

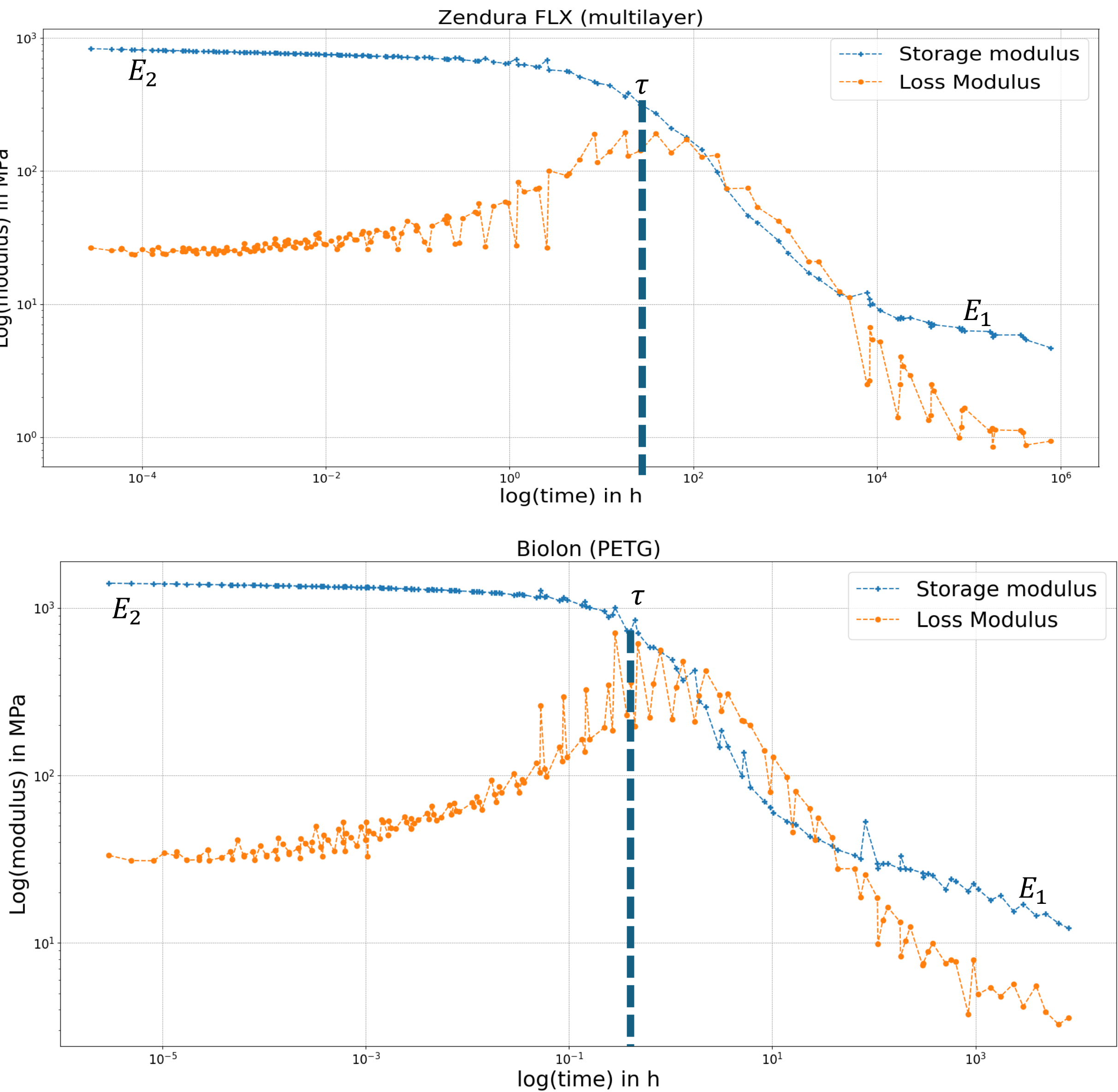
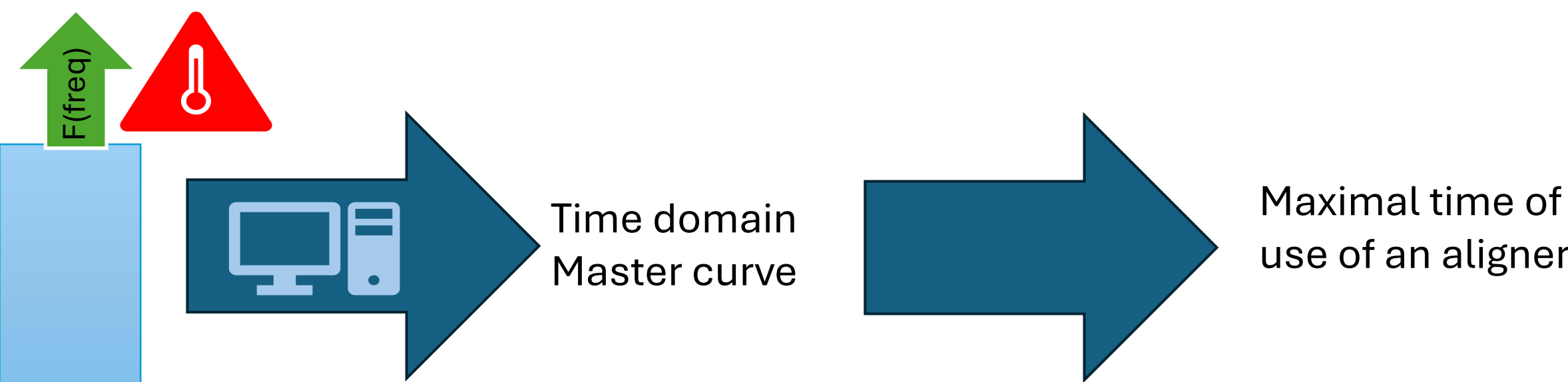
Invisible orthodontics

