

# Department of Chemistry: Part III Project 2015/16

Prof. A Chemist

## Chemical studies of chemistry

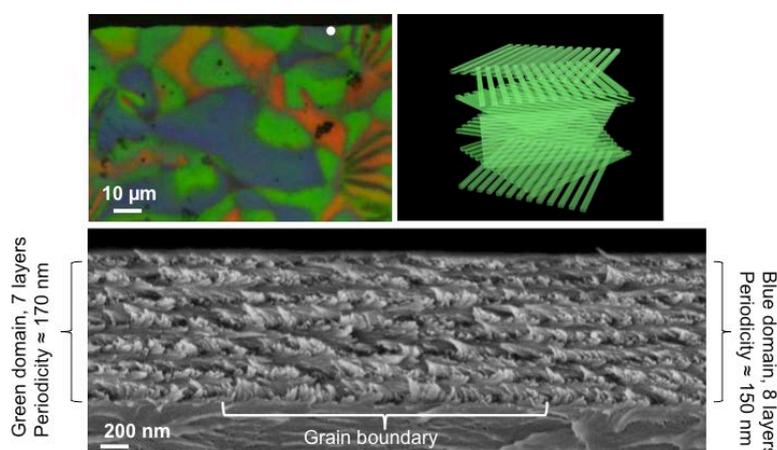
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### Dynamic of formation of chiral nematic Liquid Crystalline Phases in aqueous suspensions of Cellulose nano-crystals

Cellulose is the most abundant biopolymer resource available in the planet. Chemically, its structure is a regular array of glucose monomers, linked together by  $\beta$ -1,4 glucosidic bonds. The high amount of hydrogen bonding that is possible between the many hydroxy-groups in the polymer leads to a high stiffness. It also causes the presence of crystallised domains that aggregate to form microfibrils, the building blocks for macroscopic fibres that sustain plant's cell wall.



In such microfibrils, both crystalline and amorphous cellulose are present. The amorphous part can be dissolved by acid hydrolysis, leaving a colloidal suspension of the cellulose nanocrystals, rod-like particles with dimensions of typically 100 - 300 nm lengths and 5 -10 nm diameters, depending on the source of the cellulose [1]. Aqueous suspension of cellulose nanocrystals forms for specific concentrations a chiral nematic phase [2]. It proves to be possible to vary the chiral nematic pitch by controlling ionic strength, counterion species [3] and different preparation conditions [4]. If the suspension is allowed to dry, a solid cellulose film is formed in which the chirality is maintained. These cellulose films display a strong iridescent colour as consequence of their chiral nematic structure. Changing the kinetics of the evaporation allows us to control the dimension of the pitch and consequently the colour of the film.

The formation of the nematic phase has been explained by Onsager[4]: isotropically distributed rod-like particles will, above a critical concentration, spontaneously sacrifice configurational entropy in order to gain a large increase in free volume for the entire system. Counter-intuitively generating order, with an overall increase in entropy. The project consists in try to extend this theory and relate it to kinetics of the formation of such chiral nematic films.

1. S. J. Eichhorn, *Soft Matter* 7, 303, (2011).
2. S. Beck et al., *Biomacromolecules* 12, 167 (2011).
3. S. Beck et al., *Cellulose* 20, 1401 (2013).
4. L. Onsager, *Annals of the New York Academy of Sciences*, 51, 627 (1949).