# Low resolution nuclear magnetic resonance for the study of nickel (II) and manganese (II) removal by ion exchange resin.

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## Abstract

Water pollution by heavy metals is a major environmental concern [1]. Adsorption is one of the most used and promising heavy metal removal techniques. However, current techniques to study the adsorption efficiency are indirect and destructive. In this research, the paramagnetic properties of some heavy metal present in wastewater (Mn (II), Ni (II)) are used. Indeed, it is well known that paramagnetic ions affect the Nuclear Magnetic Resonance (NMR) relaxation times of water protons, which can be measured by benchtop NMR relaxometry [2-3]. Therefore, the purpose of this study is to prove the abilities of direct and non-destructive NMR relaxometry to monitor the removal of paramagnetic heavy metals in batch experiment by ion exchange resins.

## Method

From the value of $T_1$ or $T_2$ measured, the amount of heavy metals ions adsorbed on resin (q) and the concentration in the solution (C) can be determined with :

$$q = \frac{V_{sample}\ A_{ion}\left([ion]_{ini} - \left(\frac{1}{T_i} - \frac{1}{T_i^{water}}\right)\Big/ r_i\right)}{m_{resin}} \quad (1)$$

With $V_{sample}$, the volume of solution; $A_{ion}$, the atomic weight; $[ion]_{ini}$, the initial ion concentration; $r_i$, the relaxivity and $m_{resin}$, the mass of resin.

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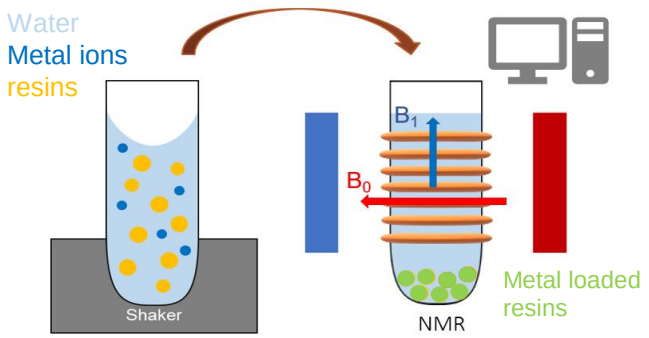


Figure 1. Experimental set-up.

## Kinetics

The kinetic of adsorption can be described by the pseudo-first order kinetic model:

$$q = q_e[1 - e^{-k_1 t}] \quad (2)$$

where $q_e$ are the amounts of adsorbate adsorbed at time t and at equilibrium, $k_1$ is the equilibrium rate constant.

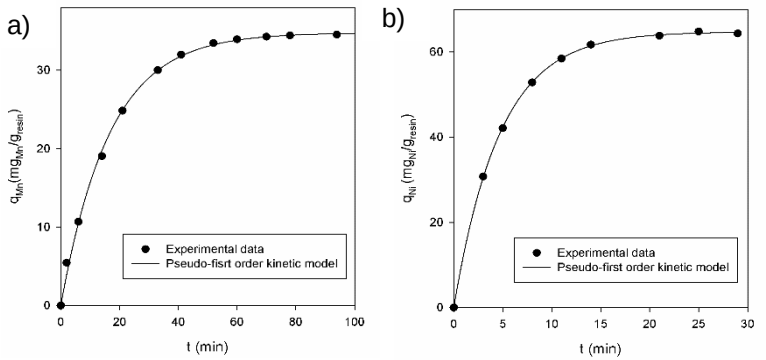


Figure 2. Fitting of the kinetics data with pseudo-first order model for (a) $Mn^{2+}$ and (b) $Ni^{2+}$ removal by Amberlite IR120 resin at 20°C.

## Isotherms

The Langmuir Isotherm can predict the maximum adsorption capacity ($q_{max}$) of a resin for different metal species present in water:

$$q_e = \frac{q_{max} K_L\ C_e}{1 + K_L C_e} \quad (3)$$

With $K_L$ is the sorption equilibrium constant, $C_e$ is the concentration at equilibrium.

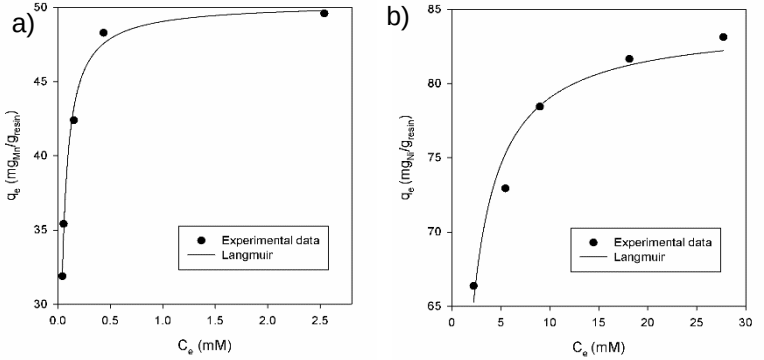


Figure 3. Fitting of adsorption isotherm with the Langmuir model of (a) $Mn^{2+}$ and (b) $Ni^{2+}$ on Amberlite IR120 at 22°C and pH=4.5.

## Conclusion

The NMR experiments allow to determine a maximum adsorption capacity of 50.3 mg $g^{-1}$ and 84.1 mg $g^{-1}$ for Mn (II) and Ni (II) respectively whereas the sorption equilibrium constant are 40.2 $mM^{-1}$ ($Mn^{2+}$) and 1.55 $mM^{-1}$ ($Ni^{2+}$). Experimental kinetic data fitted well with the pseudo-first-order kinetic model. The next step will be to reproduce these experiments for other adsorbents and paramagnetic ions in different conditions.

[1] Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J., *Molecular, Clinical and Environmental Toxicology. Experientia Supplementum*,101, 133-164 (2012). [2] Gossuin, Y., Hantson, A.-L., & Vuong, Q. L, *Journal of Water Process Engineering*, 33, 101024 (2020). [3] Gossuin, Y., & Vuong, Q. L., *Separation and Purification Technology*, 202, 138-143 (2018).

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