Invisible orthodontics (IO) is a novel orthodontic technique that utilises the patient's preformed dentition, with slight misalignment, to guide the tooth into its correct position. The preforms are manufactured using flat-extruded sheets of invisible thermoplastics shaped by thermoforming and laser cutting. [1]

The viscoelastic properties of the chosen thermoplastic and the professional's experience in performing the treatment not only determine the efficiency but also the level of pain and comfort during the entire treatment. [2] Thus, too stiff materials can be disastrous in the wrong hands. At the same time, soft plastics would have a negligible effect on dentition. Hence, viscous properties are crucial in determining how stress decays over time. [3], It is essential to have a rapid and easily forming thermoplastics, which means a low characteristic time to settle deformations, but the orthodontic treatment requires the opposite.

Experimental

We obtained the master curve of commercial multilayered aligners in tensile configuration at 38 °C by performing frequency sweeps from 23 °C to 140 °C with heating steps of 5 °C and an amplitude of 0.5 % deformation. The equipment utilised was an Anton Paar MCR 702e Multidrive rheometer equipped with a DMTA head



Material	Composition	α	β	τ (h)	E1 (Mpa)	E2 (Mpa)
Zendura FLX	Multilayer (Tg 120 °C)	0,63	0,23	18,3	6,8	720
Maflex Premium	Multilayer (Tg 120 °C)	0,59	0,17	87,4	12,1	803
Prismlab pro S	Multilayer (Tg 120 °C)	0,61	0,23	4,27	8,3	790
Biolon	PETG (Tg 80 °C)	0,75	0,24	0,6	14,6	1271
Taglus PU flex	TPU (Tg 95 °C)	0,49	0,22	13,7	7,4	1595
Tritan MP100	PCTG (Tg 120 °C)	0,59	0,21	50,3	7,3	1192
Tritan MP200	PCTG (Tg 130 °C)	0,62	0,18	48,9	12,6	1073

References

- [1] C. T. Drake, S. P. McGorray, C. Dolce, M. Nair, and T. T. Wheeler, 'Orthodontic tooth movement with clear aligners', *ISRN Dent.*, vol. 2012, p. 657973, 2012, doi: 10.5402/2012/657973.
- [2] B. Gold, S. Siva, S. Duraisamy, A. Idaayath, and R. Kannan, 'Properties of Orthodontic Clear Aligner Materials - A Review', *J. Evol. Med. Dent. Sci.*, vol. 10, pp. 3288–3294, Sep. 2021, doi: 10.14260/jemds/2021/668.
- [3] P. Albertini, V. Mazzanti, F. Mollica, F. Pellitteri, M. Palone, and L. Lombardo, 'Stress Relaxation Properties of Five Orthodontic Aligner Materials: A 14-Day In-Vitro Study', *Bioengineering*, vol. 9, no. 8, p. 349, Jul. 2022, doi: 10.3390/bioengineering9080349.
- [4] T. Pritz, 'Five-parameter fractional derivative model for polymeric damping materials', *Journal of Sound and Vibration*, vol. 265, no. 5, pp. 935–952, Aug. 2003, doi: 10.1016/S0022-460X(02)01530-4.

