Présentation Flash du labo

Laboratoire Polymères et Materiaux Avancés

UMR 5268 CNRS/SOLVAY

LYON

Remarques

Laboratory general way of working :

- The topics of the lab are relevant to applications and industrial issues
- BUT to make real progress we develop entirely new ideas relevant to fundamental concepts of polymer physics:
  - Glass transition mechanisms in polymer, polymer blends, in the vicinity of interfaces
  - Reinforcement mechanisms in filled elastomers
  - Inter-diffusion of polymer blends or polymer/solvent systems close and bellow Tg
  - Glass transition mechanisms in H-bonded polymers
  - Statistical mechanics of rupture and damaging in soft and hard materials
  - Rheology of polymer blends (with or without nano-particle inclusions) : experiments, theory and modeling
  - Plasticization mechanisms at solid and molten states
  - ....

Les forces

Lab Staff

- Solvay : 4 Researchers + 1 senior Technician
- 3 Academic researchers (CNRS : 2 DR2 + 1 CR2 hired in 2014 “Concours”)
- □10 non permanent

Non Permanent People Evolution

From 2007 to 2013, 23 people have exited the Lab (10 Post Docs, 13 PhDs)

- 12 p. hired by Industry :
- 10 p. have found Academic Position :

Objective to reach a permanent staff of 4 Academic researchers.

Les thématiques principales

- Heterogeneous polymer systems: polymer blends and dispersion of nano-fillers
  - Filled elastomers and Experimental control of Morphology
  - Mesoscopic Theory & modeling
  - Dynamics close to T_g
  - Filled elastomer blends
  - Foams
- Physical properties of polymers with strong interactions
  - Experimental characterization of Miscibility and dynamics
  - Multiscale modeling
  - Damaging & fatigue of semi-crystalline polymers
- Physical properties of filled polymers
  - Dynamics and reinforcement
  - Filler/surface interaction Modeling
  - Mesoscopic Theory & modeling
  - Wear & Tear

Quelques faits marquants

- Understanding and controlling fatigue damage in reinforced semi-crystalline polymers
  - ⇒ Experimental and Modeling work
  - ⇒ Polyamide : extension by a factor of 3 of the fatigue lifetime
  - ⇒ 2 patents and several papers published
- Permeability-Shock property compromise
  - ⇒ to reduce the water intake of polyamides materials
  - ⇒ Collaboration with chemists from Solvay
  - ⇒ new oligomer additives with strong interaction with the polar groups of polyamide have been proposed and synthesized.
  - ⇒ 2 patents
- Physics of Reinforcement of filled rubbers
  - ⇒ Combination of Mechanical measurements, Xray diffraction with in situ stretching and Quantitative measurements of crosslink densities with NMR in filled and unfilled elastomers.
  - ⇒ Theoretical understanding of the effect of dynamical heterogeneities and filler/polymer interactions in the mechanical properties of filled rubber (reinforcement and Payne Effect)
- Diffusion in polymers close to and below Tg.
  - ⇒ Calculation of the diffusion of solvent through a polymer matrix
  - ⇒ Description of the so-called "case II" diffusion.
  - ⇒ Development of theoretical models and simulation tools

