Preparation of poly(alpha-methyl-styrene) shells for inertial confinement fusion targets

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Using spherical polymeric hollow shells as targets for the laser-driven ICF (inertial confinement fusion) is currently considered as one of the most promising point of research. In the present study, a series of high-molecular-weight poly(alpha-methyl-styrene) (PAMS) samples with varying mass characteristics have been prepared by low-temperature cationic polymerization procedures in dichloromethane, dichloromethane-hexane (PAMS32), chloroform-hexane (PAMS25), initiated with tin tetrachloride, boron trichloride and boron trifluoride.

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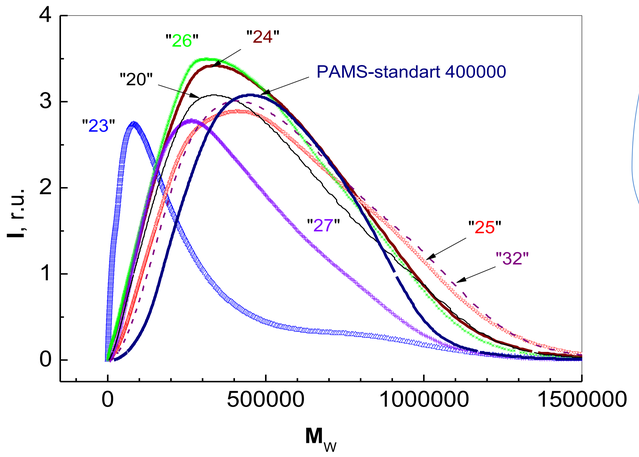
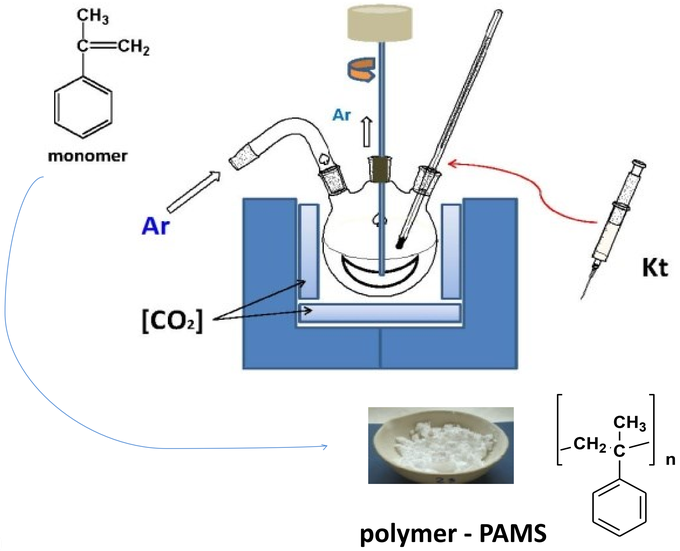
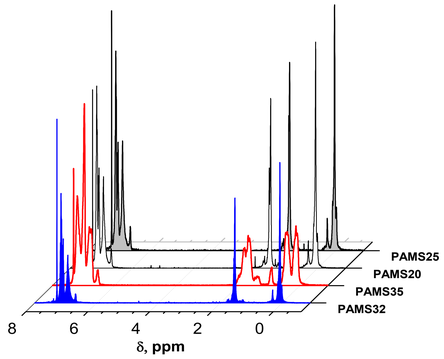
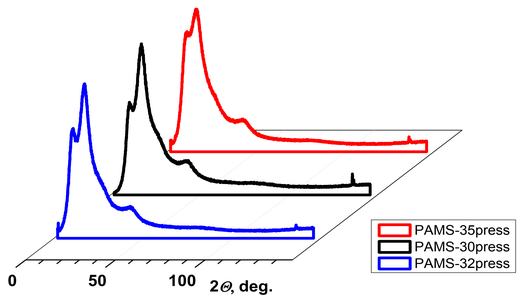
PAMS	Monomer, mass.%	Kt	T, °C	Time, h	Conversion, %	M_w
20	9	BF_3	-70-74	1.5	87	335000
23	5	BF_3	-90 -74	7	81	111800
24	7	BF_3	-76 -80	6	88	331400
25	11	BF_3	-64 -76	5	93	396600
26	8	BCl_3	-68 -73	6	88	318000
27	8	BF_3	-66 -78	5	96	286000
32	9	BF_3	-72-77	4	>90	420000
35	9	n-BuLi	-79-85	4	15	



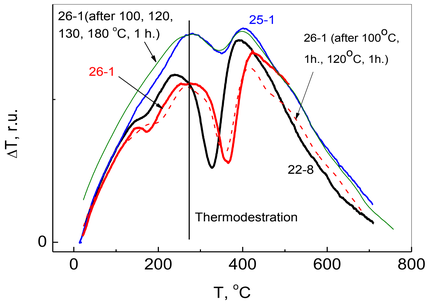




Examining the structure of polymers by nuclear magnetic resonance technique revealed the syndiotactic arrangement of repeating units in the stereoregular polymeric chain. PAMS35 have been prepared by low-temperature anionic polymerization procedures in tetrahydrofuran initiated with n-BuLi.

