Thermodynamic of interactions and relaxation properties of the POSS-containing nanocomposites based on polyurethane matrix

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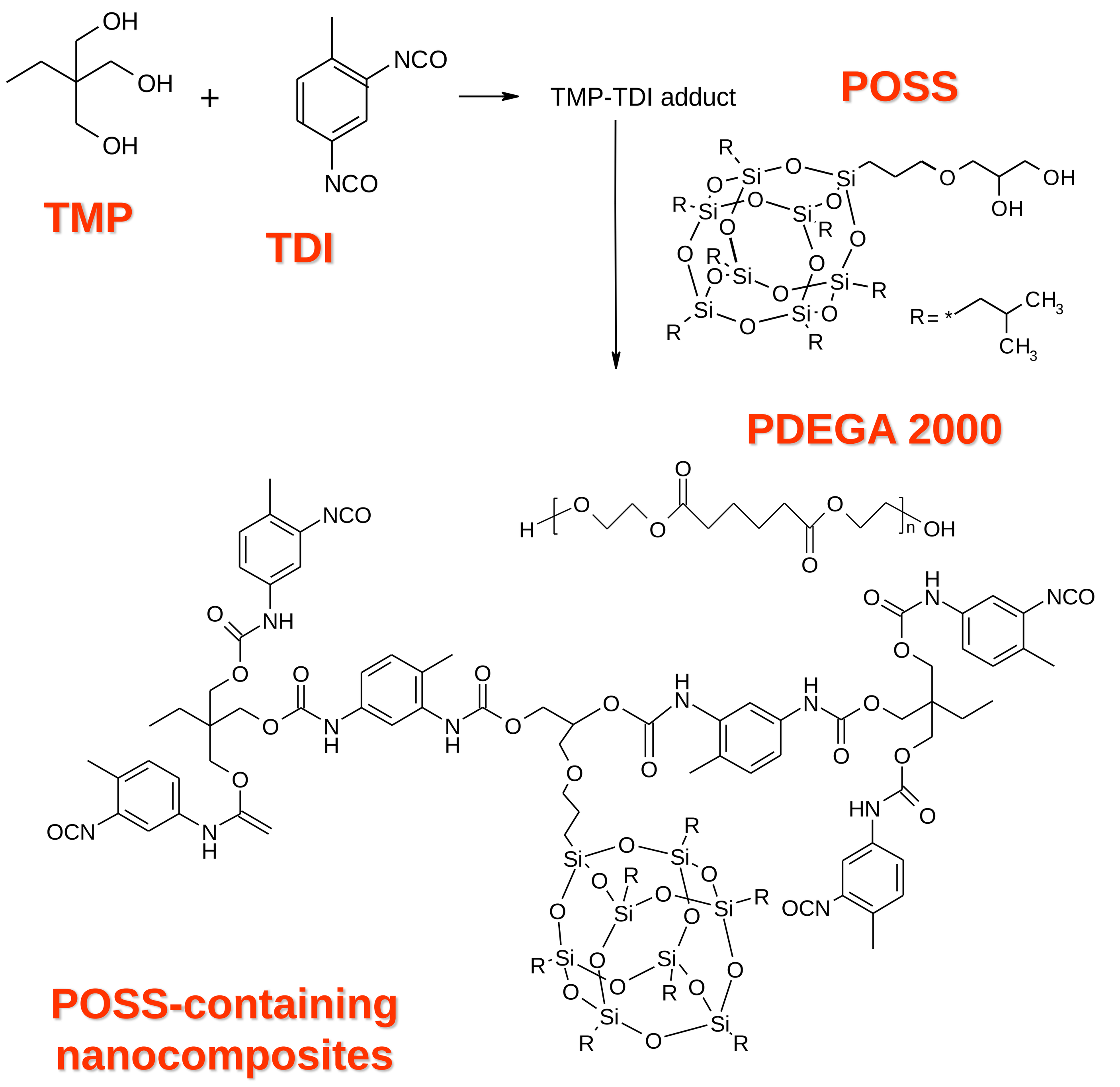
Aims

To investigate the influence of the POSS content (1-10 wt.%) on the thermodynamic of interactions and relaxation properties of the POSS-containing nanocomposites based on polyurethane matrix

Methods

- *Vacuum installation with McBain balance (handmade, Ukraine)*
- *Dynamic mechanical analyzer Q800 (TA Instruments, USA)*
- *Scanning electron microscopy JEOL JSM 6060 LA (Japan)*