Fatigue in Polyamid

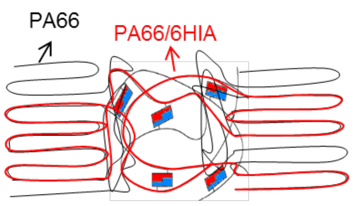
- Molecular Control of H bonded Polymer

Synthesis & characterization of new materials

Preparation of **block PA66/6HIA copolymers**
by Reactive Extrusion

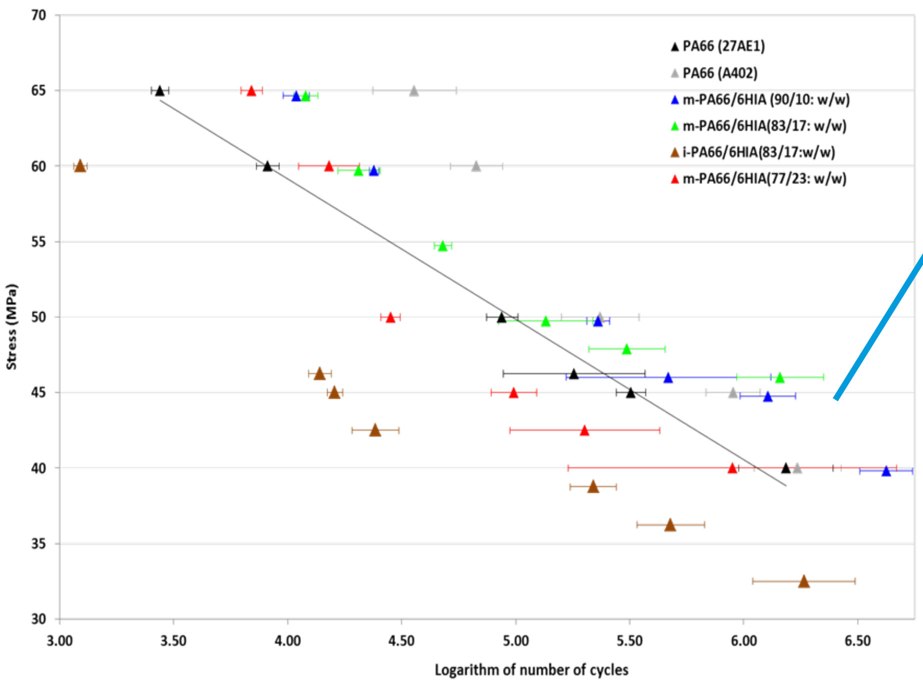
Co-polycondensation reaction at the molten state

Phenolic functions anchored in the crystalline phase thanks to PA66 blocks



→ **Coupling between the amorphous and the crystalline phases is preserved**

Assessment of fatigue Life time (Wohler curves)



At low stress (long lifetime), block copolymers including phenol functions can enhance the fatigue lifetime

But it turned out that PA66/6HIA copolymers exhibited :

- **Different Tg (what we wanted to control and make vary)**
- **Different molecular weights / weights distribution**
- **Different crystalline structures, crystalline fractions**

We proposed a general interpretation frame in order to evaluate the relative contribution of these different microstructural parameters to fatigue lifetime

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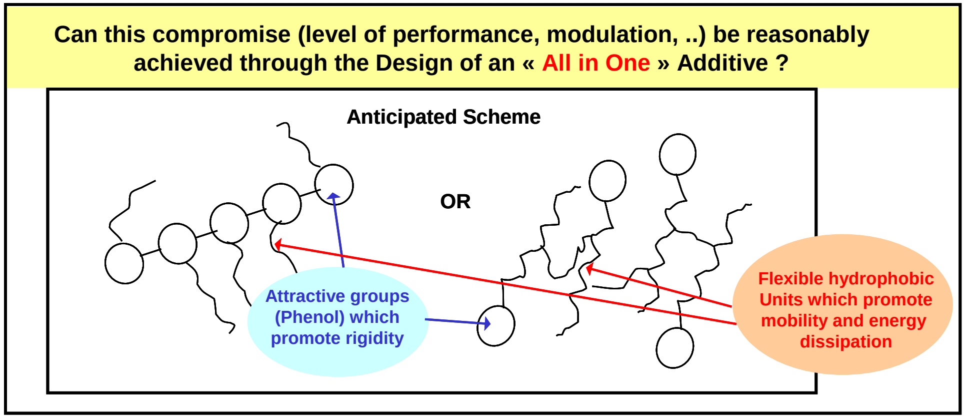
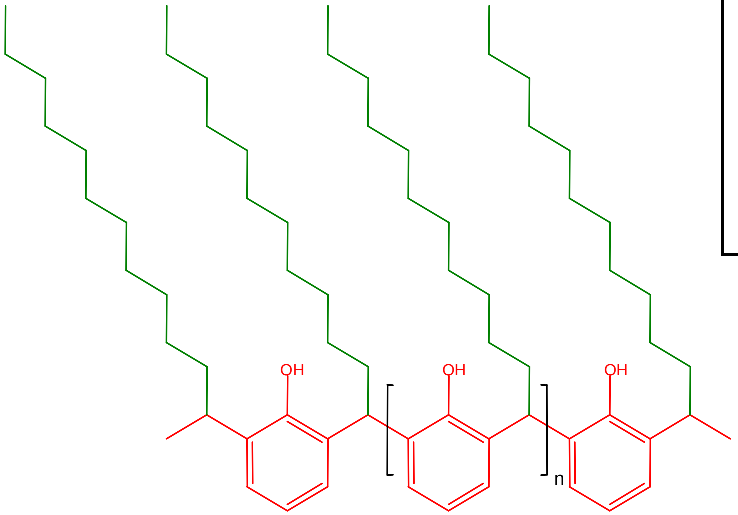
Compromis perméabilité/résistance au choc

