

Copper (II) Sequestration by PAMAM Dendrimers in Tap Water

ABSTRACT

Dendrimers are nanomaterials that have been widely studied for a variety of applications due to their distinctive properties. One such property specifically of the generation 2-PAMAM Dendrimer is its particular affinity for copper (II) ions. This could be influential in selective heavy metal extraction, particularly in contaminated water. Our research aims to test the sequestration and selectivity of PAMAM dendrimers with amine surface groups for copper (II) ions in a chemical environment with interfering species, such as tap water, using Inductively Coupled Plasma spectroscopy. Ongoing research has involved developing methods for dendrimer extractions and creating calibration curves for standards to ensure accurate and reproducible results.

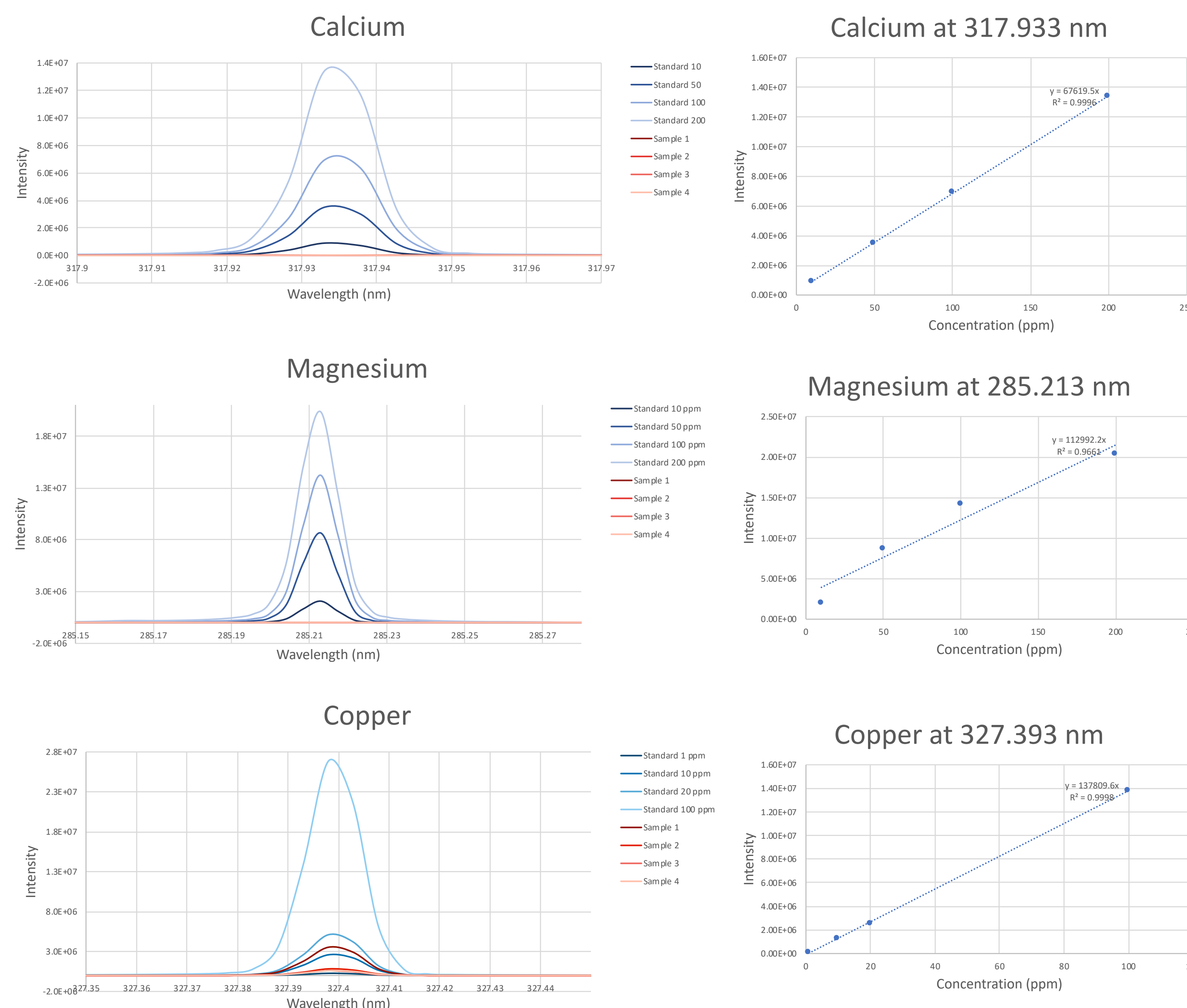
METHODOLOGY

Hard water refers to the amount of dissolved minerals in water. Berrien Springs has particularly hard tap water, and thus resulting in an ideal environment to test dendrimer sequestration. Standards solutions for calcium (Ca) and magnesium (Mg) (10, 50, 100, and 200 ppm) and copper (Cu) (1, 10, 20, 100 ppm) in 2% HNO₃ were created to imitate a tap water environment. Three drops of 0.25 M CuSO₄ prepared in deionized water was deposited into a small test tube, followed by three drops of PAMAM dendrimers. The mixture was allowed to react and separate into two layers, with the aqueous layer of excess copper on top and the dendrimers with captured atoms at the bottom. A pipette was used to extract the dendrimers, which were then weighed in a crucible and placed in an oven at 500° C for five hours. The remaining contents were dissolved in HNO₃ and run in the ICP.

Inductively coupled plasma optical emission spectrometry (ICP-OES) is used to analyze the standards and dendrimer samples. ICP-OES uses the high temperatures of argon plasma to break down compounds into their individual elemental particles. The electrons emit light of a certain wavelength specific to that element that is detected with a high-resolution spectrometer. The intensity of that light is directly proportional to the amount of element in that sample. A calibration curve can then be created using the known concentrations and measured intensity; thus the unknown concentrations of the samples can be determined by using the linear regression.

RESULTS