Synthesis of POSS-containing nanocomposites based on PU



Result & Discussion: SEM

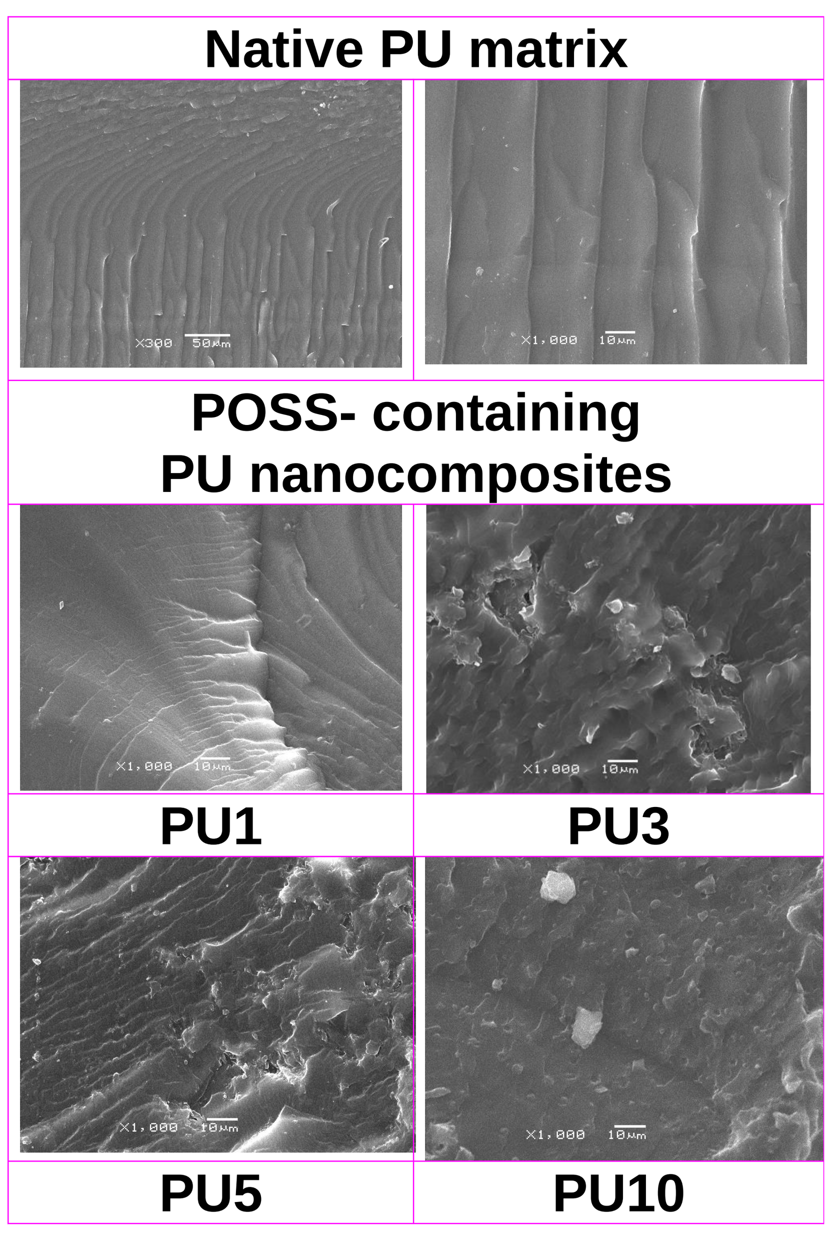


Fig.3

The microstructures of fracture surfaces of native PU matrix and nanocomposites with different content of POSS (1-10 wt.%) are shown in Fig.3. The fracture surfaces of nanocomposites are considerably rough and uneven compared to the surface of a native PU matrix. The aggregation of POSS nanoparticles in nanocomposites starting from 3 wt.% ocurs and increases with an increase in POSS content

