TIME DEPENDENT RHEOLOGICAL MODELING FOR POLYMERS FROM GLASSY TO FLUID STATES BASED ON NETWORK THEORY

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Despite of the large number of constitutive models available in the literature complete modeling of the time dependent mechanical behavior of thermoplastics polymers is still an open question. Present study deals at validating and enriching a potential alternative route for constitutive equations to model time-dependent mechanical behavior of polymers [1-4]. Starting point of such an approach is the fact that as polymers are covalent chains, which presumably should impact or control most of their properties, the central component of modeling concept should be a polymer-like component rather than elastic spring or dashpot. Statistical network is chosen as "central component" within the general thermodynamical frame. Inelastic phenomena are, for their part, introduced through the evolution of involved state variables representing microstructure.

To summarise, three main interactions between statistical chains are considered:

- First, permanent nodes or tight entanglements represented by a density that do not vary.
- Second, mobile entanglements represented by a density and their level of freedom. This latter is assumed to increase with increasing elastic energy.
- Third, weak bonds between adjacent chains (van der Walls or H-bond etc.) that constrain the chain mobility up to a certain level of energy were the bond can be broken. This interaction does not have any possible "slippage" per se but they can disappear or be restored as a function of strain stress and/or energy.

The three different contributions are set into two parallel branches: one representing the initial model and combining the entanglements and the permanent nodes whereas the second branch only concerns weak interactions.

Both the two branches obey to the above concept. In the first branch, the chain extensibility is assumed to be constant whereas in the second branch extensibility and the level of connectivity (e.g. density of links) in the chain network must be correlated. Kinetics law of and are defined as a function of the stored elastic energy in each branch. Then according to previous work, mechanical problem can be written in a fully three dimensional form.

Theoretically this concept must allow modeling solid as well as liquid and transition domains. Based on experimental validations with various polymers either amorphous or semi crystalline and on DMA analysis over a wide range of temperature, this paper deals at presenting linear visco elastic limit of the model as well as discussing physical meaning of parameters and applicability of the model.

1. N. Billon, *J. Appl. Polym. Sci* **2012**, 125, 4390.
2. N. Billon; A Durin; JL Bouvard *9th International Conference on Mechanics of Time Dependent Materials Montreal, Canada* **2014**
3. A. Maurel-Pantel; E. Baquet; J. Bikard; J.L. Bouvard; N. Billon *Int. J. of Plasticity* **2015**, 67, 102.
4. F. Gehring, JL Bouvard and N. Billon, *J. Appl. Polym. Sci* **2016**, 133, 43837.