NMR relaxometry for adsorption studies: proof of concept with copper adsorption on activated alumina

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Water pollution by heavy metal is a major environmental problem [1]. Adsorption is one of the most used and promising heavy metal removal techniques. The development and evaluation of new adsorbents is thus an important topic. Some heavy metal ions - like Cu^{2+}, Mn^{2+}, Cr^{3+}… - 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 paramagnetic ion concentration in solution. For the adsorption of Cu^{2+}on activated alumina, we show, after a comparison with conventional methods, that NMR T_2 relaxometry can be used to perform kinetics study and obtain a Langmuir isotherm [2]. 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 (Fig.1). For the kinetics study, a single tube is used since the measurement is nondestructive. The NMR experiments allow to determine a maximum Cu^{2+} adsorption capacity q_{max} = 4.32 mg(Cu)/g(Al_2O_3) and an equilibrium adsorption constant K = 0.61 mM^{-1}. T_1 based relaxometry can also be used to evaluate the amount of Cu^{2+} adsorbed on alumina, 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.

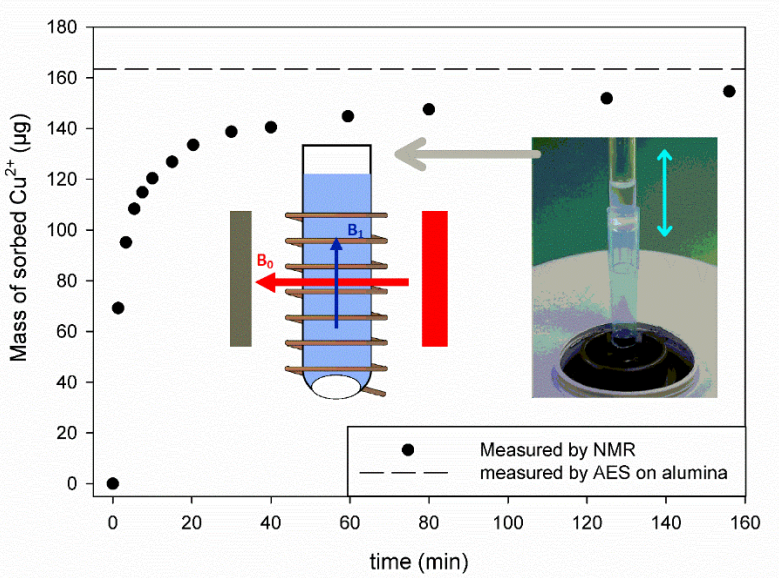

Fig. 1. Principle of the adsorption follow-up by NMR relaxometry

References

[1] Heavy Metals In Water, 2014. http://doi.org/10.1039/9781782620174.
[2] Y. Gossuin, Q. L. Vuong *Sep. Pur. Technol.* **202**,138-143 (2018).