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Ph.D. in Chemistry

Polymeric Aerogels

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XII cycle 2011-2014

Abstract

Aerogels are a unique class of materials characterized by a highly porous network, being attractive for many applications such as thermal and acoustic insulation, capacitors or catalysis. [1]

In more recent years, polymeric aerogels based on thermoplastic uncrosslinked polymers, where the knots of the three-dimensional networks are physical, not formed by covalent chemical bonds but by small crystallites, have been obtained [2]. These *physically cross-linked aerogels* are generally prepared by supercritical CO_2 extraction of thermoreversible organogels.

Besides aerogels, another class of porous materials, which has received attention in the last decade by the scientific community, is constituted by semicrystalline thermoplastic polymers whose crystalline phase is nanoporous, i.e. presents a density lower than the corresponding amorphous phase.[2] In this thesis monolithic aerogels, where the crystallites that constitute the physical knots exhibit a nanoporous-crystalline form have been prepared for polymer that exhibit a nanoporous crystalline phase e.g. syndiotactic polystyrene (s-PS) [2] and poly(2,6-dimethyl-1,4-phenylene)oxide (PPO).[2c]

Physically cross-linked aerogels have also been prepared for poly(2,6-diphenyl-1,4-phenylene oxide) (PPPO), that does not exhibit a nanoporous crystalline phase, but a highly absorbent amorphous phase.[2d] Moreover the preparation of aerogels of polyethylene, is described.

The fast kinetics and high sorption capacity of VOCs by aerogels, as well as their good handling characteristics, make these new materials particularly suitable as a sorption medium to remove selectively traces of pollutants from water and air.

Furthermore nanocomposites aerogels, with large amounts of both intercalated and exfoliated organically modified montmorillonite (OMMT) and including the nanoporous-crystalline δ form of s-PS, were prepared.[3] Also for high OMMT content, the aerogel preparation procedures occur without re-aggregation of the exfoliated clay, which is instead observed for other kinds of polymer processing. Analogous aerogels

were prepared with graphene oxide (GO) leading to complete GO exfoliation as well as its substantial reduction.

The most important result is that the aerogel preparation allows the inclusion of also large amount of nanofillers, without aggregation, at least up to a content of 20 wt%. This allows to improve mechanical and electrical properties of the nanoporous-crystalline aerogels of s-PS. Composite aerogels exhibiting large nanofiller content, can be also used as masterbatches for polymer composites.

References

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