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The organic-inorganic interpenetrating polymer networks: the kinetics of formation, thermal and relaxation properties

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In recent years, the hybrids of the organic-inorganic materials that contain titanium have attracted an increased interest due to their unique mechanical, thermal, optical, and photocatalytic properties.

The organic-inorganic interpenetrating polymer networks (OI IPNs) were obained on the basis of crosslinked polyurethane (PU), polyhydroxyethylmethacrylate (PHEMA) in the presence of poly(titanium oxide) (-TiO_2-)$_n$. Poly(titanium oxide) was formed *in situ* by sol-gel method using titanium isopropoxide (Ti(OPr^i)$_4$) in the medium of hydroxyethylmethacrylate (HEMA). The ratio of the components of PU/PHEMA in the initial and OI IPNs was 30/70 wt % and the content of (-TiO_2-)$_n$ was varied from 2.5 to 4.6 wt % in OI IPNs. The ratio of Ti(OPr^i)$_4$/H_2O was 1/1 and 1/2 mol, respectively.

The kinetics of the formation of OI IPNs was investigated by the calorimetric method. It was showed that the reaction of the formation of urethane in OI IPNs was catalyzed by (-TiO_2-)$_n$ which resulted in obtaining *in situ* sequential IPNs. The rate of the PHEMA formation decreases with an increasing content of (-TiO_2-)$_n$ due to appearance of the “cell” effect.

The methods of the dynamic mechanical analysis (DMA) and the differential scanning calorimetry (DSC) showed that IPNs and OI IPNs are two-phase systems with the distinct relaxation transitions of PU and PHEMA components. However, the increasing content of (-TiO_2-)$_n$ to 4.65 wt % in OI IPNs leads to decrease the intensity of the relaxation transition for PHEMA and decrease the value of the molecular mass of polymeric segment between two cross-links (M_c). The introduction of (-TiO_2-)$_n$ in the polymer matrix leads to decrease the value of the heat capacity increment (ΔC_p) (by DSC method), that indicates a significant increase of the crosslink density in the polymer system. It was shown that the system was formed with a smaller crosslink density with the ratio of Ti(OPr^i)$_4$/H_2O = 1/2 than with the ratio of Ti(OPr^i)$_4$/H_2O = 1/1. The investigation of hybrid OI IPNs by thermogravimetric analysis (TGA) showed that the introduction of Ti component in the IPNs significantly increases the thermal stability of the samples in the temperature range of 300-400 °C.