Hollow Poly(alpha-methylstyrene) Shells for Inertial Confinement Fusion Targets

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Poly(alpha-methylstyrene) is a perspective material for preparing hollow shells used as targets in internal confinement fusion [1–3]. Present contribution describes synthesis of a series of poly(alpha-methylstyrene) samples by low-temperature cationic polymerization of the monomer. The synthesis conditions were shown to strongly influence the molecular-mass data of the polymers obtained. Nuclear magnetic resonance examination of all poly(alpha-methylstyrene) samples points to the stereoregular syndiotactic structure of their macromolecular chains. The X-ray analysis reveals the amorphous nature of the polymers. Thermogravimetry and differential thermal analysis techniques were used to follow the thermal destruction of the polymers. In this way, the thermal range of a complete decomposition was established for polymers synthesized in the presence of tin tetrachloride, boron trichloride and trifluoride in the capacity of polymerization catalysts.

The above poly(alpha-methylstyrene) samples were used for the preparation of spherical hollow shells of 2.3 mm in diameter and 10 to 60 micrometer wall thickness by the microencapsulation technique. Herewith solutions of the poly(alpha-methylstyrene) batches in various solvents and at various concentrations were applied. In the capacity of solvents mixtures of benzene, toluene, ortho-xylene, ethylene dichloride, tetrachloroethane, dichloropropane, fluorobenzene and fluorotoluene were tested. The hollow shells were formed in an aqueous salt-containing medium from the polymer solutions with the use of a special homemade droplet generator having three co-axial tubes. To obtain the stable hollow droplets-shells, it is important to optimize the rates of all three flows – that of the water (inner filling of the shells), polymer solution, and the outer aqueous phase that carries the droplets from the generator into the large receiver. The latter contained aqueous solution of polyvinyl alcohol and ammonium salts of various compositions. Hardening of the shells was achieved by heating the final suspension at a definite time-temperature mode of operation.

Examining the final shells by scanning electron spectroscopy technique showed a strong dependence of their wall morphology and surface quality on the preparation conditions. Reasons for the appearance of various defects on the surface and within the wall layer are discussed. Only shells prepared under well-optimized conditions display an acceptable spherical form and smooth surface. Mechanical properties of final hollow shells – their strength and deformation behavior were tested under static uni-axial loading conditions using an UIP-70 equipment (Russia). Partly supported by RFBR 15-52-45116.

References

1. Cook R., McQuillan B., Takagi M., Stephens R., Inertial Confinement Fusion, Semiannual Report, October 1999 - March 2000, v.1, N1, p.1.
2. Cook R, Buckley S.R., Fearon E., Letts S.A. Fusion Technology, 1999, v.35, p.206.
3. McQuillan B.W., Greenwood A. Fusion Technology, 1999, v.35, p.194.