. As in the classic case, the protection effect was quantisized from the curve of the effect vs 0-100% PP, 100-0 % PS.

Main recognition of the protection effect has been done by the diffused reflection spectroscopy (DRS) [1] developed in our Laboratory for the application to irradiated polymers. The dependence of intensity of bands in the DRS spectrum, attributed to keton groups, which are final products of oxidation, shows clearly the protection effect of PP, executed by PS.

The second method of observation of radiation effects is gas chromatography (GC), applied for irradiation products analysis. The maximum sensitivity has been achieved using the instrument type GC 2014 by Shimadzu, with thermal conductivity detector, column packed with molecular sieves 5A. Radiation induced formation of gaseous produced at ambient and lower temperatures is unique in the field of chemistry of polymers. There is no form of energy, except ionizing radiation, to cause chemical reactions to produce a wide spectrum of low molecular weight compounds, starting with hydrogen. Hydrogen is abstracted from PP, causing a variety of effects, e.g. forming alkyl radicals on the chain. The PS competes successfully with oxygen for these centers, preventing the oxidation of polymers. The aromatic free PP is oxidized easily, whereas the presence of PS prevents this reaction. The paper [2] showed already the advantages of determination of radiation yield of hydrogen in the evaluation of mechanisms of radiolysis of hydrogenated nitrile rubber. Also methane and carbon oxide can be measured by gas chromatography now, as well the consumption of oxygen which reacts with free radicals on the polypropylene chain. The range of protective effect of PS in the zone of single-ionization spurs is estimated to 8-12 mers of PP.

[1] Z.P. Zagórski: Int. J. Polym. Materials 52 (2003) 323.
[2] J. Bik, W. Głuszewski, W.M. Rzymski, Z.P. Zagórski, Kautschuk Gummi Kunstst 57 (2004) 651.