- Graphs of intensity vs. wavelength (left) represent the amount of that particular element at a range of wavelengths selected by the ICP-OES settings.
- The linear graphs (right) are of intensity vs. concentration in ppm of the standards. These are the calibration curves and are done at a peak wavelength specific to each element.
- The data was baselined with a standard 2% HNO₃ solution to set the background intensity to zero, which was subtracted off each spectrum's intensities.



- A linear regression was performed on the calibration curves and a regression equation was created using the slope and y-intercept.
- The correlation coefficient (R²) represents how close the linear regression matches the data points on a scale of 0 to 1.
- The table below compiles the element, peak wavelength, linear equation, and R² to be used to determine the concentrations of the unknown samples.

Element	Wavelength (nm)	Regression Equation	R ²
Ca	317.933	$y = 67619.5x$	0.9996
Mg	285.213	$y = 112992.2x$	0.9661
Cu	327.393	$y = 137809.7x$	0.9998

DISCUSSION

- The calibration curves had high R² values, which represents excellent linearity and reliable predicted sample concentrations.
- According to the calibration curve with the current method, there is such a low concentration of calcium and magnesium in the samples that the regression equation had to be forced through zero to get an approximate concentration. It makes sense that there should be a low concentration, because the CuSO₄ was made of DI water, which has all ions removed. Detection limits will have to altered to detect even smaller concentrations of the analytes for future samples.
- Nonetheless, the samples have a significant concentration of copper, confirming the dendrimer's affinity to copper atoms.
- Sample 1 has a higher concentration than the rest because of an error in the extraction with the dendrimer

	Ca (ppm)	Mg (ppm)	Cu (ppm)
Sample 1	0.755	0.206	12.87
Sample 2	0.570	0.123	3.020
Sample 3	0.609	0.128	2.468
Sample 4	0.722	0.153	2.157

- Future work will involve continuing the same procedure with a CuSO₄ solution made with tap water, as well as spiking another CuSO₄ solution with excess calcium and magnesium atoms to introduce an environment with interfering ions. This will assist in proving that these dendrimers will only capture copper, which can be used in future water purification and heavy metal extraction materials.

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