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Modelling liquid crystal elastomers and potential application as a reversibly switchable adhesive¹

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Liquid crystal elastomers (LCEs) are rubbery materials that composed of liquid crystalline polymers (LCPs) crosslinked into a network. The rod-like mesogens incorporated into the LCPs are have random orientations in the high temperature isotropic phase, but can adopt the canonical liquid crystalline phases as the temperature is lowered. Smectic liquid crystal elastomers have highly anisotropic mechanical behaviour. This arises in side chain smectic-A systems because the smectic layers behave as if they are embedded in the rubber matrix [1]. The macroscopic mechanical behaviour of these solids is sensitive to the buckling of the layers, so is a multiscale problem. A coarse grained free energy that includes the fine-scale buckling of the layers has been developed [2], which enables continuum modelling of these systems. In the first part of this talk I present a model of the mechanical behaviour of side chain smectic elastomers. The properties of nematic LCEs, such as their high loss tangent, and mechanical strain hardening, might enable them to be used as reversibly switchable pressure sensitive adhesive (PSA). PSAs are typically made from viscoelastic polymers. The quality of their adhesion can be measured by the *tack energy*, which is the work required to separate two bodies. To obtain a high tack energy a PSA should be capable of a large strain. It should strain soften at low strain to produce crack blunting, and then strain harden at high strain to stiffen the fibrils formed late in the debonding process. I will present a model of the tack energy of weakly crosslinked nematic polymers. To describe the constitutive properties of this system the nematic dumbbell model of Maffettone *et al.* was used [3]. This constitutive model was then combined with the block model of Yamaguchi *et al.* describing PSAs [4]. It was found that the parallel orientation of the nematic has a higher tack energy than both the isotropic and the perpendicular director orientation [5].

[1] C. M. Spillmann et al, Phys. Rev. E 82, 031705, (2010).

[2] J. Adams, S. Conti and A. DeSimone, Mathematical Models and methods in Applied Sciences, 18, 1 (2008).

[3] P. L. Maffettone and G. Marrucci, Journal of Rheology 36 (8) 1547 (1992).

[4] T. Yamaguchi, H. Morita, and M. Doi, Eur. Phys. J. E 20, 7 (2006).

[5] D. R. Corbett and J. M. Adams, Soft Matter, DOI:10.1039/C2SM26868J (2012).

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