Formulation d'additifs à liaisons fortes + flexibilité

- Matériau Polyamide à propriétés barrières aux fluides élevées
(Polyamide material having high fluid barrier properties.) FR 0952395 2009 & WO 2010/115951 A1 2010.
- Composition polyamide modifiée comprenant au moins un composé phénolique (Modified polyamide composition containing at least one phenolic compound). WO 2011/048055 A1 2011





Synthesis based on reneawble raw matters

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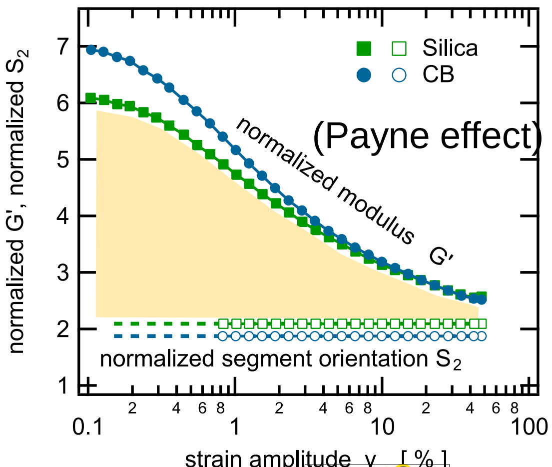
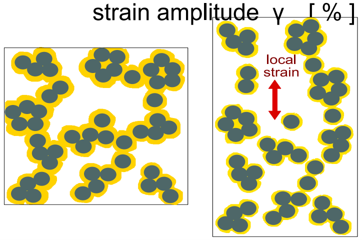
Reinforcement in Filled Natural Rubber Elastomers

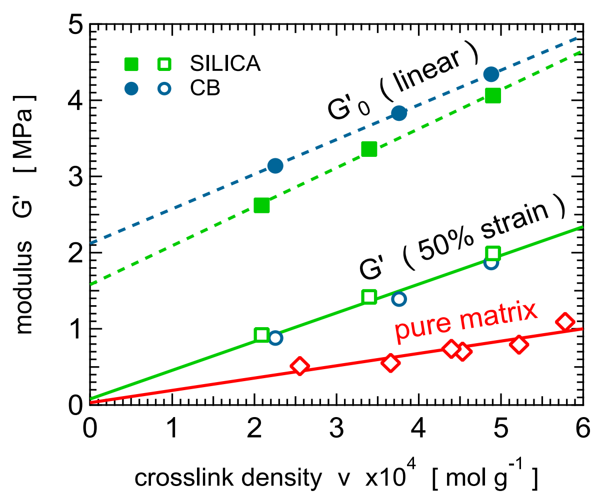
Arnaud Vieyres, Roberto Pérez-Aparicio, P. Sotta, O. Sanseau, D. Long P.-A. Albouy (LPS Orsay)