Results & Discussion: Sorption properties and thermodynamic of interactions

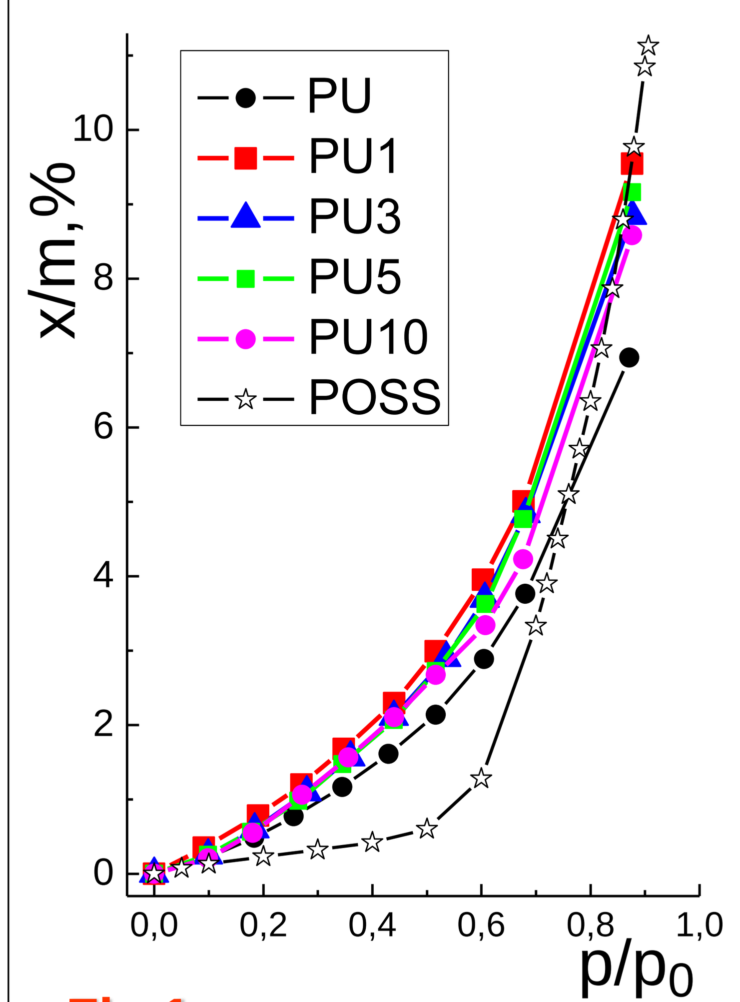


Fig.1

The isotherms of methylene chloride ($MeCl_2$) vapour sorption (Fig.1) and free energy of mixing Δg^m of samples with methylene chloride(Fig.2) are presented; x/m is the amount of $MeCl_2$ relative to the dry sample; p/po is the relative pressure of $MeCl_2$; ω_2 is weight fraction of solvent in the sample

From Fig.1, the sorption isotherms of solvent vapors by POSS-containing PU nanocomposites are higher than of the native PU. With an increase in the amount of POSS, the vapor sorption values increase, thereby demonstrating a decrease in the density of the obtained nanocomposites.

Based on results of Fig.2 (free energy of mixing Δg^m of solvent with polymers and POSS), the thermodynamic (TD) parameters of PU and POSS interactions were calculated. The free energy of PU and POSS mixing is positive for all systems with different amount of POSS.

Sample	TD parameter
PU1	+5.31
PU3	+3.44
PU5	+3.73
PU10	+2.85

That means the thermodynamic incompatibility between this PU and POSS takes place.

