



## Microrheological study of human respiratory mucus

Milad Radiom, Romain Hénault, Salma Mani, Aline Grein-Iankovski, Xavier Norel, Jean-François Berret

### ► To cite this version:

Milad Radiom, Romain Hénault, Salma Mani, Aline Grein-Iankovski, Xavier Norel, et al.. Microrheological study of human respiratory mucus. *Mucus, Cilia and Mucociliary Interactions*, Feb 2023, Barga, Italy. hal-04005597

**HAL Id: hal-04005597**

**<https://cnrs.hal.science/hal-04005597>**

Submitted on 26 Feb 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

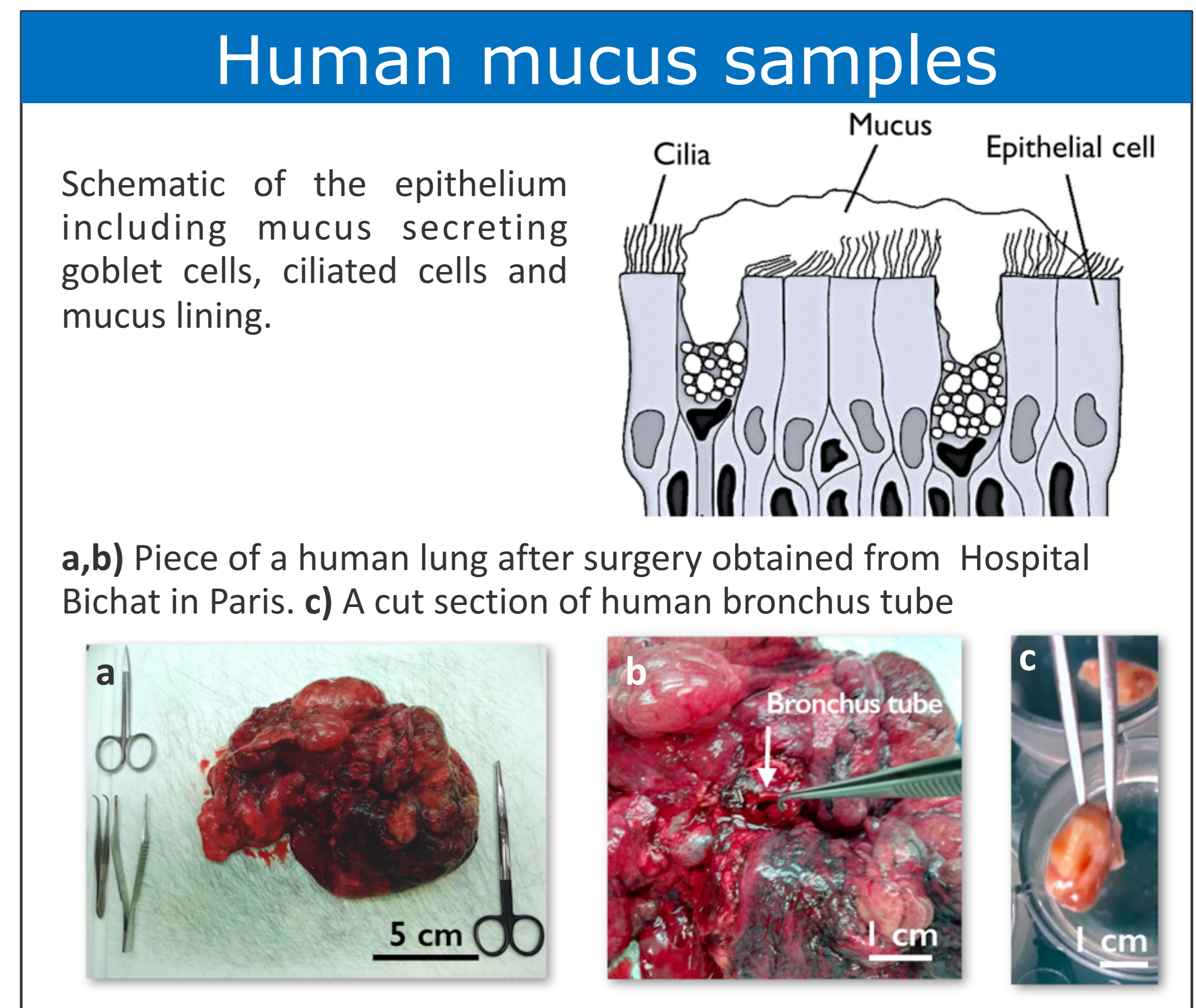
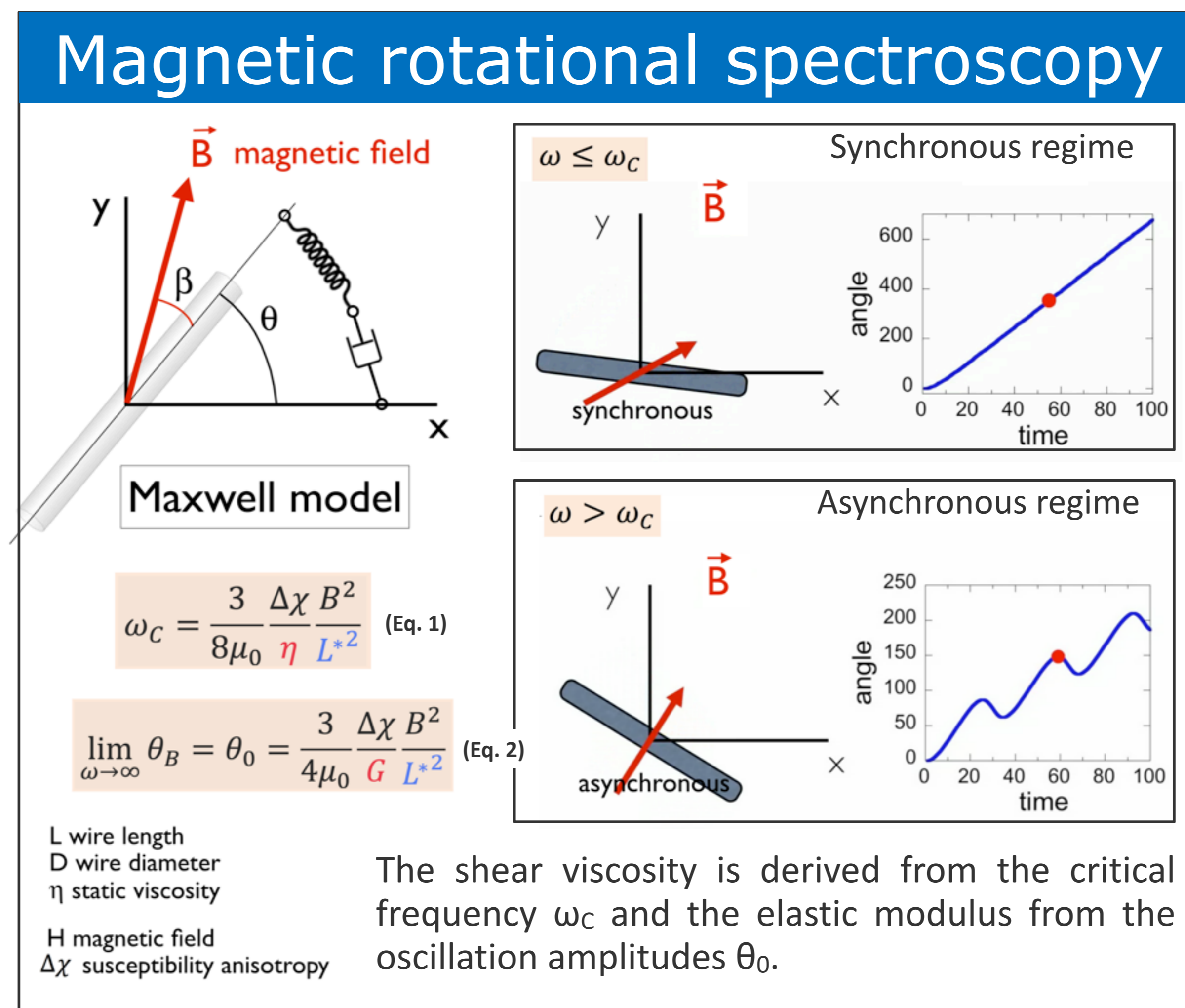
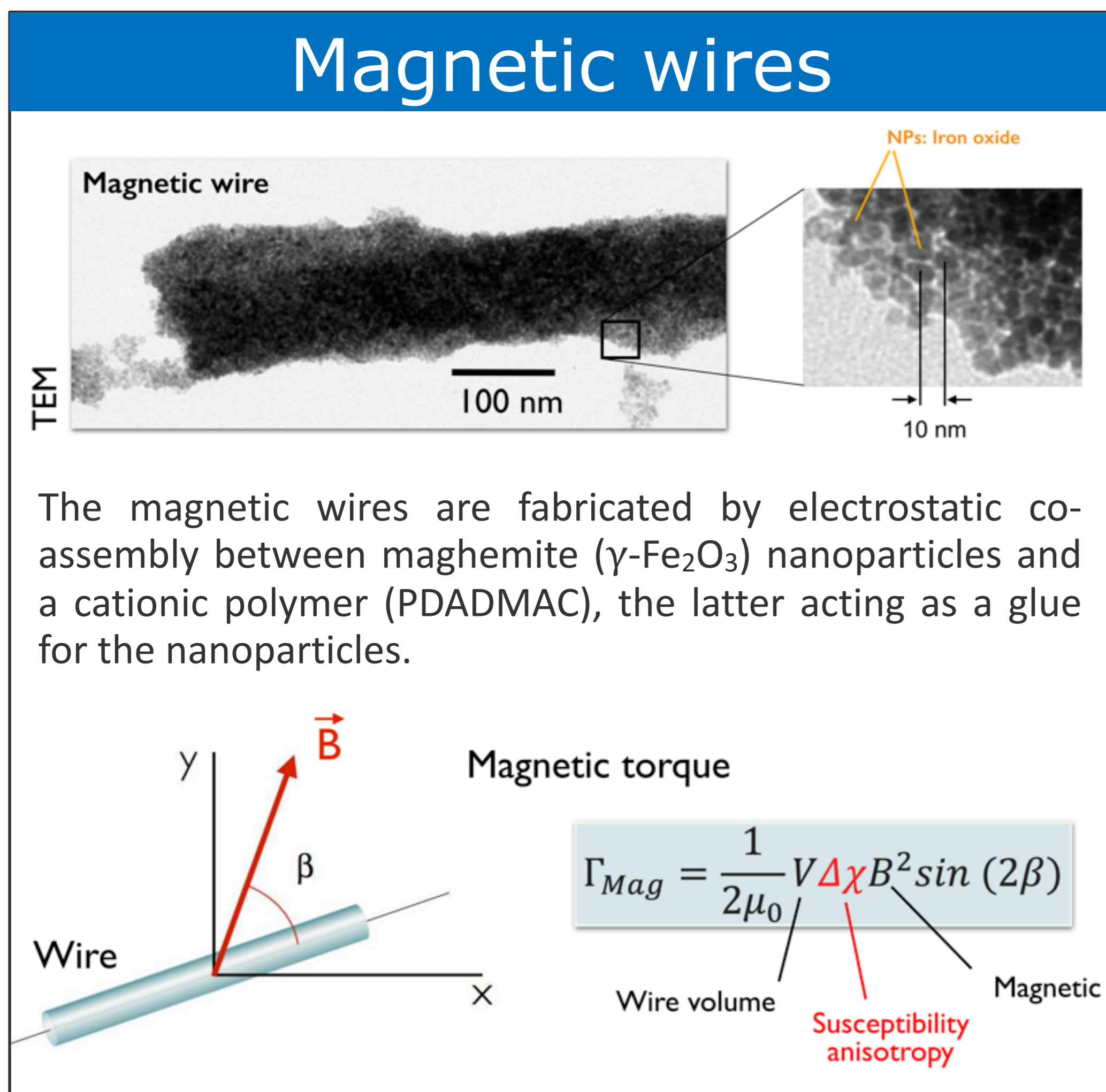