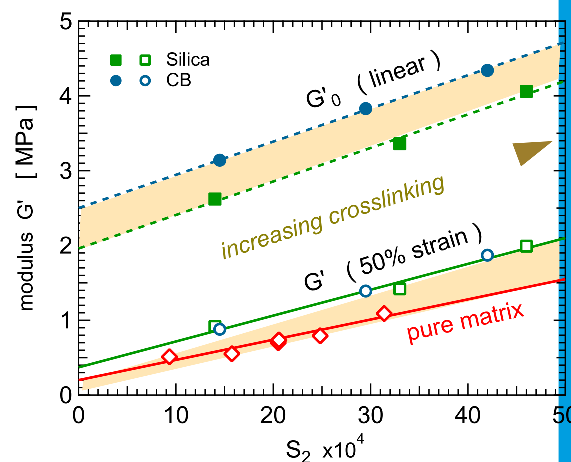
To compare specific response of the elastomer matrix to the global response (mechanics)
We combine:

- Mechanical measurements (global response)
- Xray diffraction with in situ stretching (selective response of the elastomer matrix)
- Quantitative measurements of crosslink densities with NMR









We discriminate 2 contributions to reinforcement

- Strain amplification in the matrix
- Rigid network

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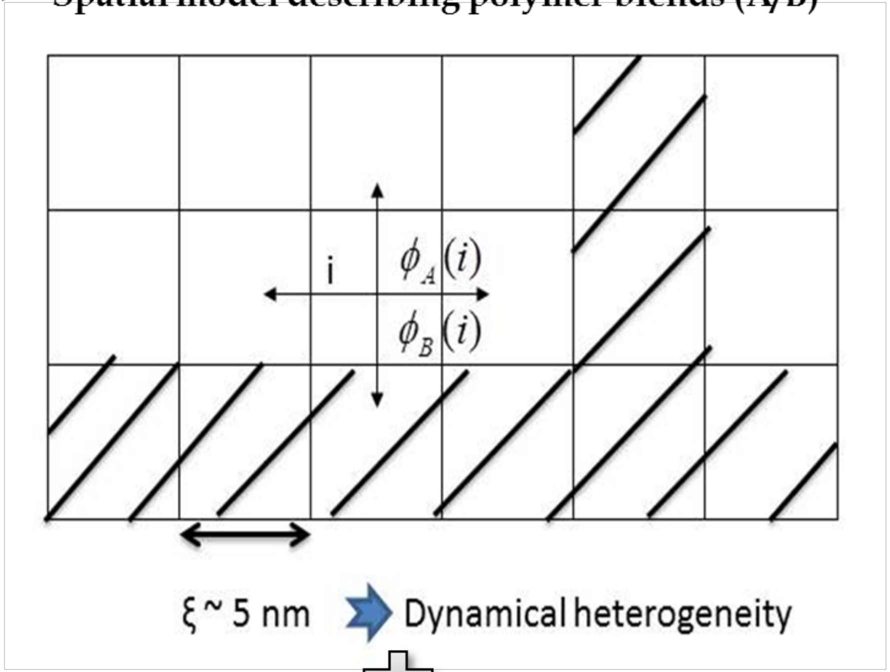
Diffusion in Polymer blends close to the glass transition temperature

- ✓ Spatial model describing polymer blends (A/B)

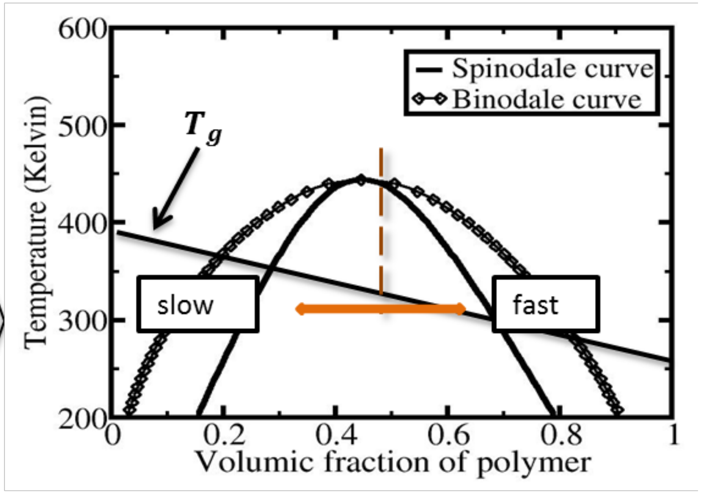


- ✓ Spatial distribution of relaxation times on a scale of a dynamical heterogeneity

