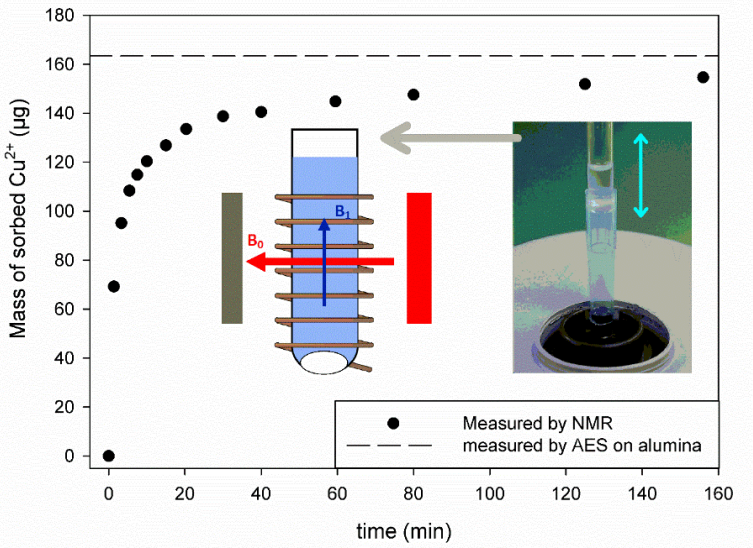
NMR relaxometry for the study of paramagnetic ions adsorption on different substrates

Y. Gossuin, Q. L. Vuong

Biomedical Physics Unit, UMONS

Water pollution by heavy metal is a major environmental problem. Adsorption and ion-exchange are among the most used heavy metal removal techniques. The development and evaluation of new adsorbents and resins is thus an important topic. Some heavy metal ions - like Cu^{2+}, Mn^{2+}, Cr^{3+}, Ni^{2+}… - are paramagnetic and known to affect the Nuclear Magnetic Resonance (NMR) relaxation times T_1 and T_2 of water protons in aqueous solutions. These relaxation times can be used to evaluate the concentration of paramagnetic ion in water. For the adsorption of Cu^{2+} on activated alumina and the capture of Cr^{3+} by an ion-exchange resin, we show - after a comparison with conventional methods - that NMR T_2 relaxometry can be used to perform kinetics study and obtain an adsorption isotherm. The T_2 relaxometric experiment is performed at 0.47 T directly in an NMR tube with 350 µl of solution and 45 mg of adsorbent. For the kinetics study, a single tube is used since the measurement is nondestructive. The NMR experiments allow to determine, for Cu^{2+} adsorption on alumina, a maximum of capacity q_{max} = 4.32 mg(Cu)/g(Al2O3) and an equilibrium adsorption constant K = 0.61 mM^{-1}. For the removal of Cr^{3+} by the ion exchange resin, the maximum capacity is q_{max} = 10.1 mg(Cr)/g(resin) and the equilibrium adsorption constant K = 0.611 mM^{-1}.

Longitudinal relaxation of the loaded substrates can also be used to evaluate the amount of adsorbed paramagnetic ion, directly on the wet sorbent. Even if it is limited to paramagnetic heavy metal ions and necessitates rather high metal concentration, NMR relaxometry could become an interesting additional tool for the study of heavy metal adsorption. Low-resolution NMR could also be used to monitor the removal of paramagnetic ion directly on the column during a column experiment.



1. Gossuin, Y., Vuong, Q. L. *Separation & Purification Technology* (2018) **202,**138-143