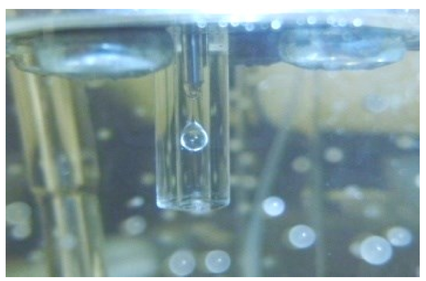


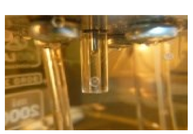
Examining the obtained polymers by the X-ray analysis revealed an amorphous structure of all samples, irrespective of their synthesis conditions.

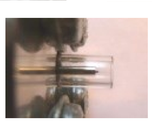


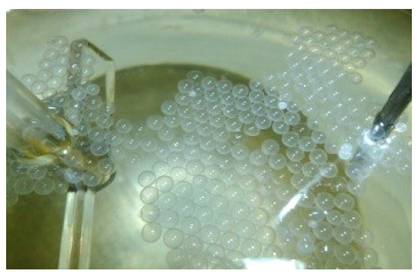
Thermogravimetry and differential thermal analysis provided essential information on the thermo destruction processes of the samples.

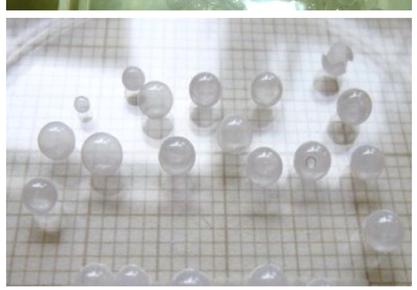
The polymers synthesized were then used for preparing spherical thin hollow shells by a modified microencapsulation technique. Small hollow beads were formed by a special home-made droplet generator that delivered a polymer solution and an aqueous salt flow through two co-axial capillaries into a container filled with an appropriate aqueous solution. Average diameter of the shells amounted up to 2.4 mm with the wall thickness between 10 and 60 mkm. Experiment protocols include series with varying rates of liquid flows delivered by the droplet generator, varying compositions of the polymer solutions and the aqueous phase, temperature of the bath where the shells were allowed to settle. Final shells prepared under optimized conditions have a regular spherical shape and a nicely smooth surface.

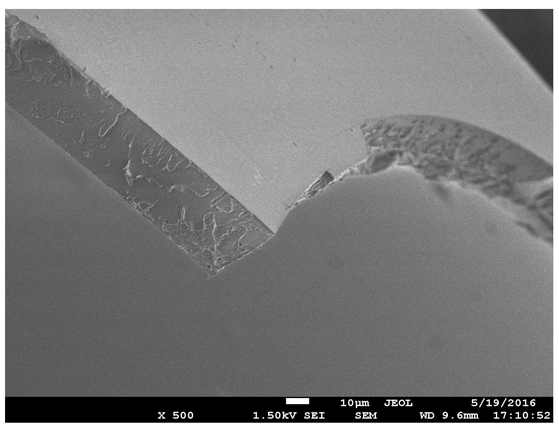




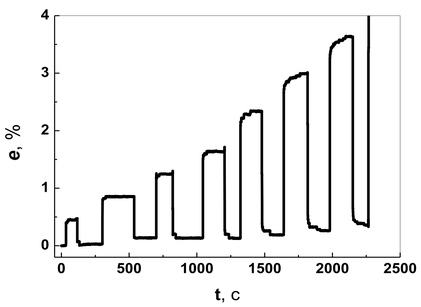








Scanning electron microscopy was used for examining the surface of shells prepared according to various protocols.



Mechanical strength of the shells and their deformation were studied under uniaxial static compression conditions. The plot shows reversible deformation of a shell PAMS-25-1 (~30 mkm thick) under step-vise increasing load of 5, 10, 15, 20, 30, 40, 50 g. Shell destruction occurred at a load of 70 g.