



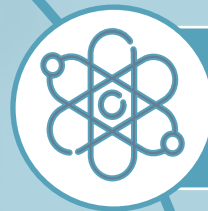
Nano4Green

Beatriz Carneiro | Beatriz Santos | Mariana Reis
Agrupamento de Escolas da Maia
Viana do Castelo 13-17 July 2020

When working in partnership with the Faculty of Sciences of the University of Porto, we used the Project-based learning (PBL) methodology to develop a project to remove heavy metal ions from contaminated water, through magnetic separation.

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Introduction



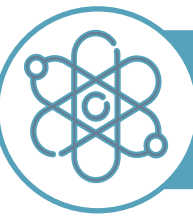
Materials and methods



Results and discussions



Bibliographic references



Introduction

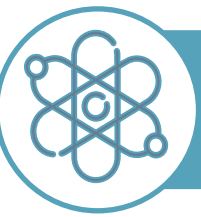
Periodic Table of the Elements

Atomic Number
 Symbol
 Name
 Atomic Mass

Atomic mass values reflect the IUPAC accepted values as of 09/2013.
 Masses expressed in [a,b] format show the lower and upper limit of atomic mass depending on the physical and chemical history of the element.
 Masses expressed in <-> format are the mass numbers of the longest-lived isotope for elements with no stable nucleus.

																		13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A																							
1 IA 1A																							2 He Helium 4.002602(2)																							
1 H Hydrogen [1.00784;1.00811]			2 IIA 2A																	5 B Boron [10.806;10.821]	6 C Carbon [12.0096;12.0116]	7 N Nitrogen [14.00643;14.00728]	8 O Oxygen [15.99903;15.99977]	9 F Fluorine [18.998403163(6)]	10 Ne Neon 20.1797(6)																					
3 Li Lithium [6.938;6.997]	4 Be Beryllium 9.0121831(5)																	11 Na Sodium 22.98976928(2)	12 Mg Magnesium [24.304;24.307]																	13 Al Aluminum 26.9815386(8)	14 Si Silicon [28.084;28.086]	15 P Phosphorus 30.973761998(5)	16 S Sulfur [32.059;32.076]	17 Cl Chlorine [35.446;35.457]	18 Ar Argon 39.948(1)					
																		3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 VIII 8		9 VIII 9		10 VIII 10		11 IB 1B	12 IIB 2B																
19 K Potassium 39.0983(1)	20 Ca Calcium 40.078(4)	21 Sc Scandium 44.955908(5)	22 Ti Titanium 47.867(1)	23 V Vanadium 50.9415(1)	24 Cr Chromium 51.9961(6)	25 Mn Manganese 54.938045(5)	26 Fe Iron 55.845(2)	27 Co Cobalt 58.933194(4)	28 Ni Nickel 58.6934(4)	29 Cu Copper 63.546(3)	30 Zn Zinc 65.38(2)	31 Ga Gallium 69.723(1)	32 Ge Germanium 72.630(8)	33 As Arsenic 74.921595(6)	34 Se Selenium 78.971(8)	35 Br Bromine [79.901;79.907]	36 Kr Krypton 83.798(2)																													
37 Rb Rubidium 85.4678(3)	38 Sr Strontium 87.62(1)	39 Y Yttrium 88.90584(2)	40 Zr Zirconium 91.224(2)	41 Nb Niobium 92.90637(2)	42 Mo Molybdenum 95.95(1)	43 Tc Technetium <98>	44 Ru Ruthenium 101.07(2)	45 Rh Rhodium 102.90550(2)	46 Pd Palladium 106.42(1)	47 Ag Silver 107.8682(2)	48 Cd Cadmium 112.414(4)	49 In Indium 114.818(1)	50 Sn Tin 118.710(7)	51 Sb Antimony 121.760(1)	52 Te Tellurium 127.60(3)	53 I Iodine 126.90447(3)	54 Xe Xenon 131.293(6)																													
55 Cs Cesium 132.90545196(6)	56 Ba Barium 137.327(7)	57-71		72 Hf Hafnium 178.49(2)	73 Ta Tantalum 180.94788(2)	74 W Tungsten 183.84(1)	75 Re Rhenium 186.207(1)	76 Os Osmium 190.23(3)	77 Ir Iridium 192.217(3)	78 Pt Platinum 195.084(6)	79 Au Gold 196.966569(5)	80 Hg Mercury 200.592(3)	81 Tl Thallium [204.382;204.385]	82 Pb Lead 207.2(1)	83 Bi Bismuth 208.98040(1)	84 Po Polonium <209>	85 At Astatine <210>	86 Rn Radon <222>																												
87 Fr Francium <223>	88 Ra Radium <226>	89-103		104 Rf Rutherfordium <261>	105 Db Dubnium <268>	106 Sg Seaborgium <271>	107 Bh Bohrium <272>	108 Hs Hassium <270>	109 Mt Meitnerium <276>	110 Ds Darmstadtium <281>	111 Rg Roentgenium <280>	112 Cn Copernicium <285>	113 Uut Ununtrium unknown	114 Fl Flerovium <289>	115 Uup Ununpentium unknown	116 Lv Livermorium <293>	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown																												
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Figure 1: Heavy metals in the periodic table



Introduction

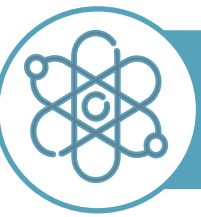
Heavy metals	Recommended Daily Intakes (adult) (per day)	
	Woman	Man
Vanadium (V)	0,010*	
Chromium (Cr)	0,025*	
Molybdenum (Mo)	0,050 - 0,4*	
Selenium (Se)	0,060**	0,075**
Zinc (Zn)	7,0 **	9,5**
Manganese (Mn)	4,6*	
Copper (Cu)	1,2**	

* - The intake is not correctly defined

** - depends on the person's age

Table 1: Recommended daily intakes of heavy metals

Heavy metals	Recommended Daily Intakes (adult) (per day)
Strontium (Sr)	-
Nickel (Ni)	-
Cobalt (Co)	-
Cadmium (Cd)	-
Mercury (Hg)	-
Thallium (Tl)	-
Lead (Pb)	-
Tin (Sn)	-
Antimony (Sb)	-
Tellurium (Te)	-
Arsenic (As)	-



Introduction

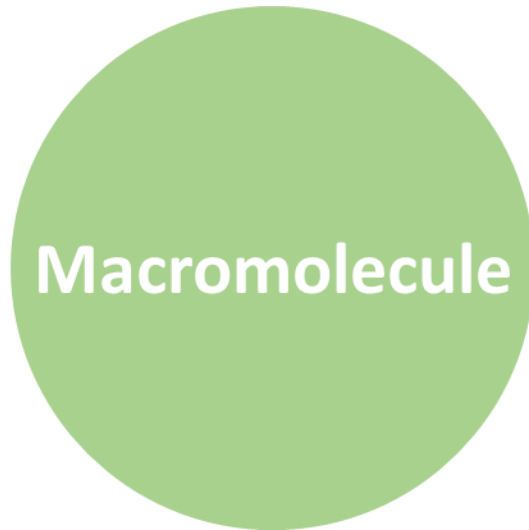
Separation by
filtration
membrane

Biosorption

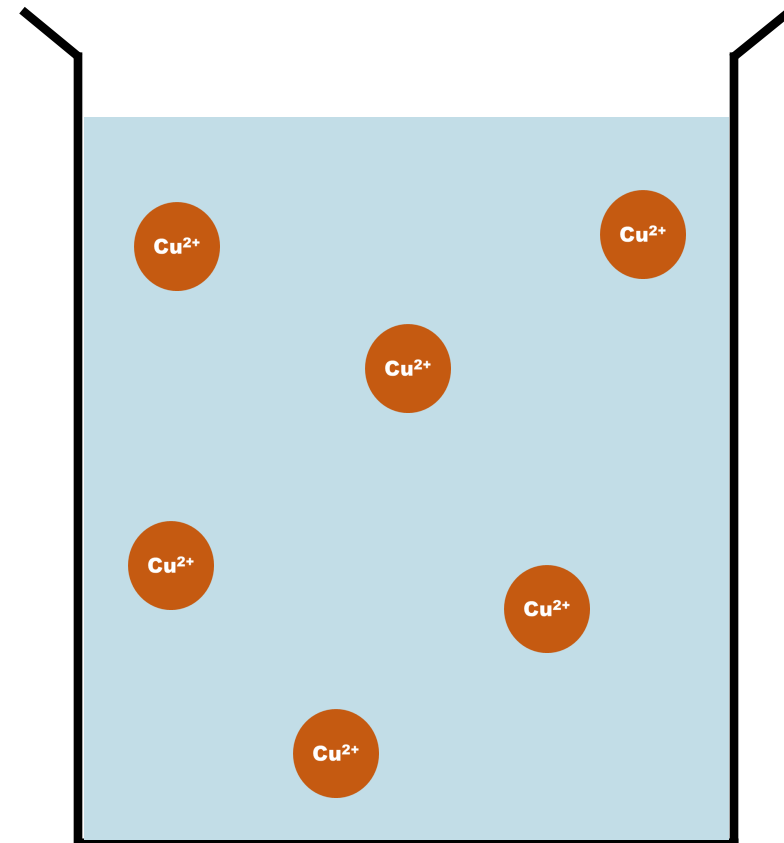
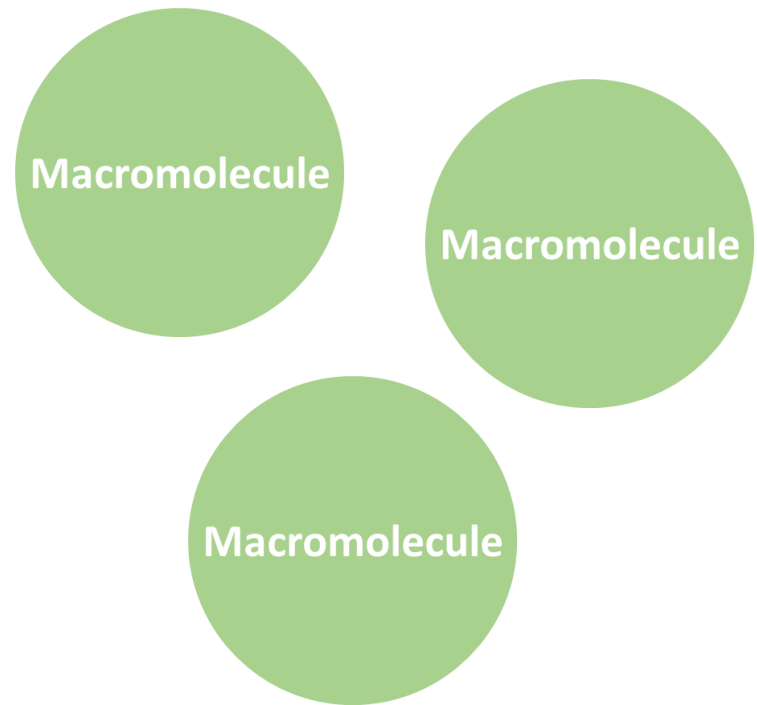
Chemical
precipitation

