



Cellulose-based Photonic Thermotropic and Lyotropic Liquid Crystal Systems

Joana Nascimento¹, Alice C. Calado¹, Luis F.V. Pinto¹, Andreia F.M. Santos¹, Ana Isabel Afonso², and Maria Helena Godinho^{1,*}

¹ *i3N/CENIMAT, Department of Materials Science, School of Science and Technology, NOVA University of Lisbon, Portugal*

² *CRIA – Center for Research in Anthropology, Department of Anthropology, School of Social Sciences and Humanities, NOVA University of Lisbon, Portugal*

*Corresponding author e-mail: mhg@fct.unl.pt

Cellulose derivatives are well known to form both lyotropic and thermotropic liquid crystalline phases [1, 2]. In this work, we focus on thermotropic cellulose derivatives that also exhibit lyotropic liquid crystalline behaviour [3]. The ability to form lyotropic phases is a key requirement for crosslinking thermotropic derivatives under different conditions, a crucial step towards the development of cellulose-based liquid-crystalline elastomers. To this end, acetoxypopylcellulose [4], propionate and butyrate hydroxypropylcellulose esters with varying degrees of substitution were synthesised, and their solutions in dimethylacetamide were prepared. The critical concentration for the formation of the lyotropic liquid crystalline phase was determined as a function of both the cellulose derivative and the degree of substitution. In parallel, the optical properties of the thermotropic cellulose derivatives and lyotropic systems were characterised as a function of temperature. For the thermotropic derivatives, the evolution of photonic properties was found to depend strongly on repeated heating and cooling cycles. All liquid crystalline systems prepared exhibited a right-handed circularly polarised (RCP) response. Furthermore, the concentration-dependent colour evolution of the lyotropic phases was shown to depend not only on solvent concentration but also on the degree of substitution and the nature of the ester substituent. Overall, this work provides insight into the role of cellulose ester substituents in governing liquid crystalline and photonic behaviour. These findings are intended to guide the subsequent crosslinking step, with the aim of preserving liquid crystalline order in the crosslinked network and achieving elastomeric liquid crystalline properties.

References

- [1] I. Rusig, M.H. Godinho, L. Varichon, P. Sixou, J. Dedier, C. Filliatre and A.F. Martins, *J. Polym. Sci. Part B: Polym. Phys.* **32**, 11, 1907 (1994).
- [2] J.X. Guo and D. G.Gray, *Macromolecules* **22**, 2086 (1989).
- [3] P.E.S. Silva, R. Chagas, S.N. Fernandes, P. Pieranski, R.L.B. Selinger and M.H. Godinho *Commun. Mater.* **2**, 1, 79 (2021).
- [4] N. Monge, L.F.V. Pinto, E. Ferreira, P.L. Almeida, J.L. Figueirinhas, A.L. Carvalho, P.J. Sebastião and M.H. Godinho, *Adv. Opt. Mater.*, e02728 (2025).

Acknowledgments

This work was supported by the ERC H2020 Synergy grant 101167171 (ALCEMIST) and by FCT – Fundação para a Ciência e a Tecnologia, I.P., through the projects LA/P/0037/2020, UIDP/50025/2020 and UIDB/50025/2020 of the Associate Laboratory Institute of Nanostructures, Nanomodelling and Nanofabrication i3N. The authors also acknowledge the COST Action CA21159 (PhoBioS).