- ✓ Dynamics (Onsager like description)

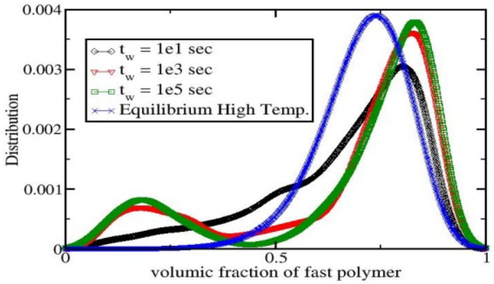
Spatial diffusion in polymer blends close to T_g

Phase separation close to T_g

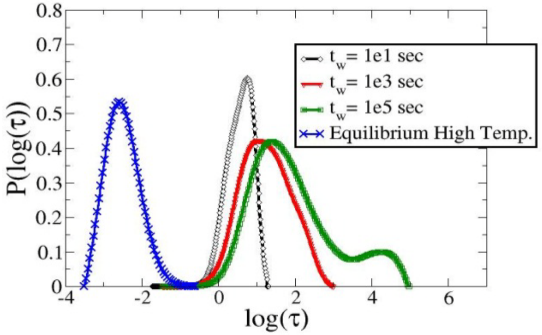


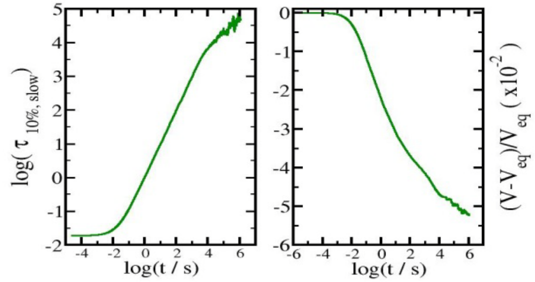
Phase diagram of blend of immiscible polymers. The two polymers have a degree of polymerisation X=50. The UCST critical temperature Tc is equal to 440 K. The blend is composed of a fast polymer ($T_g = 250\ K$) and a slow polymer ($T_g = 390\ K$).