Adsorption

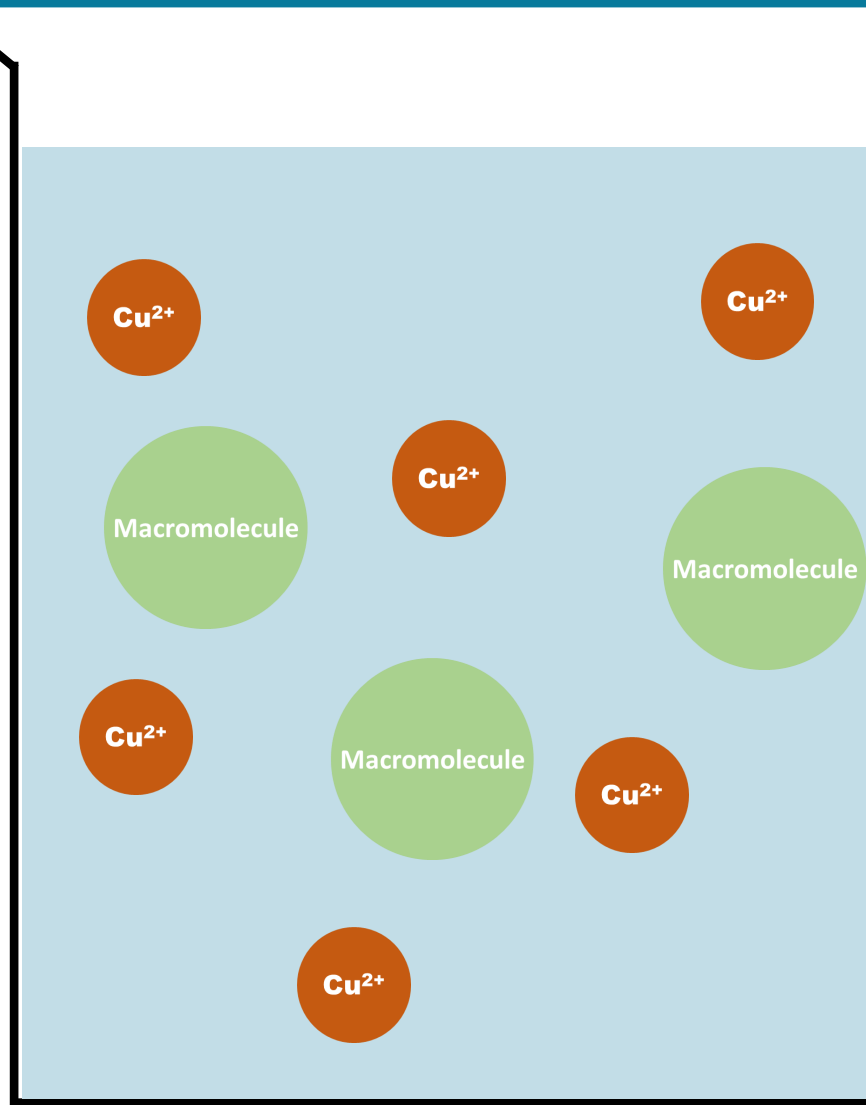
Separation by filtration membrane



Separation by filtration membrane



Separation by filtration membrane



Macromolecule

Cu^{2+}

Cu^{2+}

Cu^{2+}

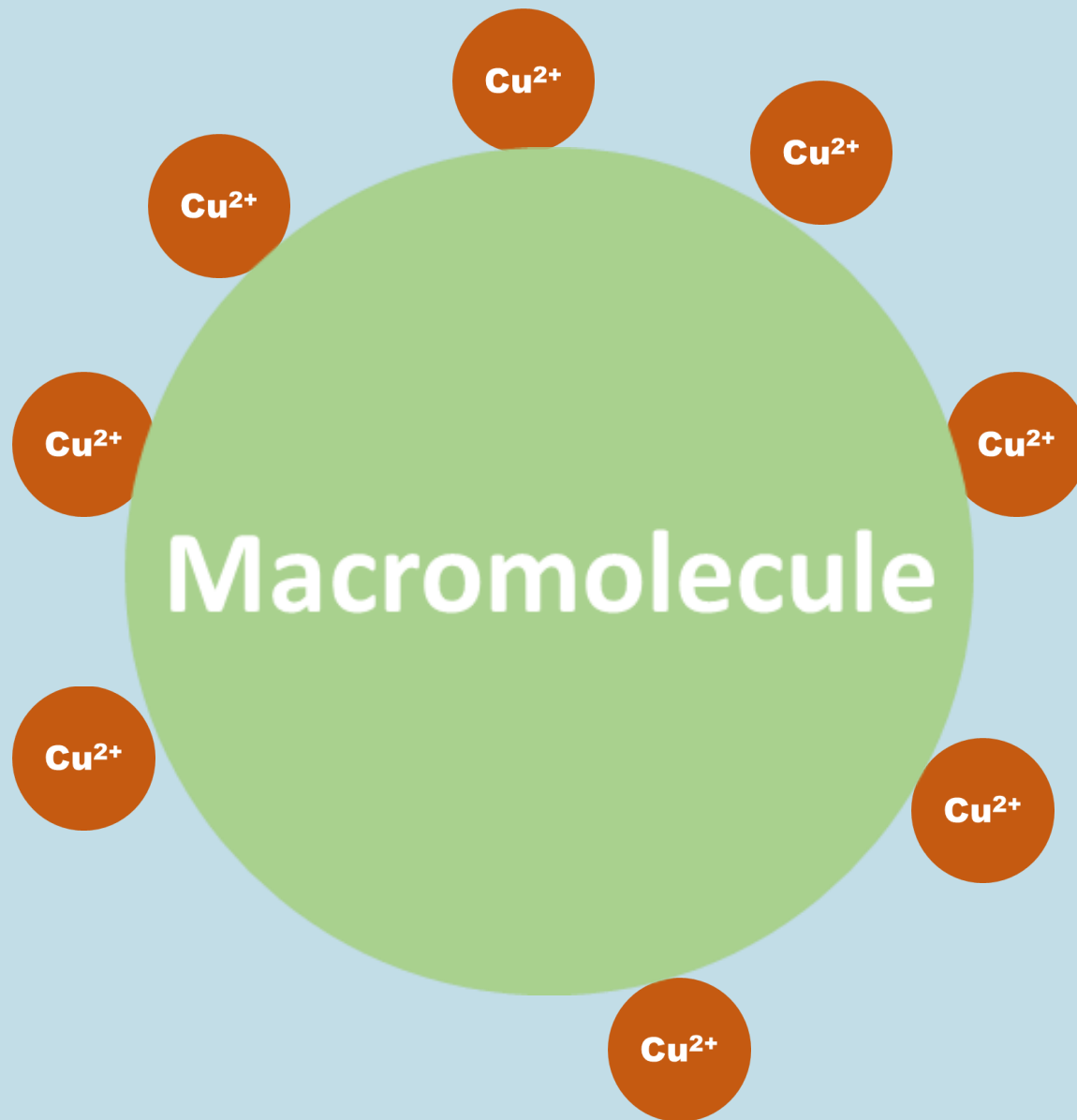
Cu^{2+}

Cu^{2+}

Cu^{2+}

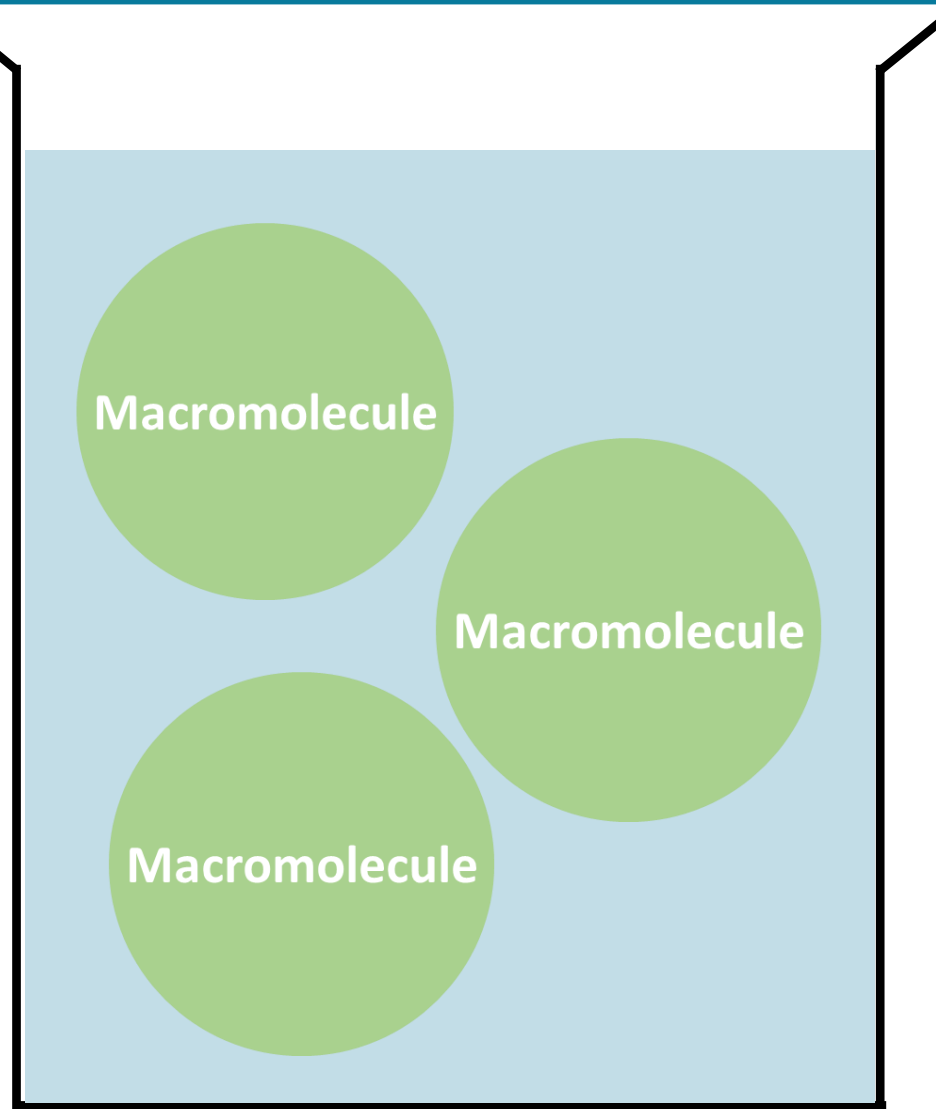
