

Thixo-viscoelastoplastic rheological characterisation of human mucus and sputum under healthy and ill conditions using a living-polymer-based Bautista-Manero-Puig constitutive model within a multimode approach

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In this work, the latest Bautista-Manero-Puig BMP+ model [1] is used as a theoretical approach to describe the thixo-viscoelastoplastic response of healthy, Cystic Fibrosis (CF) and Chronic Obstructive Pulmonary Disease (COPD)[2–3] affected mucus-sputum samples. The BMP+ model reproduces quantitatively the rheological signature responses of mucus-sputum in steady and unsteady simple flows under conventional shearing protocols. From such deep theoretical characterisation, predictions are presented under highly non-linear flow settings, such as LAOS, and steady and unsteady uniaxial extensional deformations, from which: (i) thixotropy appears linked intimately with a critical stress measure for sample fluidisation, giving quantitative agreement with values reported in the medical literature; (ii) an internal-structure rearrangement is observed under LAOS in the form of ribbon-like Lissajous curves with secondary intersections; and (iii) in extensional deformations, augmented strain-hardening peaks in extensional viscosity are predicted, related to an additional source of flow resistance in the expectoration process, dominated by mixed shear-to-extensional flow in the scale of major airways [2–3]. This thixo-viscoelastoplastic response is hypothesised to serve as: (i) a prospective aid to determine the healthy or ill state of a patient using advanced rheological characterisation; (ii) an auxiliary tool for the evaluation of new treatments; and (iii) may be extended to the analysis of newly-appearing illnesses in the respiratory systems, such as COVID-19, which has been found to hold a close relationship with CF in terms of sputum consistency and symptoms.

[1] López-Aguilar et al., Phys. Fluids 35 (2023) 063101.

[2] Tabatabaei et al., J. Non-Newton. Fluid Mech. 222 (2015) 272–287.

[3] López-Aguilar et al., Rheol Acta 54 (2015) 287–305.

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