Distributed under a Creative Commons Attribution 4.0 International License

## ABSTRACT

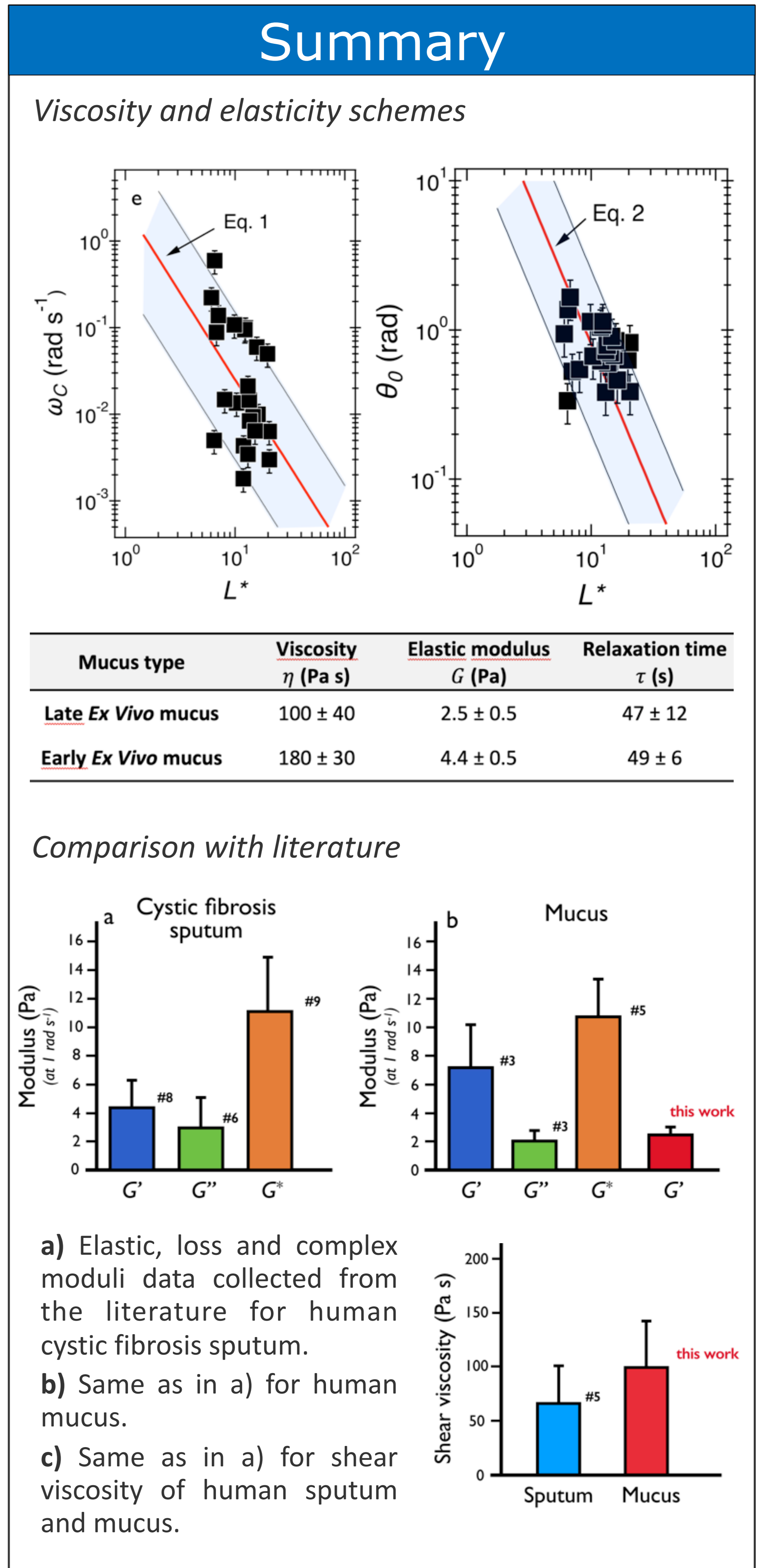
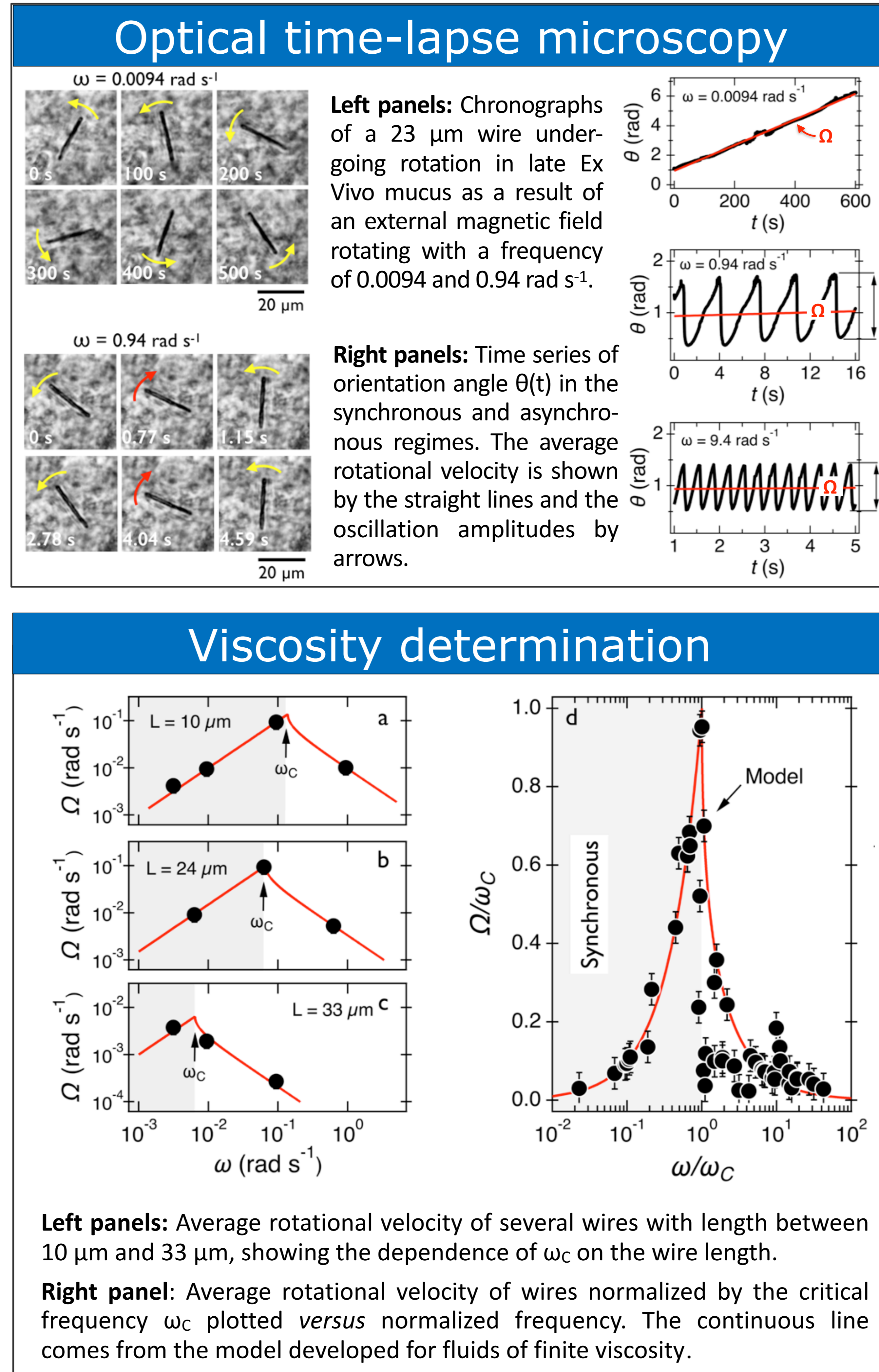
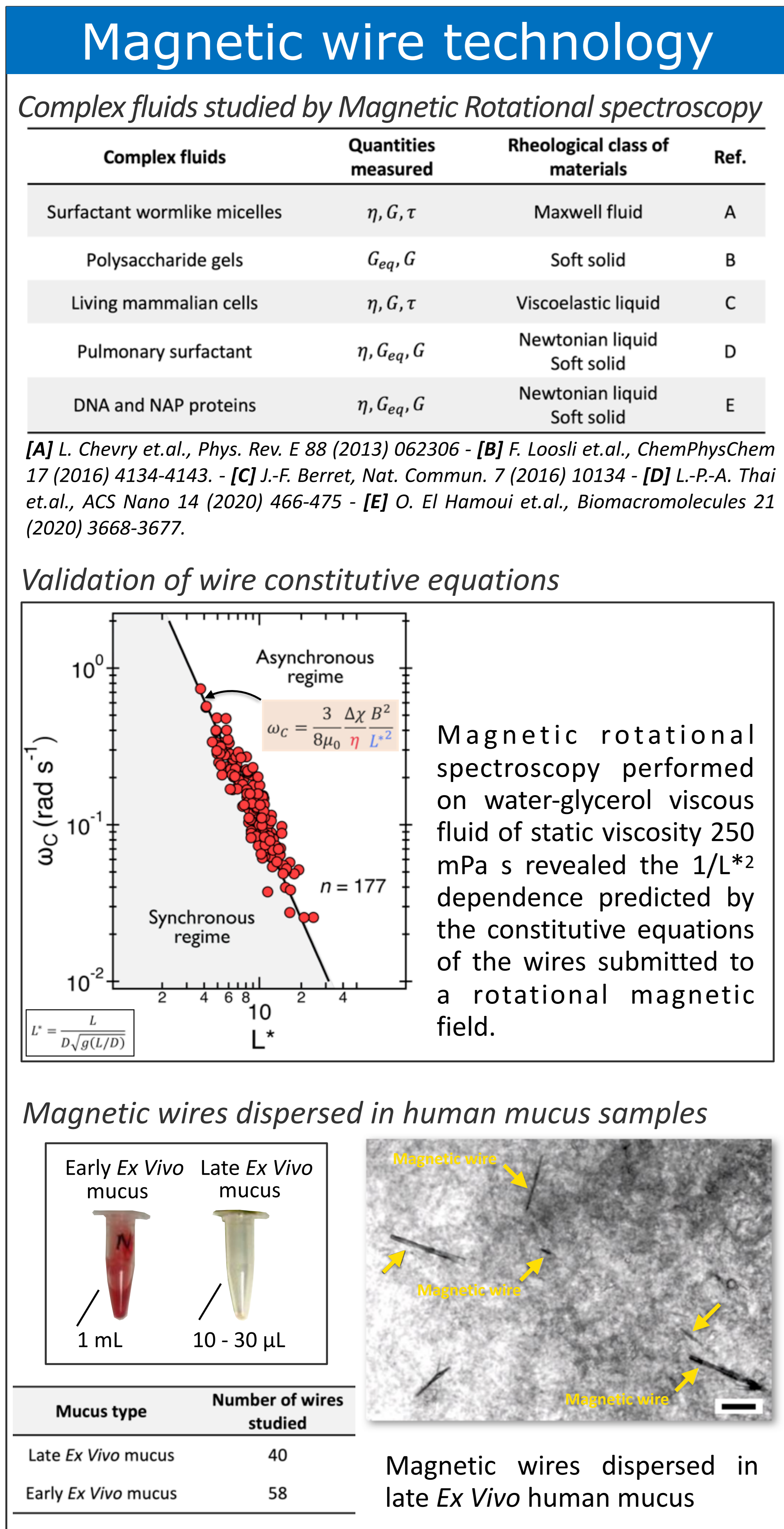
Mucus is a viscoelastic gel secreted by the pulmonary epithelium in the tracheobronchial region of the lungs. The coordinated beating of cilia moves mucus upwards towards pharynx, removing inhaled pathogens and particles from the airways. The efficacy of this clearance mechanism depends primarily on the rheological properties of mucus. Here we use magnetic wire based microrheology to study the viscoelastic properties of human mucus collected from human bronchus tubes. The response of wires between 5 and 80  $\mu\text{m}$  in length to a rotating magnetic field is monitored by optical time-lapse microscopy and analyzed using constitutive equations of rheology, including those of Maxwell and Kelvin-Voigt. The static shear viscosity and elastic modulus can be inferred from low frequency ( $3 \times 10^{-3} - 30 \text{ rad s}^{-1}$ ) measurements, leading to the evaluation of the mucin network relaxation time. This relaxation time is found to be widely distributed, from one to several hundred seconds. Mucus is identified as a viscoelastic liquid with an elastic modulus of  $2.5 \pm 0.5 \text{ Pa}$  and a static viscosity of  $100 \pm 40 \text{ Pa s}$ . Our work shows that mucus exhibits secondary inhomogeneities associated with the relaxation time of the mucin network that may be important for its flow properties. The results of this work were published in the journal *Soft Matter*, under the reference : M. Radiom, R. Hénault, S. Mani, A.G. Iankovski, X. Norel, J.-F. Berret, *Magnetic Wire Active Microrheology of Human Respiratory Mucus*, *Soft Matter* 17 (2021) 7585-7595.