Cu^{2+}

Cu^{2+}

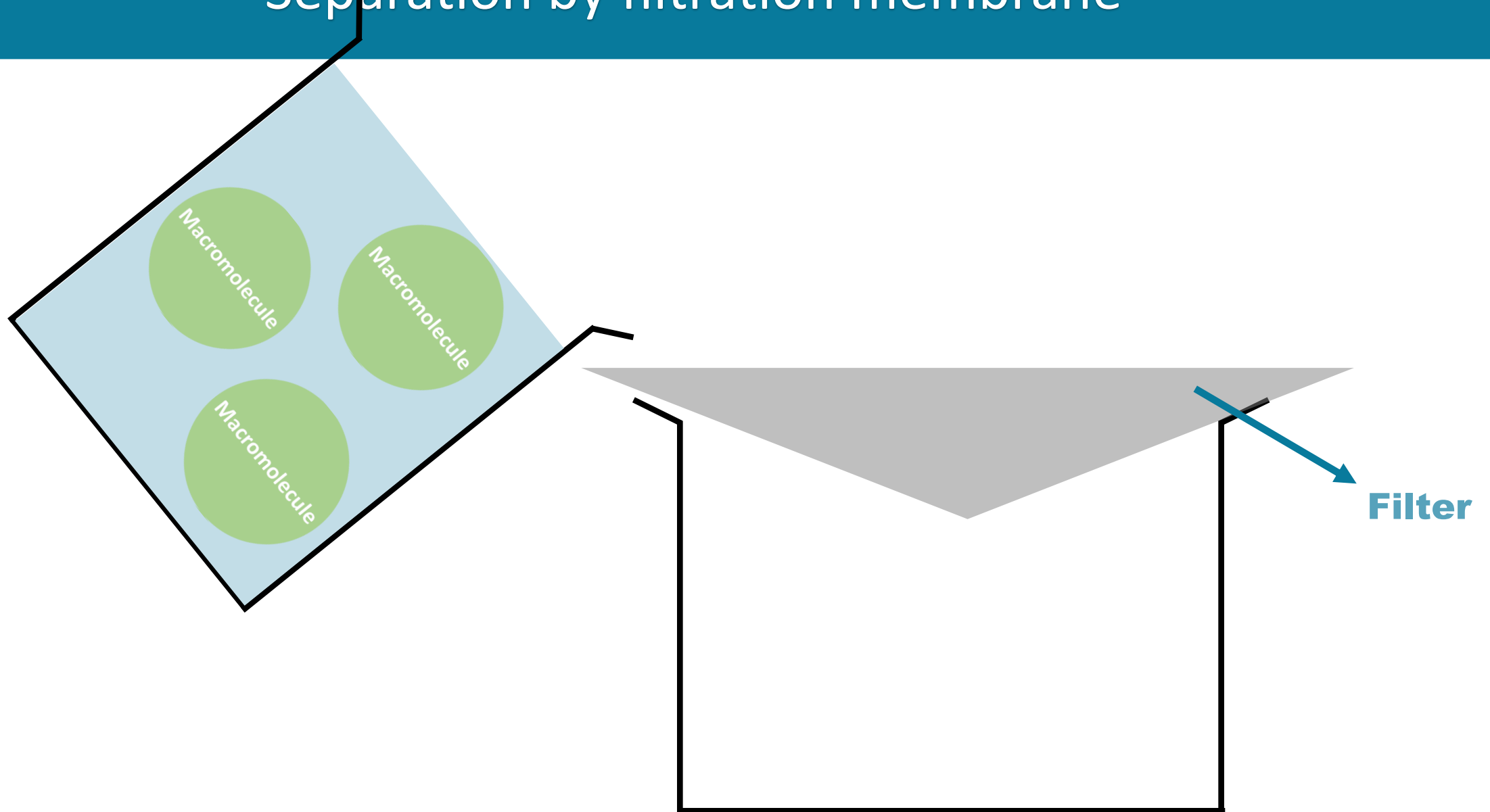


Macromolecule

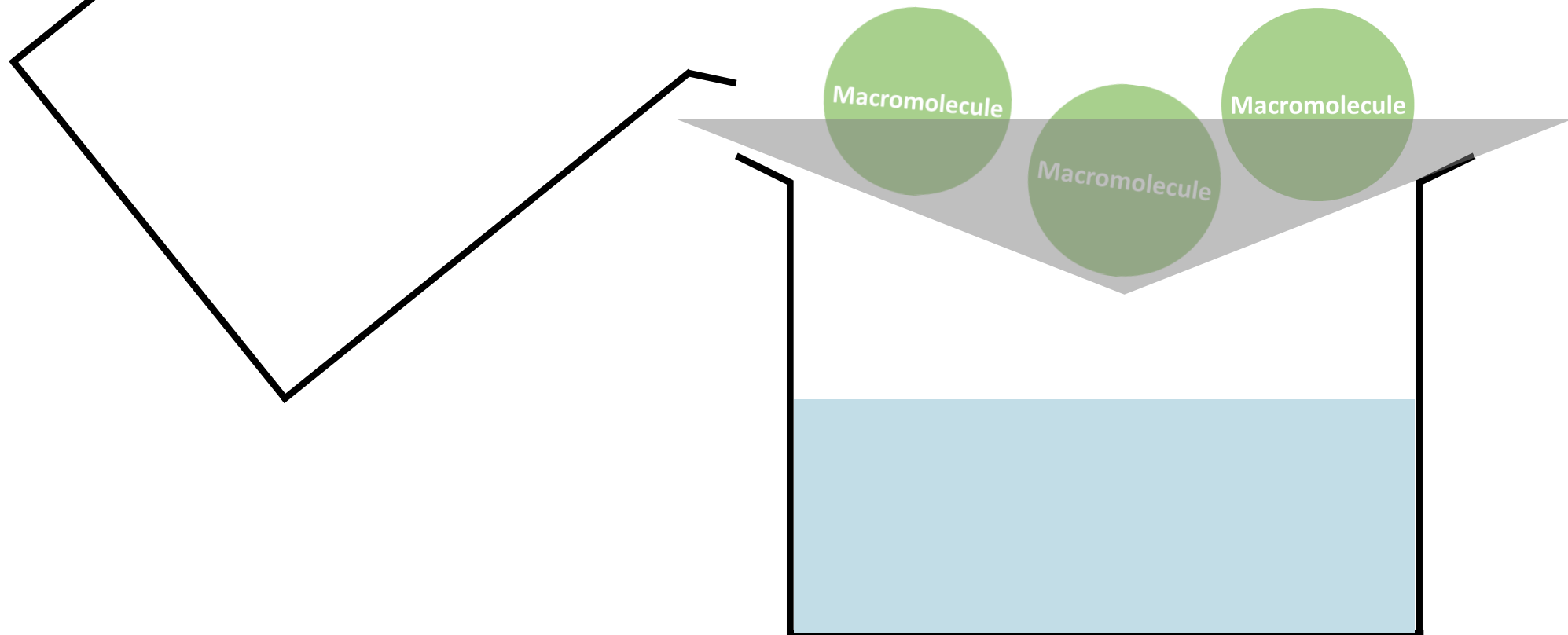
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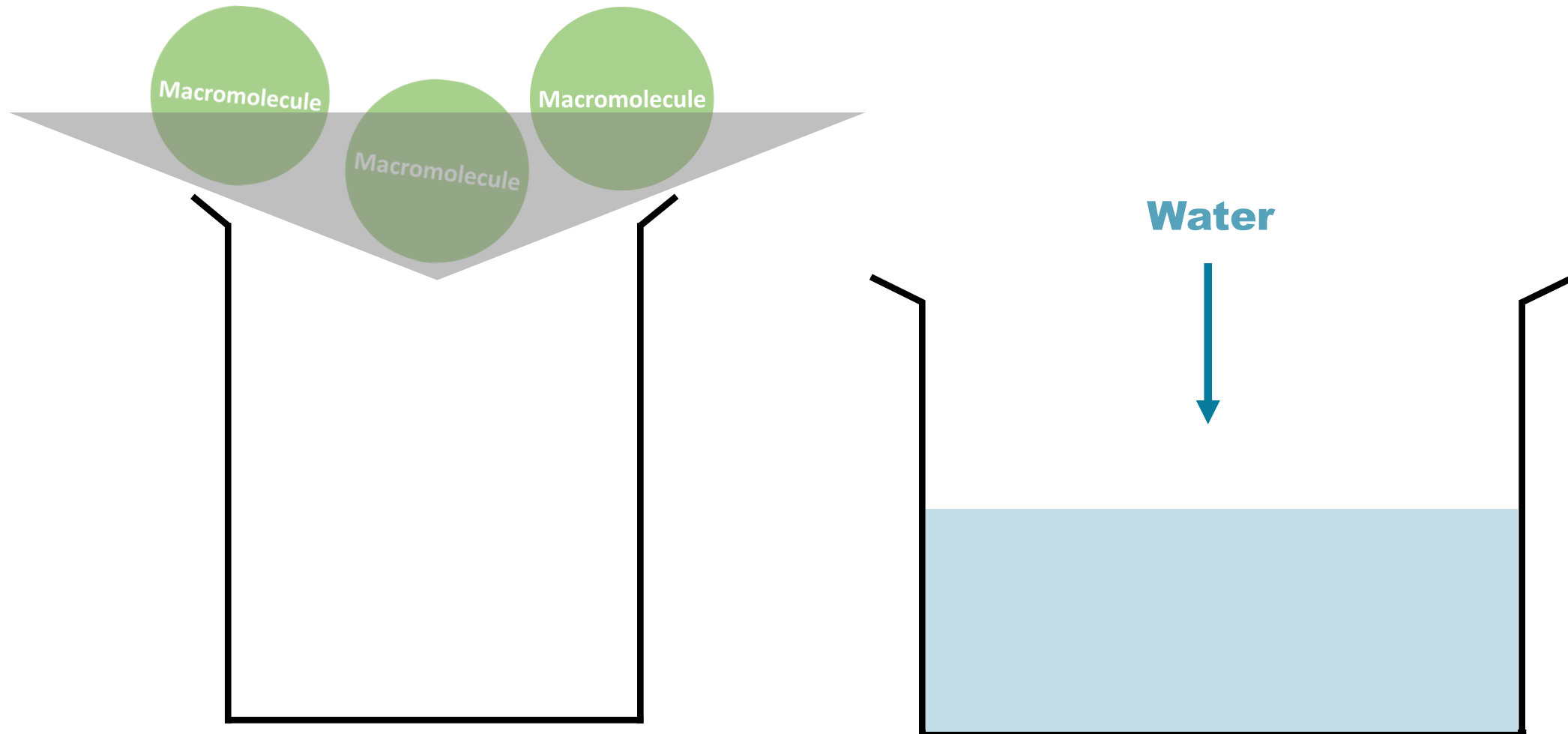
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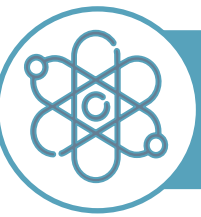


