

Improving interfacial properties of immiscible polymer with vitrimers

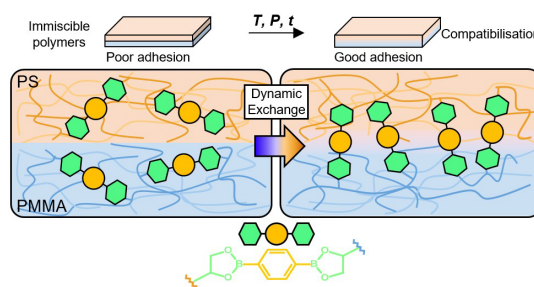
Claudia Spina¹, Dimitris Vlassopoulos², Costantino Creton^{*1}

¹ SIMM, ESPCI Paris, PSL University, Sorbonne Université, 75005 Paris, France

² Institute of Electronic Structure and Laser, FORTH, University of Crete, 71110 Heraklion, Greece

*costantino.creton@espci.psl.eu

A significant portion of polymeric materials consists of polymer blends, multilayer polymers, and adhesive joints. Nevertheless, most polymer pairs exhibit unfavourable thermodynamics for blending, leading not only to macroscopic phase separation, but also to thin interfaces which result in poor interfacial adhesion between the two phases of the polymer and low performance of the final material.¹ Therefore, improving the mechanical strength of the polymer-polymer interface has always been a focus of interest. Various strategies have been explored to address this issue, including the use of block copolymers^{2,3}, carbon nanotubes⁴, and reactive interfacial compatibilisation⁵. Vitrimers, a class of polymers cross-linked with dynamic bonds that can change their network topology through bond exchange reactions, have been assessed as an alternative tool to improve adhesion between immiscible polymers.⁶ In this work, a dioxaborolane-based precursor vitrimer⁷ has been embedded into two immiscible polymers, polystyrene (PS) and polymethyl methacrylate (PMMA)¹, with cross-linking performed in an extruder. The dioxaborolane bond exchanges are then easily thermally activated at high temperatures, allowing for dynamic bond breaking and reformation at the interface between the two polymers. An Asymmetric Double Cantilever Beam (ADCB) test was subsequently used to evaluate modifications in the adhesion properties^{8,9}, measuring the critical energy release rate (G_c) on samples where the vitrimer is mixed in a low percentage and under various conditions of adhesion temperature, pressure, and time. Subsequently, in this work we will explore the possibility of disassembling the two adhered polymers by taking advantage of the dynamic nature of the vitrimer bonds, which should enable the formation of a strong interface at low temperature but increasingly weaker as the bonds become dynamic.



References:

- [1] C. Creton, E.J. Kramer, H.R. Brown, C.-Y. Hui, *Molecular Simulation Fracture Gel Theory*, 53–136 (2002)
- [2] H.R. Brown, K. Char, V.R. Deline, P.F. Green, *Macromolecules* **26**, 4155–4163 (1993).
- [3] B. Bernard, H.R. Brown, C.J. Hawker, A.J. Kellock, T.P. Russell, *Macromolecules* **32**, 6254–6260 (1999).
- [4] F.I. Seyni, L. Barrett, S. Crossley, B.P. Grady, *Polym. Eng. Sci.* **61**, 1186–1194 (2021).
- [5] E. Boucher, J.P. Folkers, H. Hervet, L. Léger, C. Creton, *Macromolecules* **29**, 774–782 (1996).
- [6] D. Montarnal, M. Capelot, F. Tournilhac, L. Leibler, *Science* **334**, 965–968 (2011).
- [7] M. Röttger, T. Domenech, R. van der Weegen, A. Breuillac, R. Nicolaÿ, L. Leibler, *Science* **356**, 62–65 (2017).
- [8] H.R. Brown, *J. Mater. Sci.* **25**, 2791–2794 (1990).
- [9] C. Creton, E.J. Kramer, C.-Y. Hui, H.R. Brown, *Macromolecules* **25**, 3075–3088 (1992).