Development of aptamer-functionalized solid supports for the analysis of trace ions in complex samples

Many metal ions are recognized as essential for the proper functioning of our organism, but some of them, such as cadmium or lead ions, are harmful even in trace amounts. Other ions, like copper ions, can also become harmful when a deficiency or excess is observed in the body. Standards and normal thresholds have been established, particularly in food products, as well as in biological matrices such as blood. Therefore, it is necessary to be able to quantify these trace metals in complex matrices. In order to overcome the performance limitations of elemental analysis instruments, such as lack of specificity or sensitivity to matrix effects, a preliminary sample treatment step is required, such as solid-phase extraction. However, conventional supports lack specificity, leading to the co-extraction of multiple metal ions. To overcome this lack of specificity, new highly specific supports are being developed, such as ion-imprinted polymers whose potential has already been demonstrated, but whose synthesis and implementation can be complex. The objective of this thesis is to investigate the use of aptamers, simple DNA or RNA strands, to develop highly specific and selective extraction supports for metal ions. While their potential has already been demonstrated for the extraction of organic molecules, few studies have focused on the extraction of metal ions such as cadmium, lead, and copper, which are targeted in this study. Following a literature review on the use of specific aptamers for these metal ions, especially in the context of sensor development, specific sequences of interest were selected for each target. These sequences were covalently attached to activated CNBr Sepharose. After evaluating the theoretical capacity of the supports by measuring the grafting rates, a detailed study of the effect of percolation and washing media on the retention of targeted ions was conducted thanks to ICP-MS measurement of each fraction, demonstrating the strong influence of ions present in the medium on specificity and selectivity. These two parameters were investigated respectively by studying the retention of other divalent cations on sorbent grafted with specific aptamers and by studying the retention of targeted ions on supports grafted with so-called control sequences, i.e. with no known affinity for targeted ions. After optimizing the procedures for each of the most promising supports capable of extracting one of the target ions, the capacities of the supports were determined. Then, the supports were successfully applied to the extraction of targeted ions from real samples such as serum, illustrating the strong potential of aptamers for the extraction of metal ions.