Separation by filtration membrane



Separation by filtration membrane





Introduction

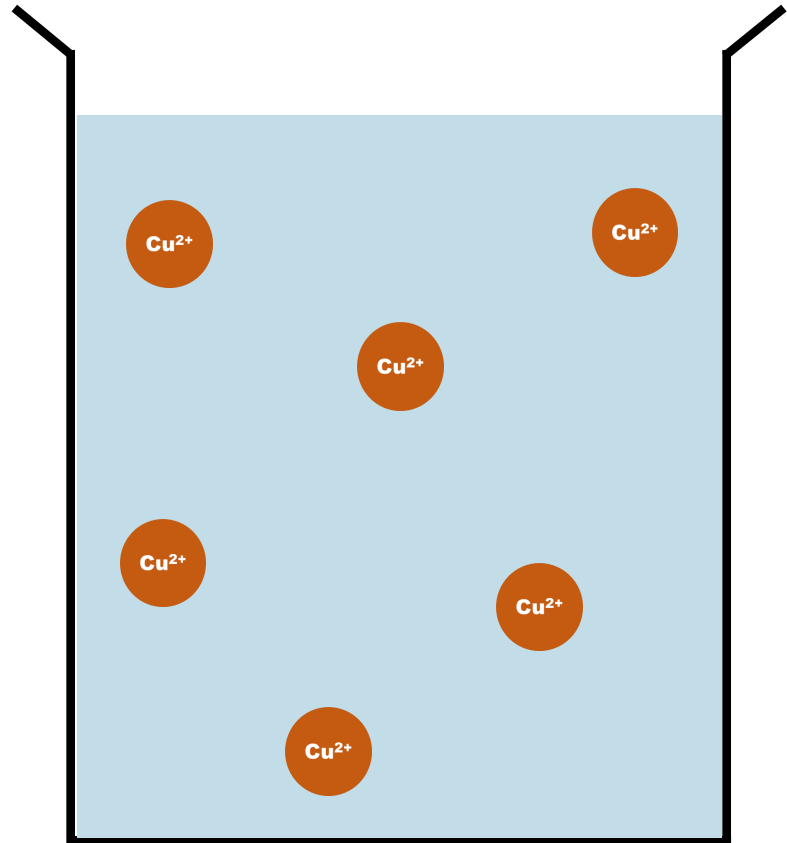
Separation by
filtration
membrane

Biosorption

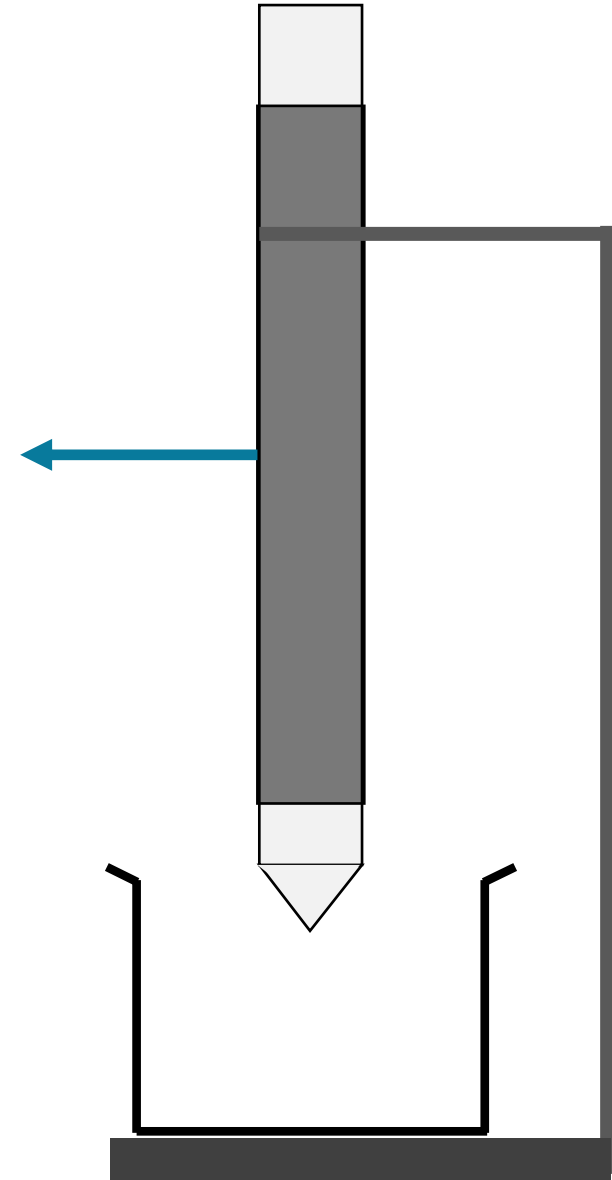
Chemical
precipitation

Adsorption

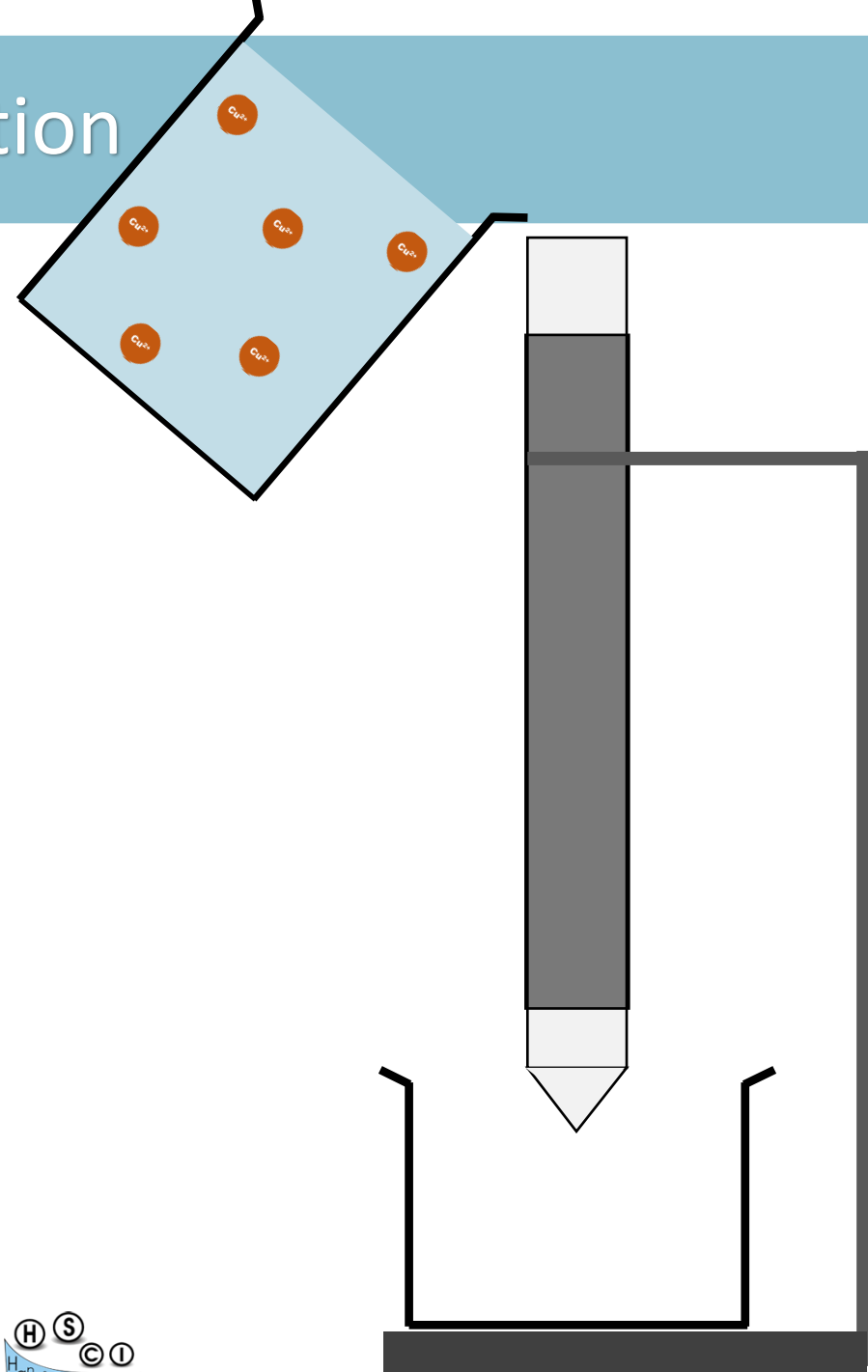
Biosorption



