LF-NMR and muco-obstructive lung diseases

M. Abrami [1] A. Biasin[2] F. Tescione[3] D. Tierno [2] A. Carbone[4] M. Conese[4] S. Di Gioia[4] D. Larobina[3] M. Maschio[5] M. Confalonieri[6] G. Grassi[2] M. Grassi[1]

[1] Dept of Eng. and Architecture, University of Trieste, Trieste, Italy
[2] Clinical Dept of Med., Surg. and Health Sciences, University of Trieste, Trieste, Italy
[3] Institute of Polymers, Composites and Biomaterials, National Research Council of Italy, Portici, Italy
[4] Dept. of Clinical and Experimental Medicine, University of Foggia, Foggia, Italy
[5] Institute for Maternal and Child Health, IRCCS Burlo Garofolo, Trieste, Italy
[6] Cattinara University Hospital, Pulmonology Department, Trieste, Italy

E-mail: mario.grassi@dia.units.it

Cystic fibrosis (CF) and chronic obstructive pulmonary disease (COPD) share the formation of respiratory pathological mucus, whose high viscosity, osmotic pressure and solids concentration depend on the pathological increase of proteins, alginate, leukocytes, bacteria and mucins following a defect in the CFTR (Cystic fibrosis transmembrane conductance regulator) protein. Although CF and COPD dysfunctions have different origins (CF: CFTR genetic defect, COPD: acquired CFTR-defect, mostly due to smoking), in both cases mucus alterations impair muco-ciliary clearance determining mucus stagnation thus favouring bacterial lung infections. Notably, the CF health costs are expanding due to the increasing number of long-surviving CF patients and the medical burden of COPD is rapidly increasing (it recently surpassed stroke as the 3rd leading cause of death worldwide). Thus, the necessity of developing a reliable, simple, cheap and fast approach to monitor lung functionality able to overcome the drawbacks of current strategies arises. Thus, we propose to measure the magnetic relaxation of mucus water through Low Field Nuclear Magnetic Resonance (LF-NMR). This approach allows the measurement of the water spin-spin (T_{2m}) and spin-lattice (T_{1m}) relaxation times of Hydrogen atoms, whose values strongly depend on the solid contents and internal architecture of the network pervading the mucus. In other words, T_{2m}-T_{1m} and, more precisely, the magnetic relaxation spectra they represent, account for the different states water experiences inside the mucus structure (for example water confined in small or big meshes). Interestingly, preliminary studies, conducted by us on healthy subjects, CF and COPD patients, showed the existence of a correlation between T_{2m} and FEV_1 (Forced Expiratory Volume in the first second, i.e. the amount that is exhaled in the first second purposefully trying to breath out as much air as possible). In addition, especially for what concerns T_{2m}, correlations with mucus shear modulus (G), solid content and local (pro inflammatory cytokines such as TNFα and IL-1β) and systemic (C-Reactive protein, neutrophils blood count) biomarkers have been demonstrated. Finally, very recently, we found a correlation between T_{2m} and the mucus bacterial concentration, T_{2m} and bacteria genera *Streptococcus*/*Staphylococcus*, the most abundant genera in COPD sputum and T_{2m} with the Shannon index that reflects the broadness mucus bacterial community. Thus, the aim of this work is to deduce many mucus characteristics and patient clinical condition by simply measuring T_{2m} and/or T_{1m}.

Keywords: *LF-NMR, Cystic Fibrosis, COPD, hydrogel, mathematical modelling*

Progetto Finanziato dall'Unione europea- Next Generation EU, Missione 4 Componente 1, CUP J53D23002200006