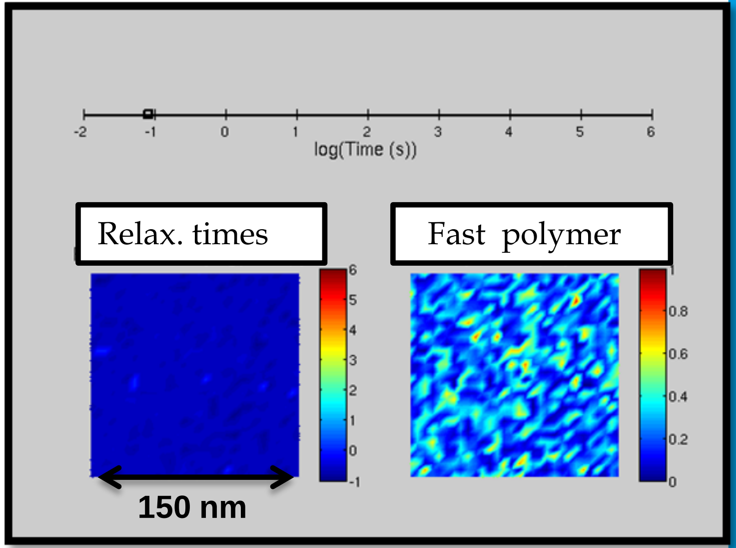
remixing and rejuvenation process



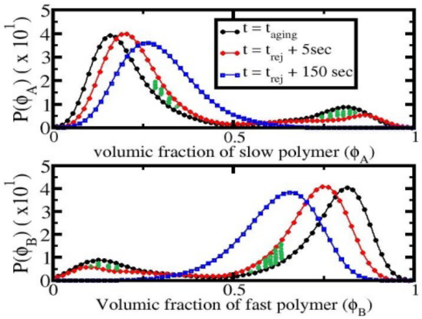
hase separating process for a system aged for a time $t_w = 3.10^5$ se
at $T_g - 10$ K with composition (70% fast polymer/30% slow polymer)

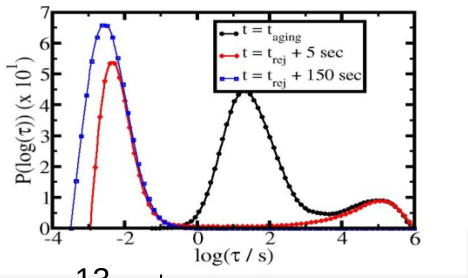


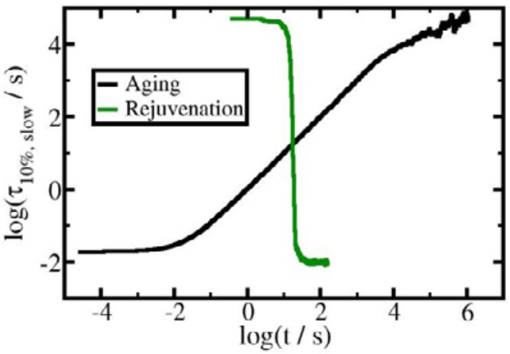


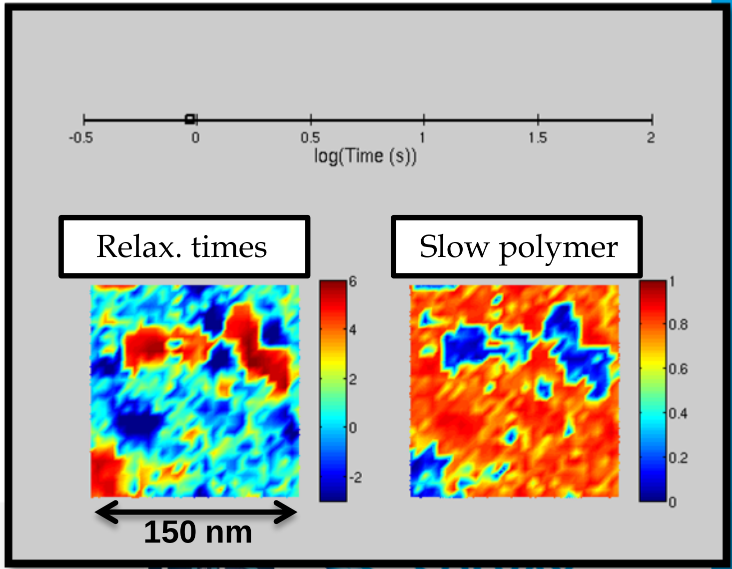


ejuvenating process at $T_g + 60$ K in a system aged for a time $t_w = 10^6$ se
at $T_g - 10$ K with composition (70% fast polymer/30% slow polymer)









Les perspectives de développement

- Development of our Rheology activity
  - Novel instrumentation to study nonlinear shear rheology of highly elastic soft matter
  - Collaboration with chemical synthesis groups.

- Participation of the local structuration of polymer material research (Pôle Rhône Alpes) with the help of Axel'One, ITE IDEEL, …

- Maintain our planning to get *"a decent amount"* our consolidate budget from external funded projects (ANR, H2020, …)

- Develop our panel of studied materials to Solvay Specialty polymer portofolio (Polysulfones, PEEK) or fluoro- polymers (PVDF, …)