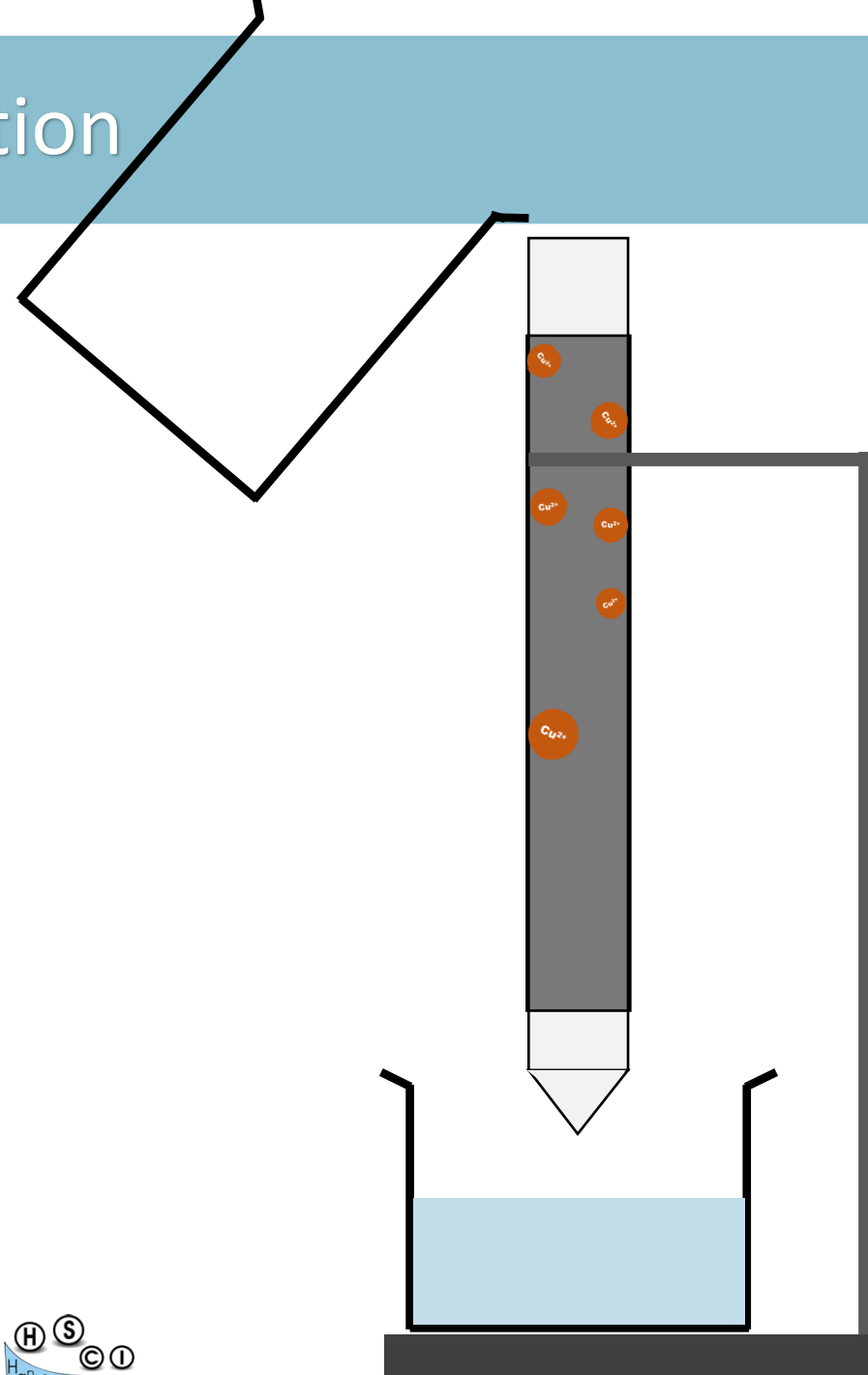
Biomass or biomolecule



Biosorption

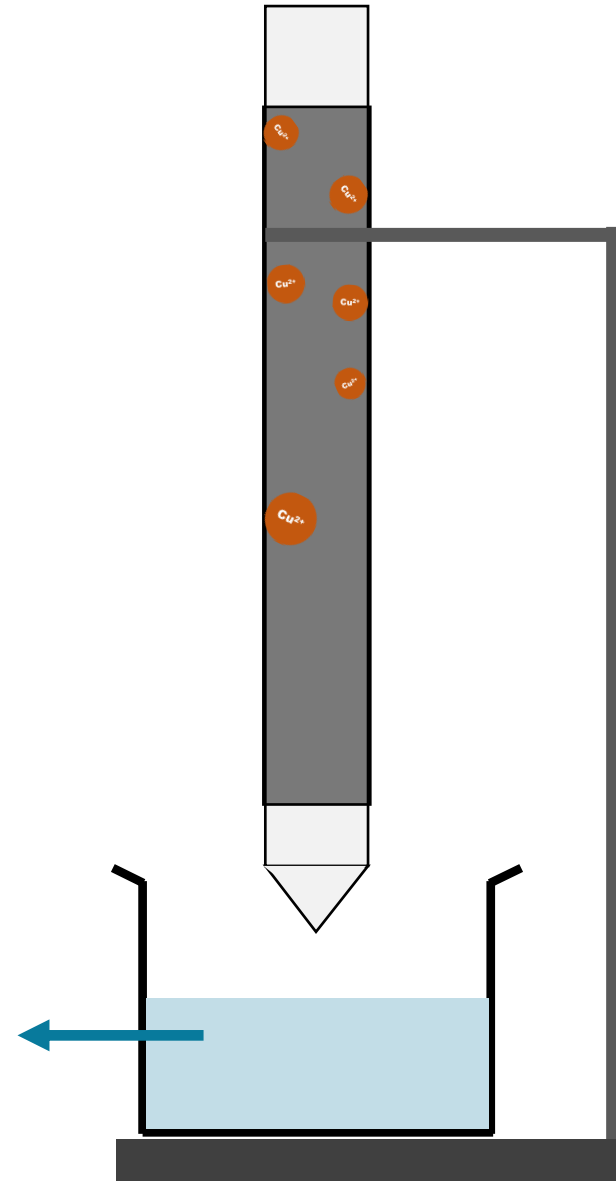


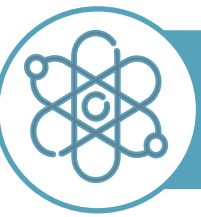
Biosorption



Biosorption

Water





Introduction

Separation by
filtration
membrane

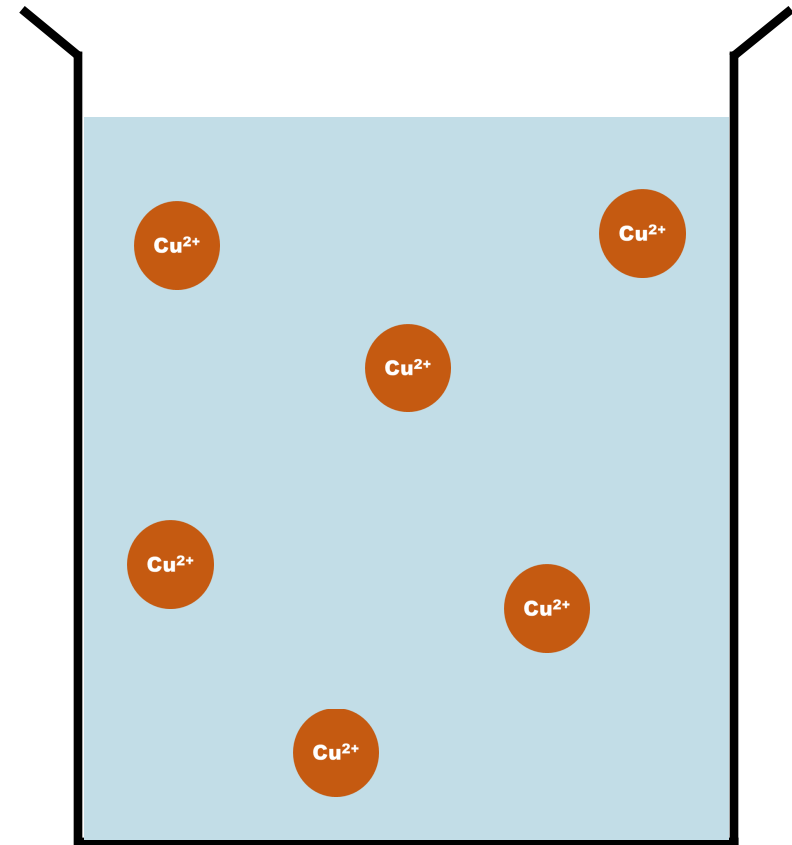
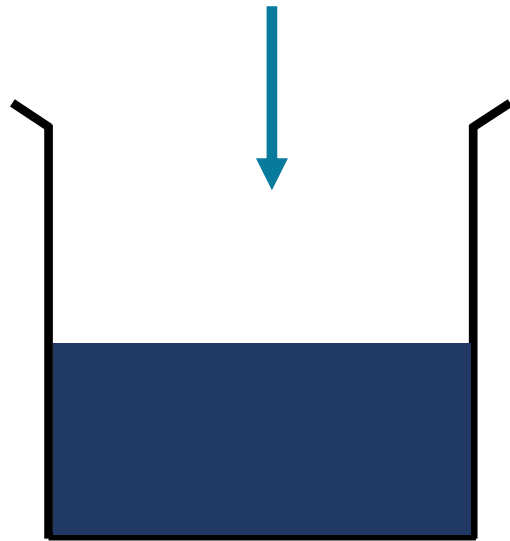
Biosorption