## INTRODUCTION



## RESULTS

Comparison with literature



## REFERENCES

- R. Bansil and B. S. Turner, Adv. Drug. Deliv. Rev., 2018, 124, 3-15  
B. Button, H. P. Goodell, E. Atieh, Y.-C. Chen, R. Williams, S. Shenoy et al., PNAS 2018, 115, 12501-12506  
B. S. Schuster, J. S. Suk, G. F. Woodworth and J. Hanes, Biomaterials, 2013, 34, 3439-3446  
J.-F. Berret, Nat. Commun., 2016, 7, 10134  
L.-P.-A. Thai, F. Mousseau, E. Oikonomou, M. Radiom and J.-F. Berret, ACS Nano, 2020, 14, 466-475  
**M. Radiom, R. Hénault, S. Mani, A.G. Iankovski, X. Norel, J.-F. Berret, Soft Matter 17 (2021) 7585-7595**

## CONCLUSION

In this work we propose a new active microrheology technique to determine the rheological characteristics of human respiratory mucus. The probes used are remotely actuated magnetic wires of lengths between 5 and  $80 \mu\text{m}$ , i.e. much greater than the size of the microcavities observed in mucus samples. Human mucus is identified as a viscoelastic liquid with an elastic modulus of a few Pa and a static viscosity of the order of  $100 \text{ Pa s}$ . This work also shows that mucus exhibits strong inhomogeneities associated with the relaxation times of the mucin network.