The 5 and 4 Parameter Pritz models⁴

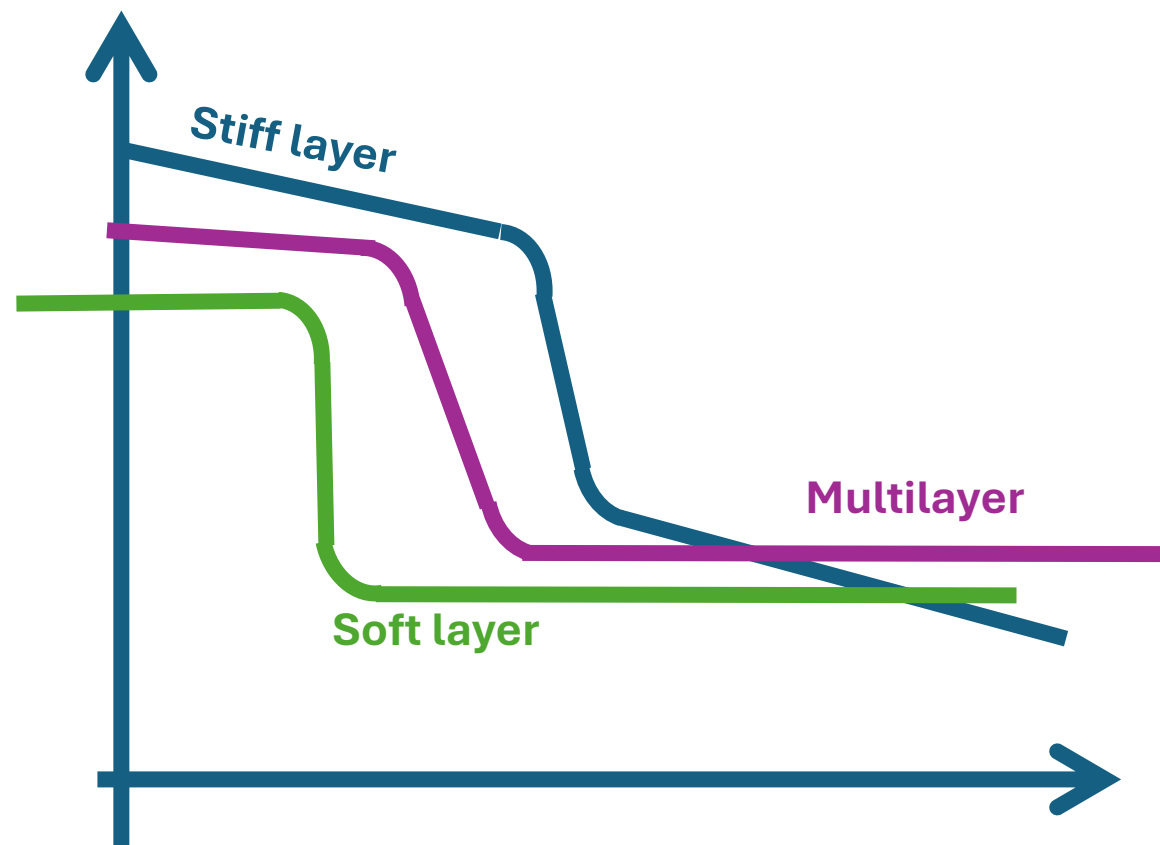