Chemical
precipitation

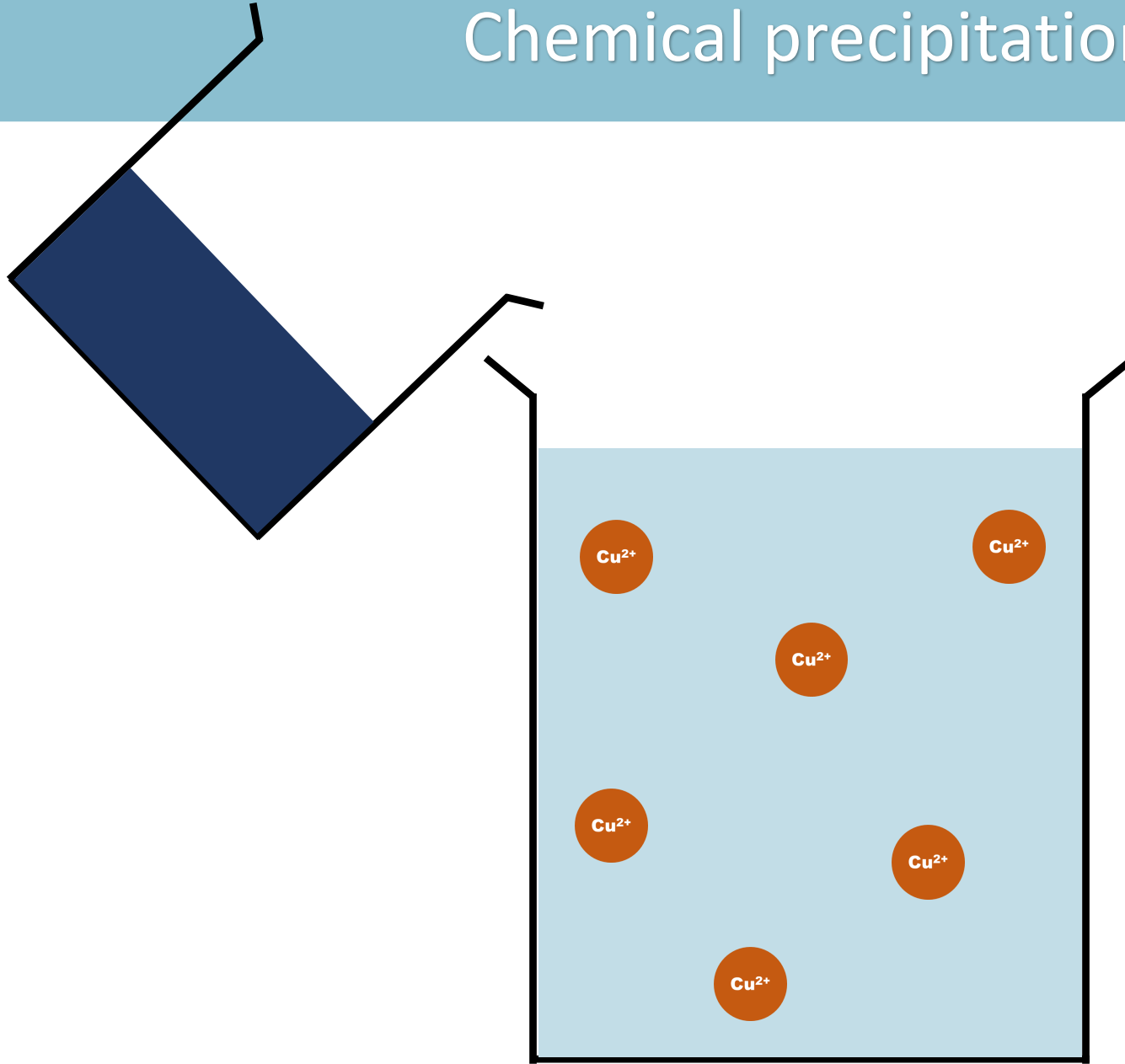
Adsorption

Chemical precipitation

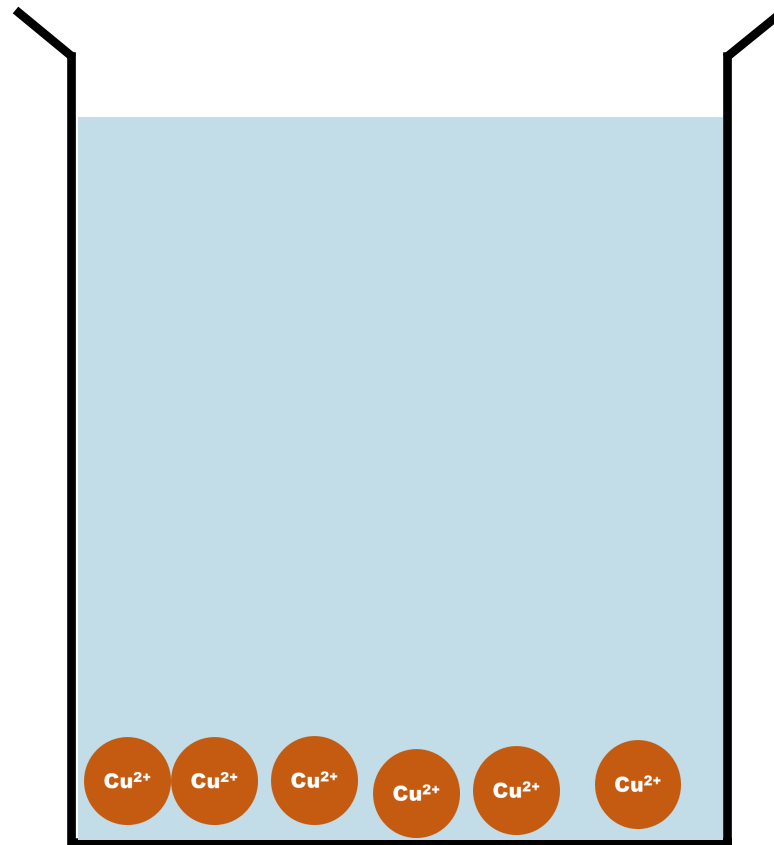
precipitation agent



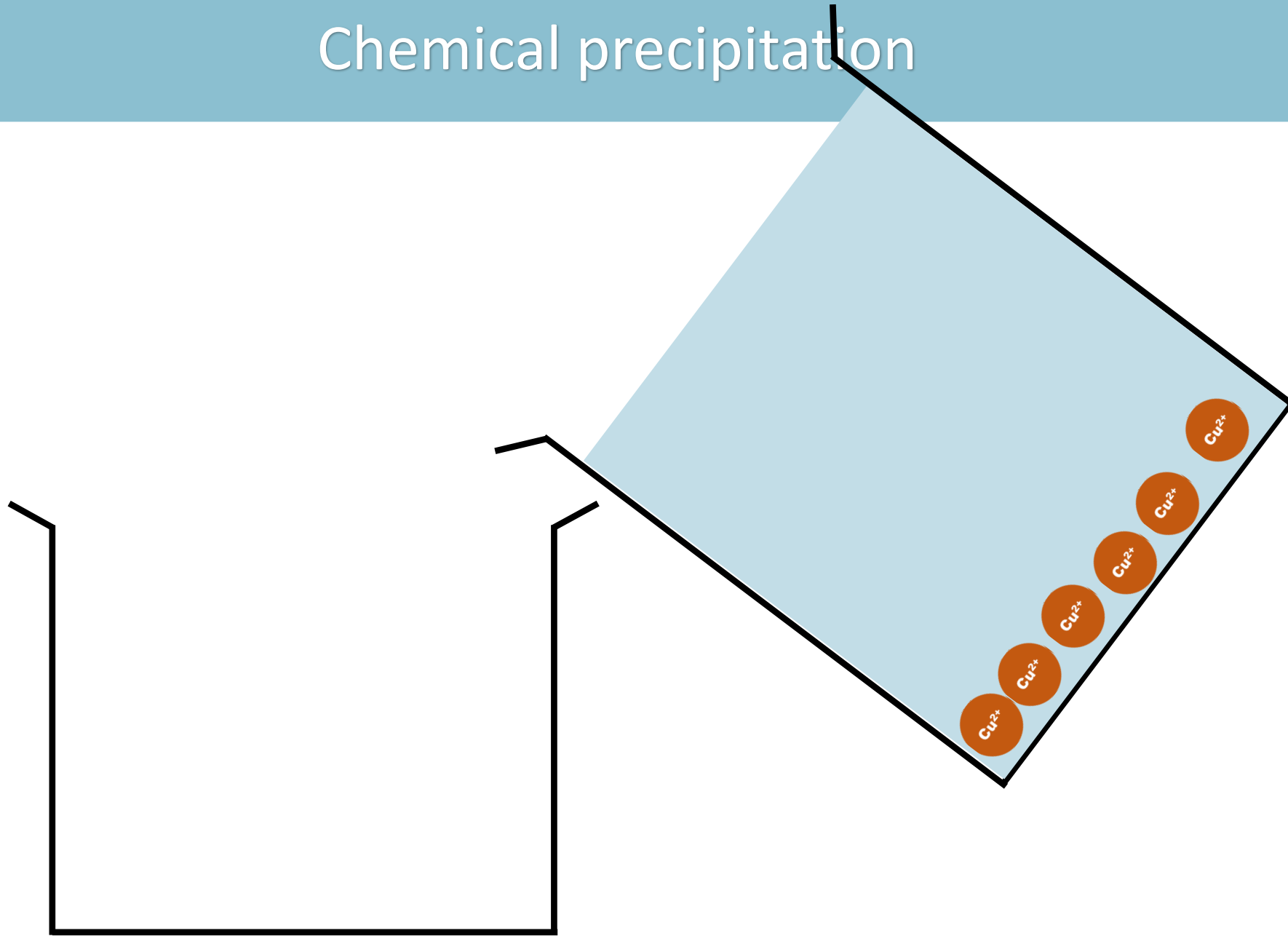
Chemical precipitation



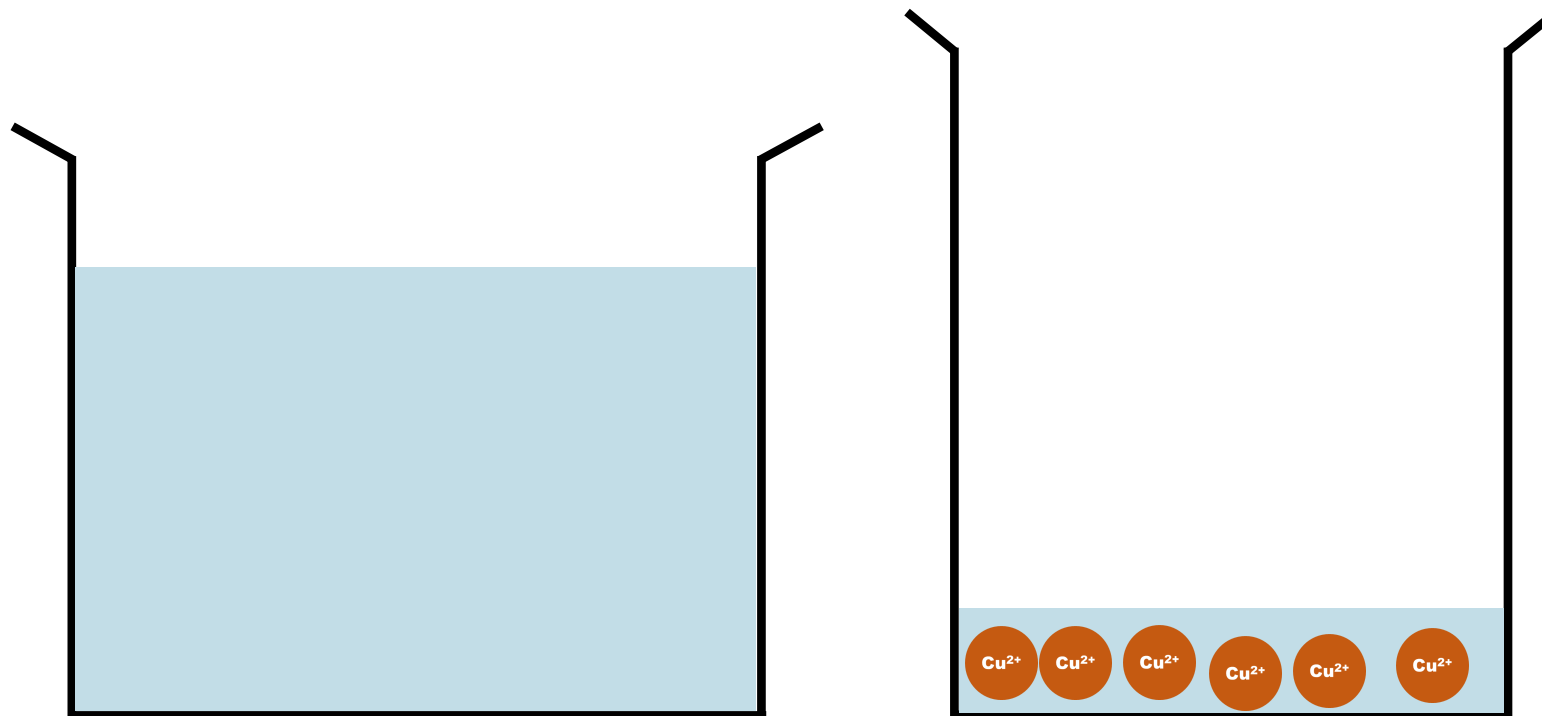
Chemical precipitation

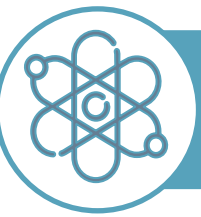


Chemical precipitation



Chemical precipitation





Introduction

Separation by
filtration
membrane

Biosorption

Chemical
precipitation

Adsorption

Adsorption

Absorption

Absorption is a condition in which something takes in another substance. The absorbed substance infiltrates the absorbing substance



A sponge absorbs water, increasing in size when it is full, and the water comes out easily when the sponge is squeezed

vs

Adsorption

Adsorption is a process in which a material (adsorbate) travels from a gas or liquid phase and forms a superficial monomolecular layer on a solid or liquid condensed phase (substrate). This can occur because of physical forces or by chemical bonds.

