Surface Pattern Formation in Chiral Liquid Crystals: From Self-Assembly to Egg Carton Architectures

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The Bouligand structure of biological cholesteric liquid crystals (BCLC) is a periodic architecture that results in repeated surface wrinkling patterns. Such patterns can be observed in hierarchical chitin fibres, twisted plywood in cellulose, and multiscale structure in collagens. The significance and applications of the wrinkling morphology have been well-studied in tribology, diffraction gratings and the ability to enhance cell proliferation or inhibit tissue growth. We propose a general phase-field approach to studying the liquid crystal director field, where three different groups of solutions (cylindrical surface, egg carton surface and chaotic pattern) are investigated, and they incorporate all the possibilities observed in nature. A novel mechanism to the anchoring-induced surface wrinkling phenomenon is presented, suggesting that the classical Herring's pressure (a widely used concept in crystal physics to explain pattern formation) is algebraically included in the director pressure existing in fibrous oriented materials. This research integrates an extensive framework for studying the intrinsic geometry and mechanism of biological and synthetic liquid crystal surfaces and provides new principles to biomimetic surface engineering.