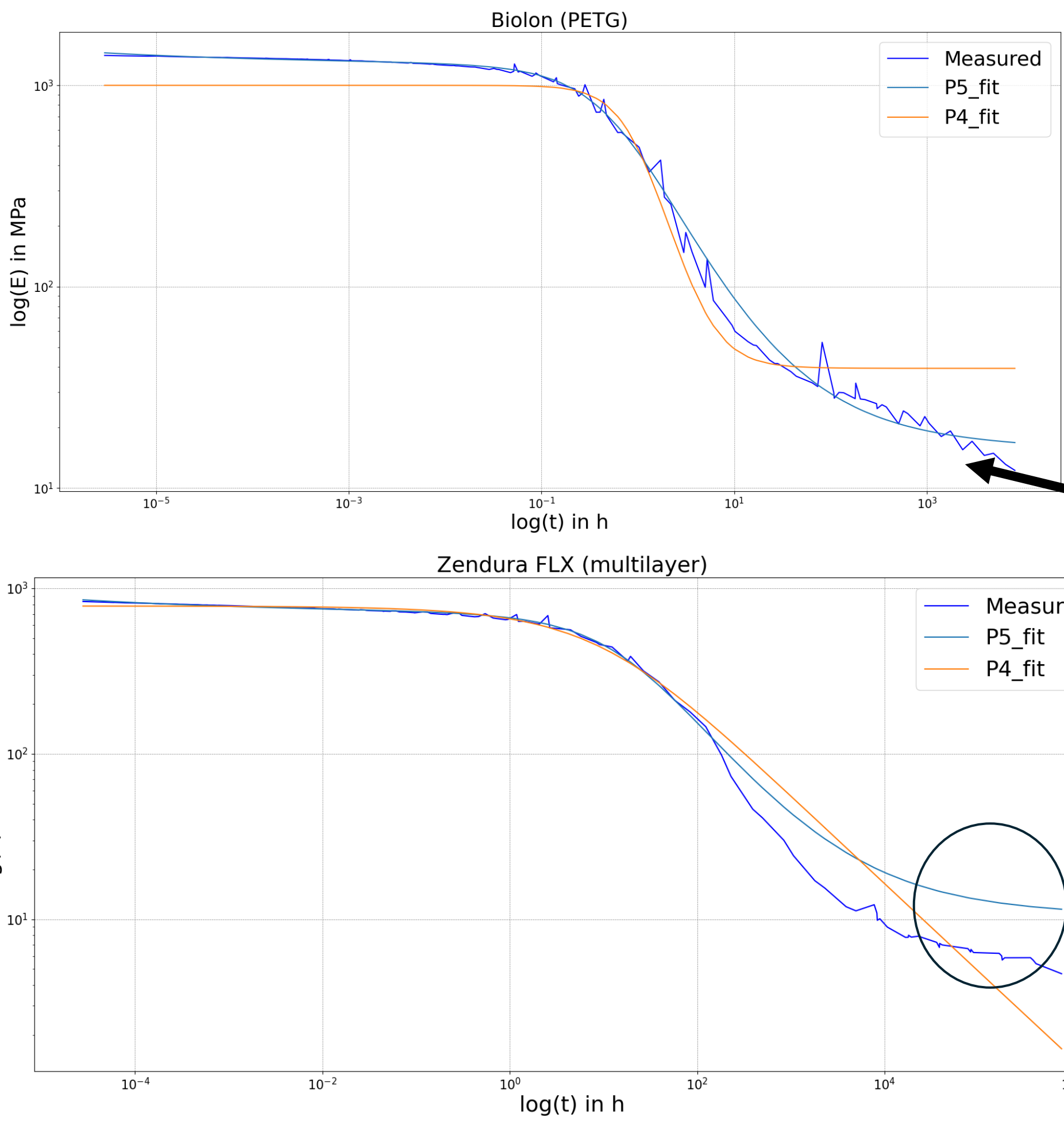
The 5-parameter Pritz model (P5)