Doesn't happen in adsorption

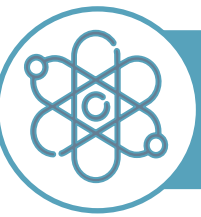


Adsorption



Adsorbent - Coal
Adsorbed - Water solution with dye

Video 1: Demonstration of the adsorption process



Introduction

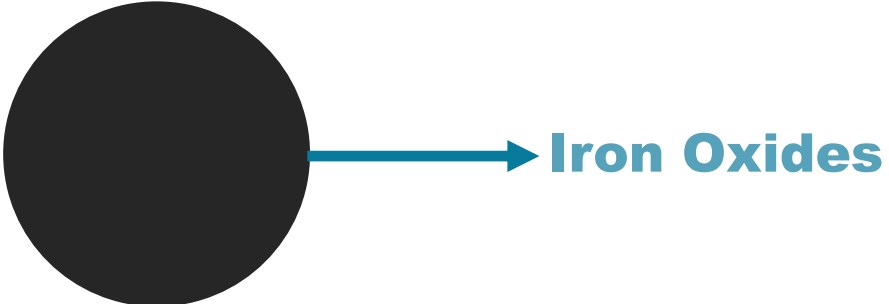
Separation by
filtration
membrane

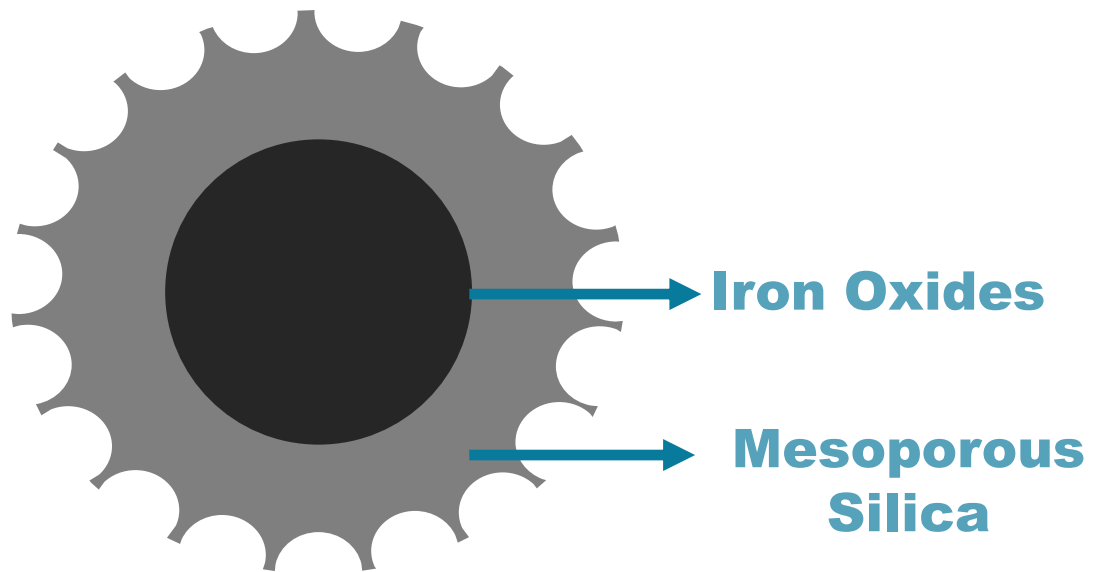
Biosorption

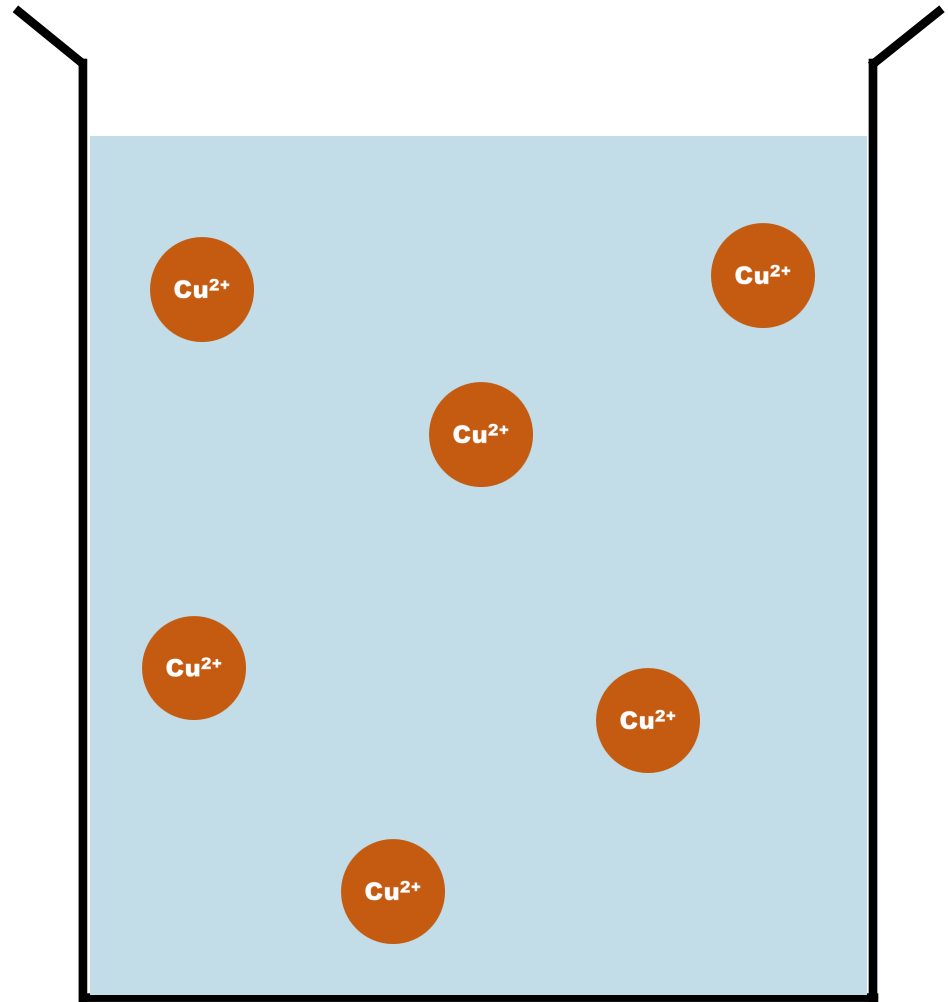
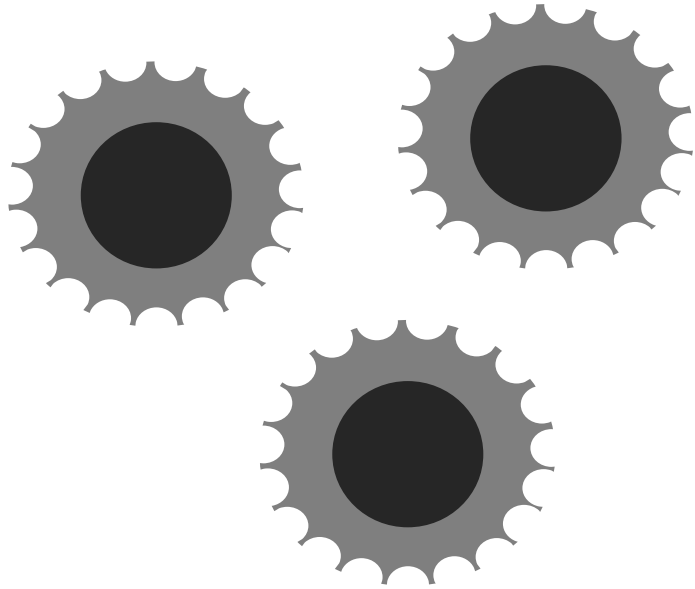
Chemical
precipitation

