Testing Sputum in Cystic Fibrosis Patients using Rheology: the Ageing Effect

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Context

Sputum rheology investigates mechanical properties of the mucus, i.e. elasticity and viscosity. Rheology is proposed as a prospective tool to follow the status of patients with cystic fibrosis (CF), and to assess the individual efficiency of current and future treatments during clinical practice (endpoints). However, this characterisation may involve sample ageing during their transient storage from collection to measurement. To better define rheological assessment protocols, the possible effect of ageing of sputum samples on their rheological properties is investigated.

Protocol

Sample Collection

- CF patients
- Spontaneous expectoration

> 1 mL sample; N = 17

Sample Preparation

Sputum is composed of highly viscoelastic mucus plugs included in a less viscoelastic matrix. This heterogeneity induces artefacts in rheology measurements.

Sample Preparation

- Vortex homogenisation

French patent FR 2757108, filed 26 July 2017

Rheological Measurements

Rheology is the study of the flow of matter that exhibits a combination of elastic, viscous and plastic behaviours by combining elasticity and fluid mechanics.

- In phase contribution:
  - G’ elastic modulus
  \[ G' = \frac{\tau}{\cos \delta} \]
- Out of phase contribution:
  - G” viscous modulus
  \[ G'' = \frac{\tau}{\sin \delta} \]
  - tan δ phase tangent
  \[ \tan \delta = \frac{G''}{G'} \]

  - tan δ < 1 ➔ Gel (solid-like) behaviour
  - tan δ > 1 ➔ Viscous (liquid-like) behaviour

Individual evolution:

- G’ and G” consistently increase over time, while tan δ essentially remains constant.
- G’ and G” increases gradually slow down within 4–6 h.

Results

- G’ and G” both increase with similar dynamics (initially fast, slows down after 4-6 h).
- G’ and G” both increase in similar proportions (x2 within 8-10 h).
- tan δ remains constant.

Concluding Remarks

1 Mucus globally thickens when stored at 4°C. This thickening effect mainly occurs within the first 4–6 h after sputum collection. However, no significant gelation or fluidisation is observed, suggesting that this thickening is not related to evaporation.

2 Since the sputum viscoelasticity evolves with storage time, care must be taken to minimise it and/or to define unified protocols if rheology is to be used as a clinical marker.

Perspectives

Measurements performed at 4°C mimic the standard sample storage conditions. Other relevant storage conditions (e.g., at room temperature (20°C), within controlled humidity, after freezing/thawing cycles) would call for complementary investigations to understand the possible changes in the mucus microstructure.