EUROPEAN MECHANICS SOCIETY

Colloquium Final Report Form

Please send this report in electronic form to the Secretary General of EUROMECH, within one month after your Colloquium. As an example, please consult the Report of Colloquium 443 (available at www.euromech.org/colloquia/after.htm).

Title Multiphysics of solid polymers : experiments and modeling

Colloquium No 550 Dates and location 1-5 July 2013 (Poitiers - France)

Chairperson Sylvie CASTAGNET (Institut Pprime, France)

Co-Chairperson Alexander LION (Universität der Bundeswehr, Munich, Germany)

Is there need of another Colloquium on the same or a related subject? Which year?

Second edition planned in 2015 possibly in Munich.

Full registration fee Delegate : 350 € (+30€ late registration)
Students : 290 € (+20 € late registration)

What other funding was obtained? Region / City of Poitiers / University of Poitiers ISAE-ENSMA : TOTAL 2500€

What were the participants offered? Welcome dinner / Reception at the City Hall and short tour in the city / Colloquium Banquet / lunches / coffee breaks

Number of members of Euromech (reduced registration fee) 4

Number of non-members of Euromech (full registration fee) 32

Number of participants from each country: 36

Austria	1	Great Britain	1	Slovakia	
Belgium		Greece		Slovenia	
Bosnia		Hungary		Spain	
Byelorussia		Ireland		Sweden	
Bulgaria		Italy	2	Switzerland	
Croatia		Latvia		Ukraine	
Czech Republic		Lithuania		Serbia	
Denmark		Netherlands	2	Montenegro	
Estonia		Norway		Turkey	
Finland		Poland		Others Japan	1
France	22	Portugal		USA	1
Georgia		Romania			
Germany	6	Russia		**Total**	36

List names of Applicants to EUROMECH.....

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Euromech Colloquium 550

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EUROPEAN MECHANICS SOCIETY

Scientific Report
Please type your report on the following pages. Use additional pages if required. Put the date and your signature at the end.

Colloquium No. 550. Scientific Report

Multiphysics of solid polymers: experiments and modeling

Date: July 1-5, 2013
Place: Poitiers (France)
Organization: Sylvie Castagnet (Institut Pprime, Poitiers)
Co-organization: Alexander Lion (Universität der Bundeswehr, Munich)

Due to interactions with their surrounding environment or to exposure to external fields, the mechanical properties of polymers can be affected. Such interactions may also lead to damage evolution or provoke degradation processes. Strong couplings, multiple time scales and pronounced gradients make the experimental characterization, the constitutive representation and the numerical simulation of these phenomena to big challenges. For instance, an experimental challenge is to isolate and determine the relative effects of variables on the coupled macroscopic behavior but also to track the key parameters governing couplings at the microstructure scale. The selection of accurate state or internal variables, the relevant expression of coupled evolution laws and reliable identification protocols are challenges for continuum mechanics. Regarding numerical issues, consistent space-discretization, versatile time-discretization and appropriate algorithms are challenges for successful and optimized numerical simulations of the coupled mechanical response.

This EUROMECH Colloquium 550 intended to be interdisciplinary and open to scientists with a common interest in multiphysics of solid polymers and more specifically in coupling between mechanics and diffusion, chemical reaction or electro-magnetic fields. It aimed to crosslink physical and mechanical approaches by bringing together experts in molecular simulation, coupled experiments, analytical approaches and numerical methods. The colloquium focused on unreinforced polymers. A special attention was paid on fully-coupled approaches when existing.
37 researchers from Germany, Netherlands, Italy, United Kingdom, Austria, Japan, United States and France participated to the Colloquium, among whom 7 PhD students. 28 presentations were given (45min for the 18 invited speakers and 30 min for submitted contributions) and 12 posters were also presented, during a specific session on the first day and later on all along the Colloquium.

Four sessions were scheduled following a progressive scheme. Thermo-mechanics was addressed first as an intrinsic coupling in polymers. Glass transition and physical ageing were discussed as key phenomena involving this type of coupling. The second session was dedicated to mass transport and plasticizing or damage effects induced by gas or liquid transport. The issue turned even more complex in the third session, since the transported species take part into chemical reactions such as cross-linking, oxidation, thermolysis or

hydrolysis. In the fourth session, electro-magneto-mechanics couplings were discussed, trying to emphasize the analogy / difference with the three first topics.

One of the main conclusions arising from discussions is that the polymer is always a heterogeneous system. It is clear at the macroscopic scale –due to a structural effect or to gradients associated with couplings– but, down to lower scales, there is always a scale at which heterogeneity is expressed. It is clear in the lamellar structure of semi-crystalline polymers or in filled rubbers, but it can also arise from several populations of penetrants in a pure amorphous polymer.
A huge challenge is therefore to be able to distinguish the different associated mechanisms. Several experiments developed to this aim were presented at the Colloquium, for instance Fourier-Transform Infra-Red spectroscopy (FTIR) in the case of water diffusion, Nuclear Magnetic Resonance (NMR) in semi-crystalline polymers, Molecular Dynamics in filled rubbers. Depending on the type of coupling, the lowest accessible scale can be different: from that of magneto-fillers down to the molecular one in the case of mass diffusion. Concerning heat diffusion, the limitation associated with infra-red methods make inverse analyses necessary.
In addition to the scale issue, another drawback is that the mostly used methods to track the microstructure evolution and deformation / damage micro-mechanisms (X-ray scattering, gravimetric analysis, FTIR for instance) very often display average information. On this point, tomography appears as an interesting technique to evaluate damage gradients and progress should be brought by increasing the resolution of devices. Molecular dynamics can be a way to better understand mechanisms at fine scales but it remains modeling, with related assumptions that can be sometimes rather restrictive.

The mechanical counterpart to these investigations of mechanisms seems to be more limited. Indentation experiments were presented as an interesting route. However, like most attempts to test the coupled mechanical response, it is based on inverse analysis and thus results model-dependent. Such approaches both work on the local behavior that is aimed to be identified and on the relevance of the model itself. Several types of modeling (phenomenological, physically and chemically-based ones) including 3D finite strain theories, were presented during the Colloquium, demonstrating recent efforts on this topic. Works on the development of special surface elements dedicated to coupling exchanges at the surface were presented too. More environment-based tests are need for an experimental confrontation.

Fruitful discussions arose from this Colloquium, both from sessions and from all the informal times during the week. The Colloquium was judged very interesting by all participants. They favorably welcomed the proposal from Alexander Lion to organize a second edition in Munich in spring 2015.
This Colloquium was hosted by Institut Pprime and ISAE-Ensma. We thank Euromech for making it possible and Région Poitou-Charentes, Grand Poitiers, University of Poitiers and ISAE-ENSMA for their financial support.