**INDENTATION RELAXATION TEST: OPPORTUNITIES AND LIMITATIONS**


Paul Baral, UdL, ECL, LTDS UMR CNRS 5513, 36 avenue Guy de Collongue, 69134 Ecully, France
paul.baral@doctorant.ec-lyon.fr
Gaylord Guillonneau, UdL, ECL, LTDS UMR CNRS 5513, 36 avenue Guy de Collongue, 69134 Ecully, France
Guillaume Kermouche, EMSE, Centre SMS, LGF UMR 5307, 158 cours Fauriel, 42023 Saint Etienne, France
Jean-Michel Bergheau, UdL, ENISE, LTDS UMR CNRS 5513, 58 rue Jean Parot, 42023 Saint Etienne cedex 2, France
Jean-Luc Loubet, UdL, ECL, LTDS UMR CNRS 5513, 36 avenue Guy de Collongue, 69134 Ecully, France



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Small scale characterization of material's mechanical behavior has been performed for fifty years using indentation tests. Many developments have been made in order to improve the reliability of both measurements and interpretations. However, determination of material's time dependent mechanical properties by means of nanoindentation techniques is still to be enhanced [1]. It is proposed to investigate the indentation relaxation – i.e. constant displacement – test as an alternative to the commonly used indentation creep – i.e. constant load – test. Effects of loading strain rate on the measured relaxation behavior are studied, analytically, from a linear viscoelastic model. It is shown that constant strain rate loading guarantees a depth-independent measure of the relaxation behavior. Moreover, indentation strain rate (ISR) affects the relaxation spectrum [2] up to a critical time constant [3] (see figure 1). These effects, highlighted analytically, are confirmed experimentally on PMMA. Limitations of the indentation relaxation test are also discussed. Two main difficulties arise from this kind of experiment. Acquisition of reliable measurements is limited, for long time characterization, by the system drift and, for short time, by the displacement control loop. A particular care has been taken in tuning the control feedback gains to limit displacement overshoot. Very low drift rate has been attained – under 0.015 $nm.s^{-1}$ – This allowed for measurements at constant displacement up to 600 s.

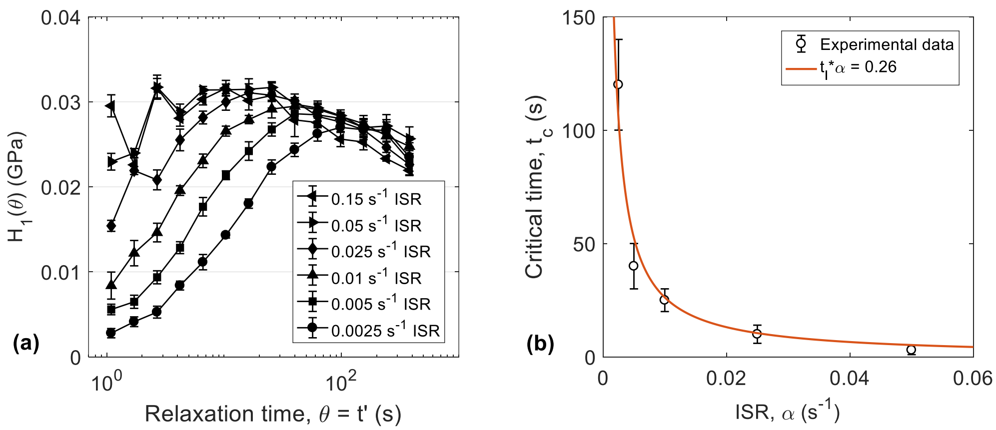


*Figure 1 – (a) First order approximation of the relaxation spectrum [2] of PMMA calculated after constant strain rate loading (ISR). t' is considered as the time from the beginning of the hold segment. Error bars represent the standard deviation calculated on five experiments, note that for some points, markers are larger than error bars. (b) Critical time, defined by the time at which relaxation spectra merge into a master curve, versus indentation strain rate (ISR). Experimental data are estimated from (a).*

References


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