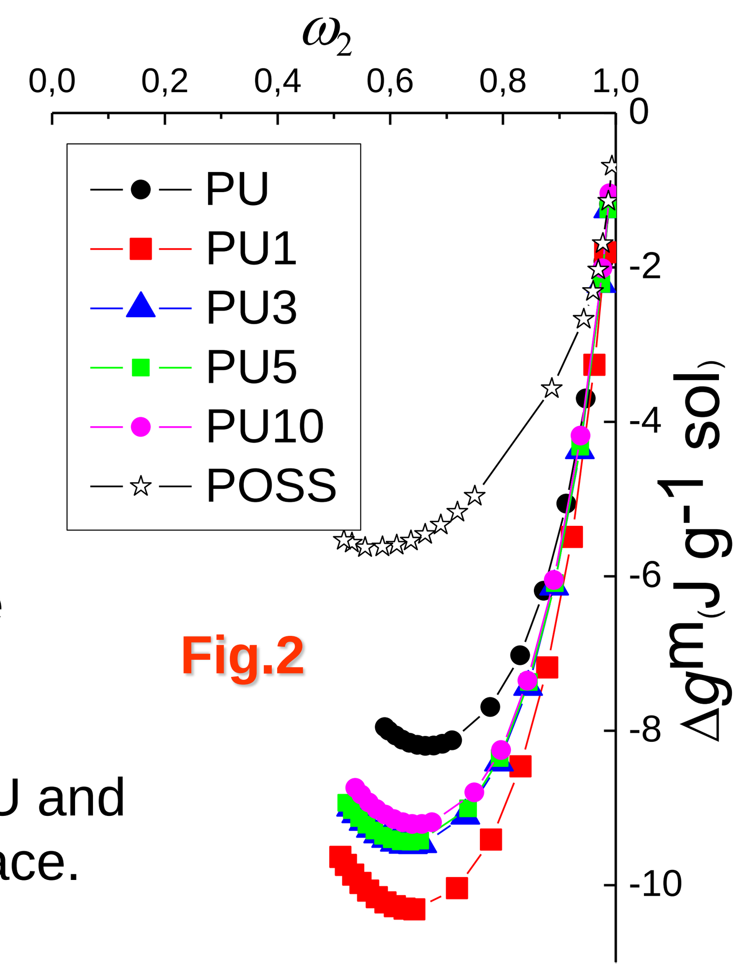


Fig.2

Result & Discussion: DMA

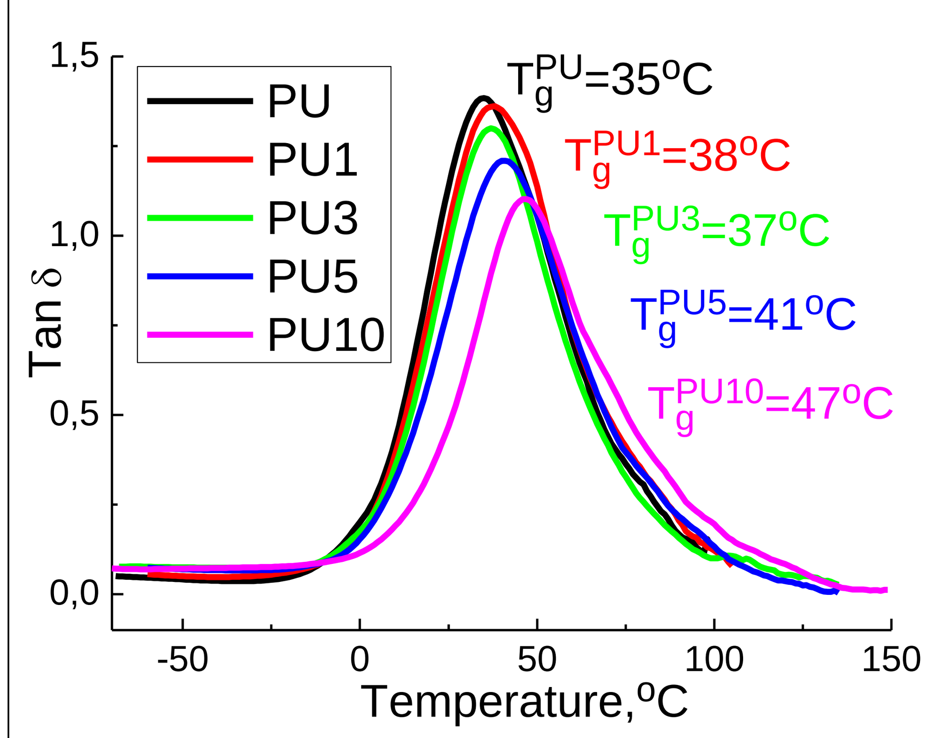


Fig.4

In Fig.4 the temperature dependences of tan δ for the native PU and nanocomposites, obtained by DMA, are presented. The introduction of POSS led to a shift of tan δ maximum towards higher temperatures. This means that the segmental motion in PU decreases with an increase of POSS content, while the glass transition temperature (T_g) of nanocomposites increases. This indicates the restriction of the segmental motion of PU chains, which causes by the introduction of POSS nanoparticles into the system.

Conclusions

The introduction of POSS into the PU (based on PDEGA and TMP-TDI adduct) matrix results in:
- increasing vapor sorption values, thereby demonstrating a decrease in the density of the obtained nanocomposites;
- the thermodynamic incompatibility between PU matrix and POSS nanoparticles takes place;
- increasing of the glass transition temperature (Tg) of nanocomposites with POSS content ;
- the segmental motion in PU decreases with POSS content;
- the heterogeneity of the material increases with amount of POSS.

Acknowledges: The authors thank the staffs of the Center Collective Using of scientific Equipments (CCUE) NASU in Institute of Macromolecular Chemistry of the NAS of Ukraine for investigation by DMA and in N.G. Kholodny Institute of Botany of NAS of Ukraine for investigation by SEM