$$\sigma(t) + D_t^\alpha[\sigma(t)] = E_1 \varepsilon(t) + (E_2 - E_1) \tau^\alpha D_t^\alpha[\varepsilon(t)] + E_1 \tau^b D_t^b[\varepsilon(t)]$$

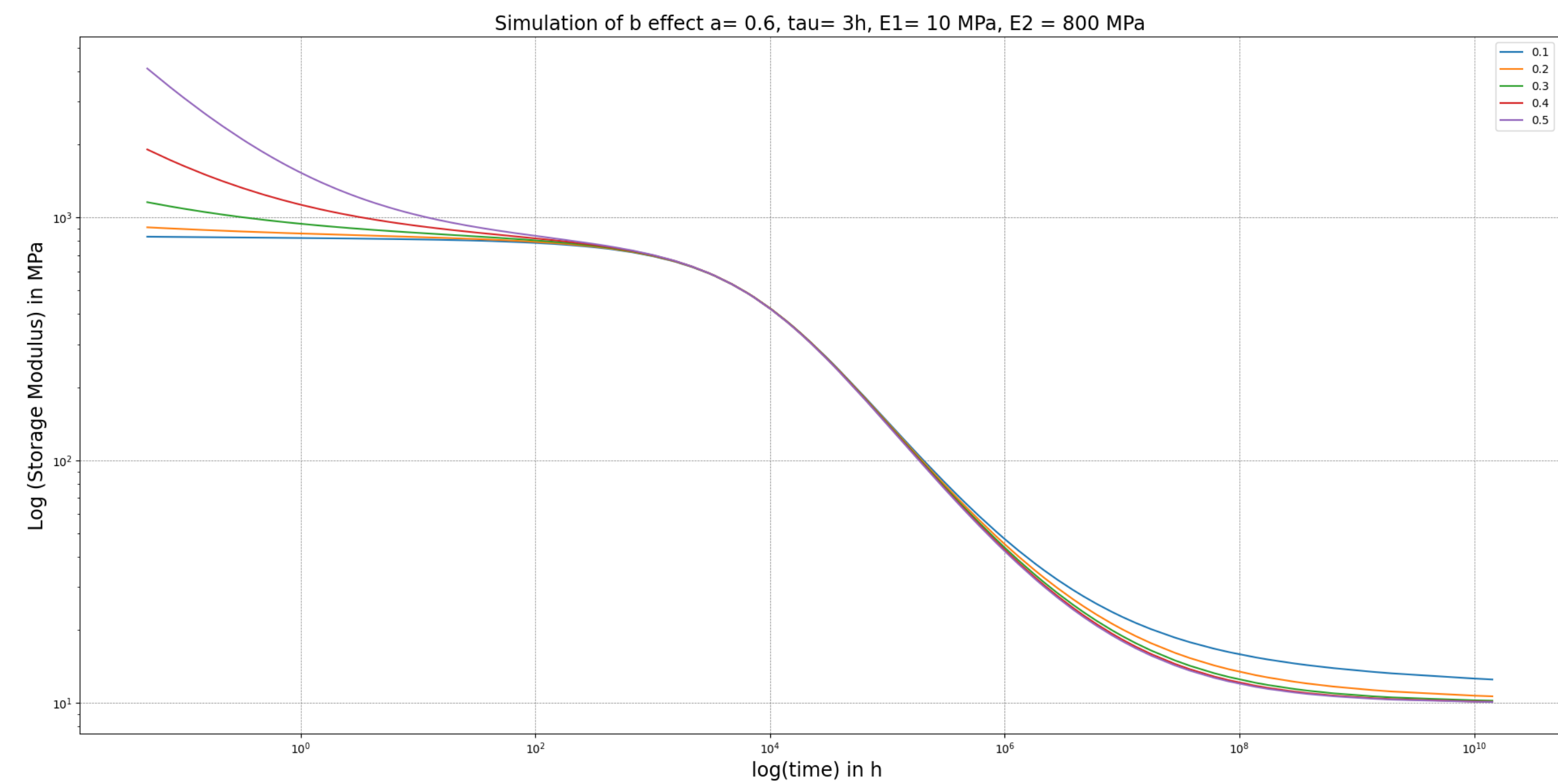
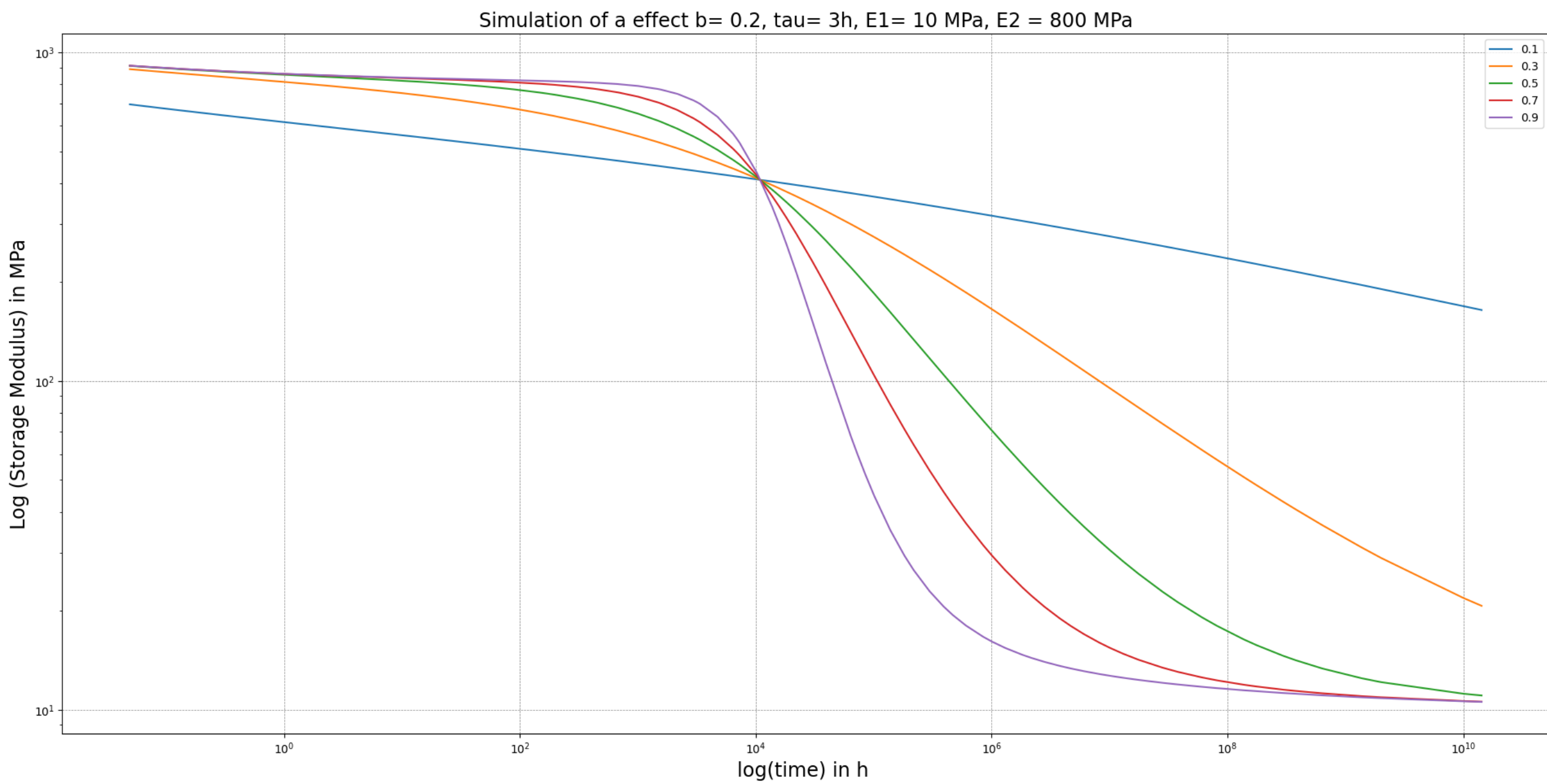
The 4-parameter Pritz model (P4)

$$\sigma(t) + D_t^\alpha[\sigma(t)] = E_1 \varepsilon(t) + (E_2 - E_1) \tau^\alpha D_t^\alpha[\varepsilon(t)]$$

Where $0 < \alpha < \beta < 1$



This type of missfit from theory always appears in multilayers but not in monolayers



α Controls The modulus main drop, and β controls the modulus change before and after the transition. Large α means a more abrupt transition, and larger β means larger variation of modulus before and after the transition

If β is sufficiently low, its contribution to the stress relaxation it may be neglected for calculations

For orthodontic treatment :

-Moderate α between 0,4 and 0.6

-Low β

Conclusions

It is possible to obtain the storage modulus variation of thermoplastics over time by performing Time-Temperature-Superposition in tensile configuration. By this method, we have obtained important data that may be useful for adjusting the prescription time for each material aligner and for a more reliable method to compare clear aligner materials. 5 Parameter Pritz model can accomodate to the data, with 4 parameters the fitting is poor. α and β are said to be controlled by the molecular weigth distribution⁴. May it be posible a monolayer with the same properties tan a multilayer?

Aknowledges

Grants for industrial PhD of the regional government of the Community of Madrid (IND2022/IND-23679). Project in colaboration with Secret Aligner S.L