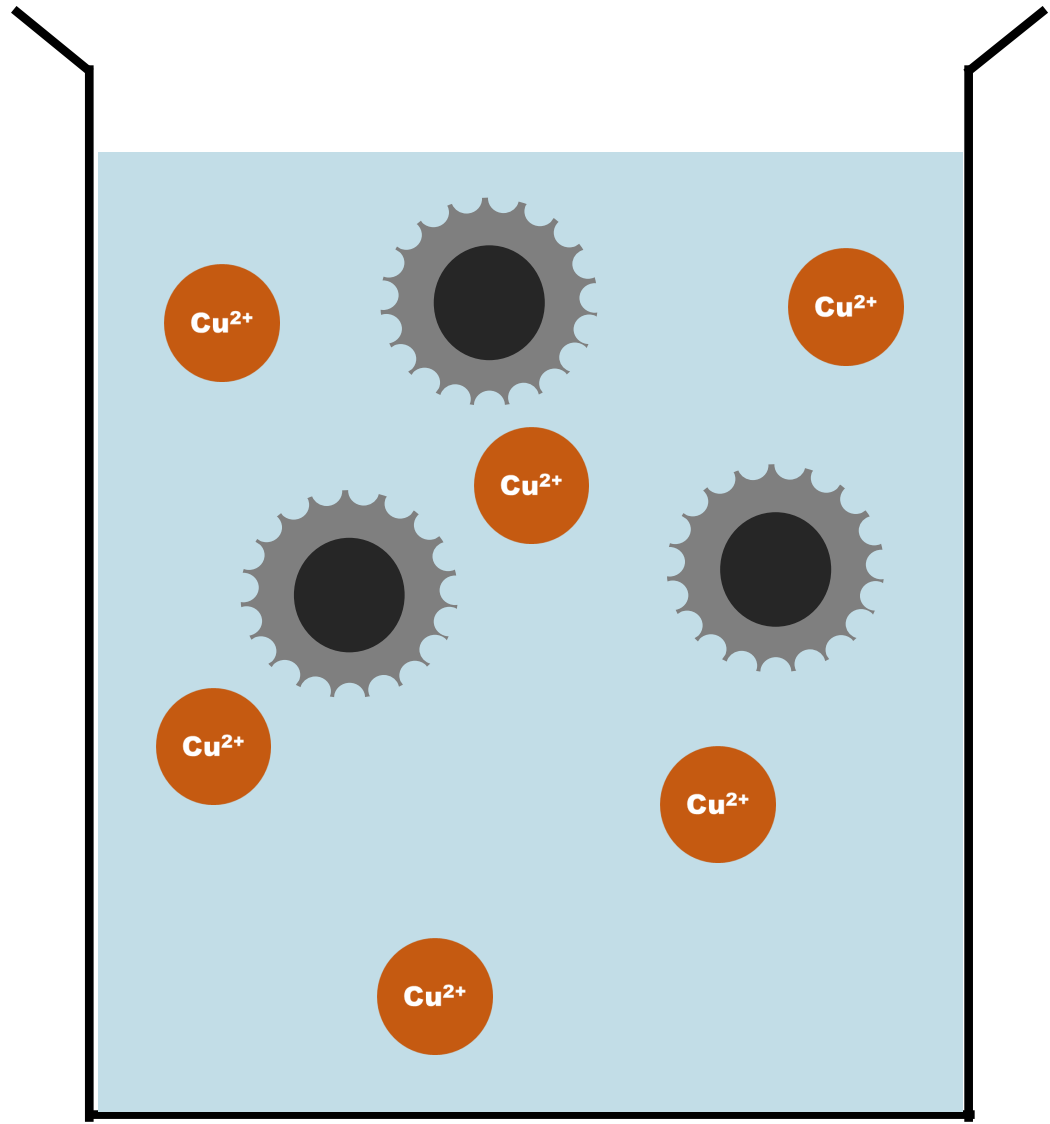
Adsorption

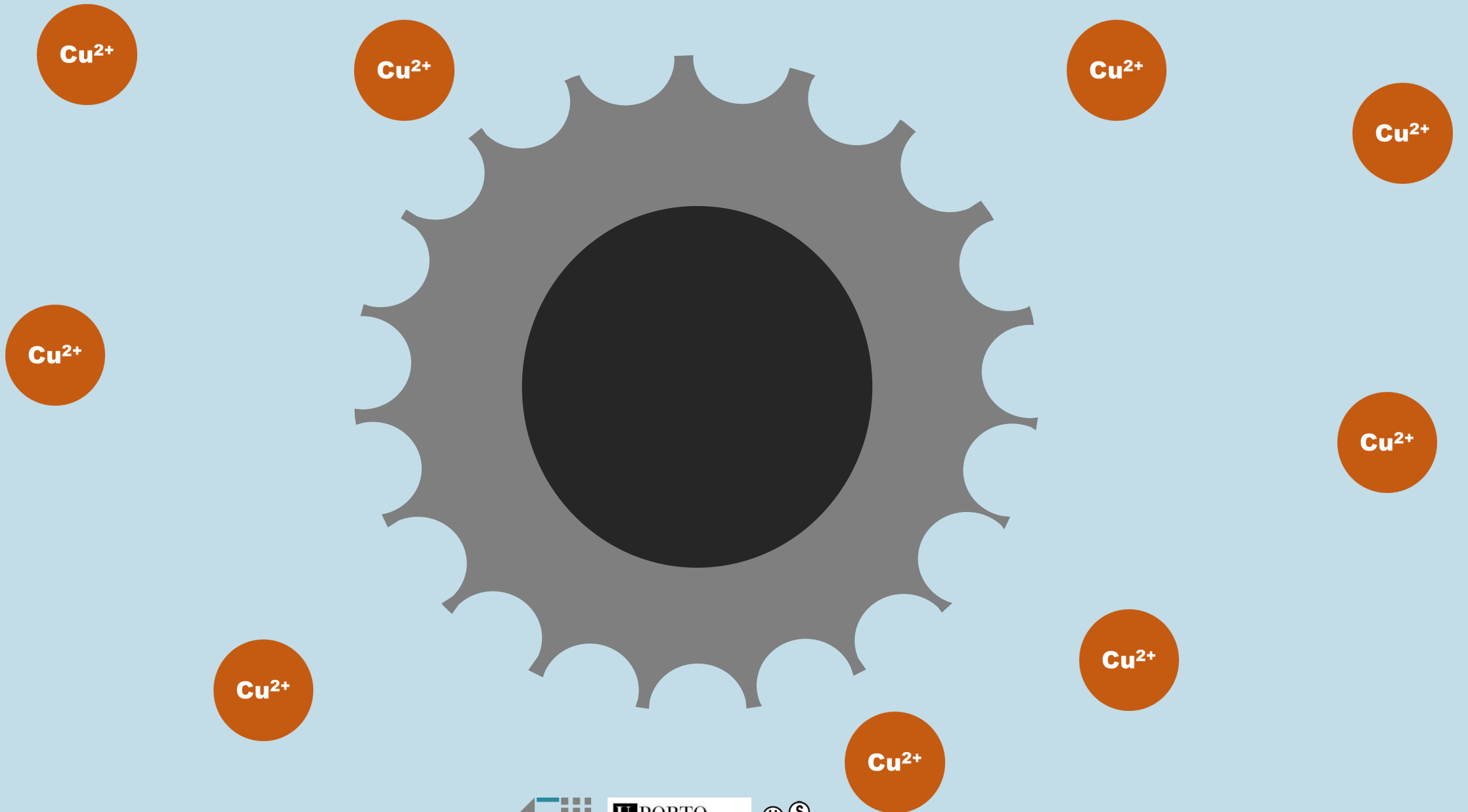
In what consists our project?

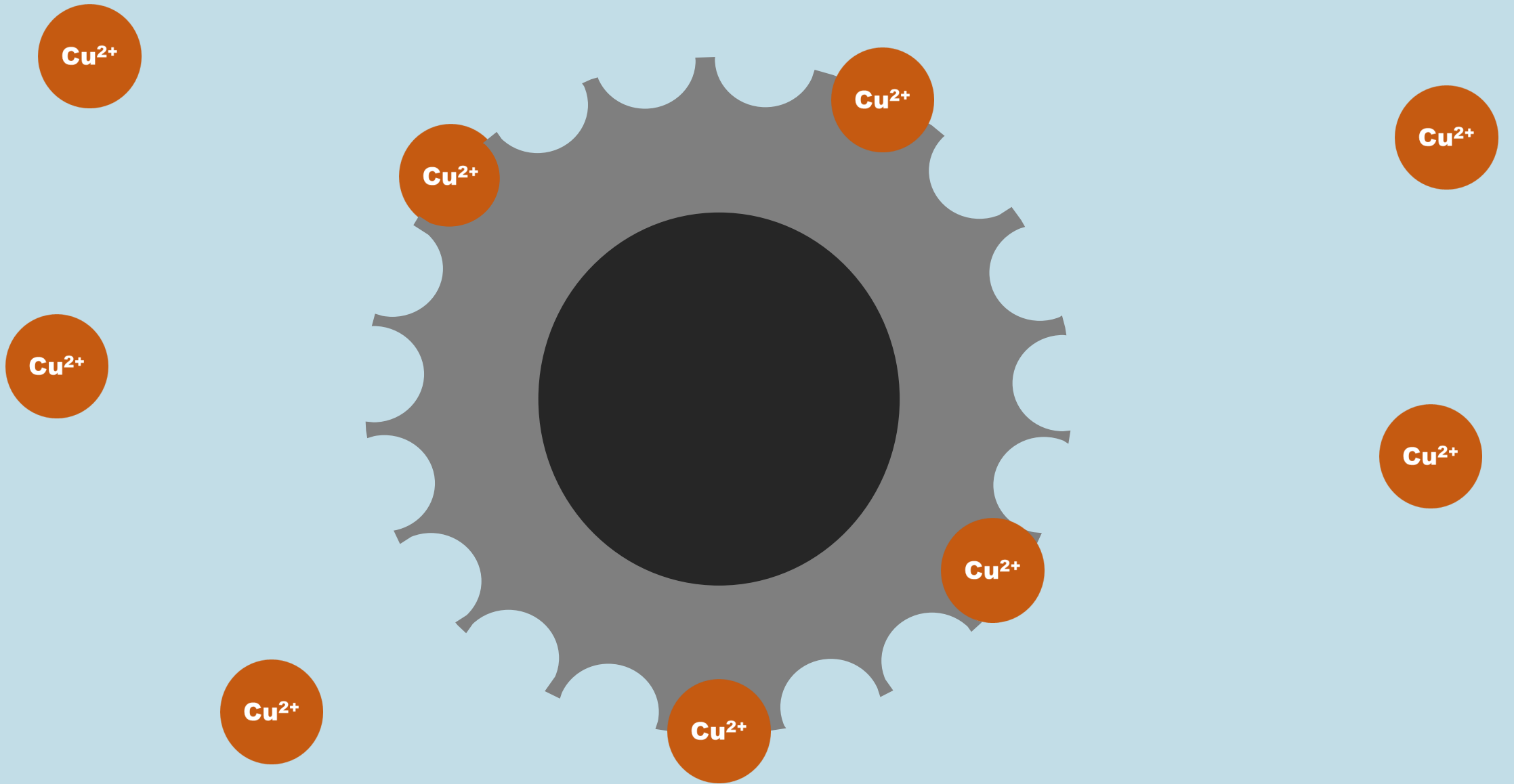


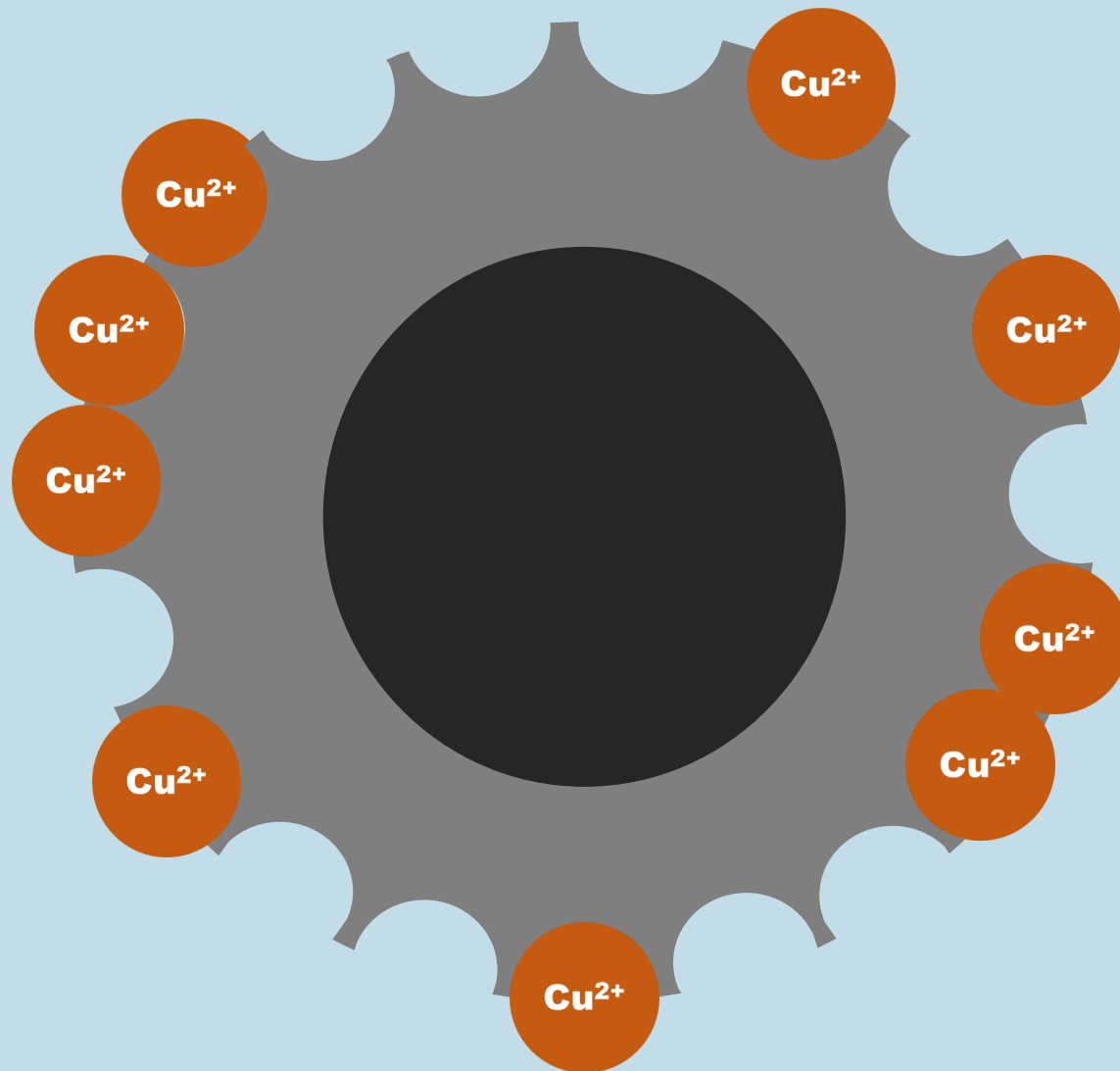


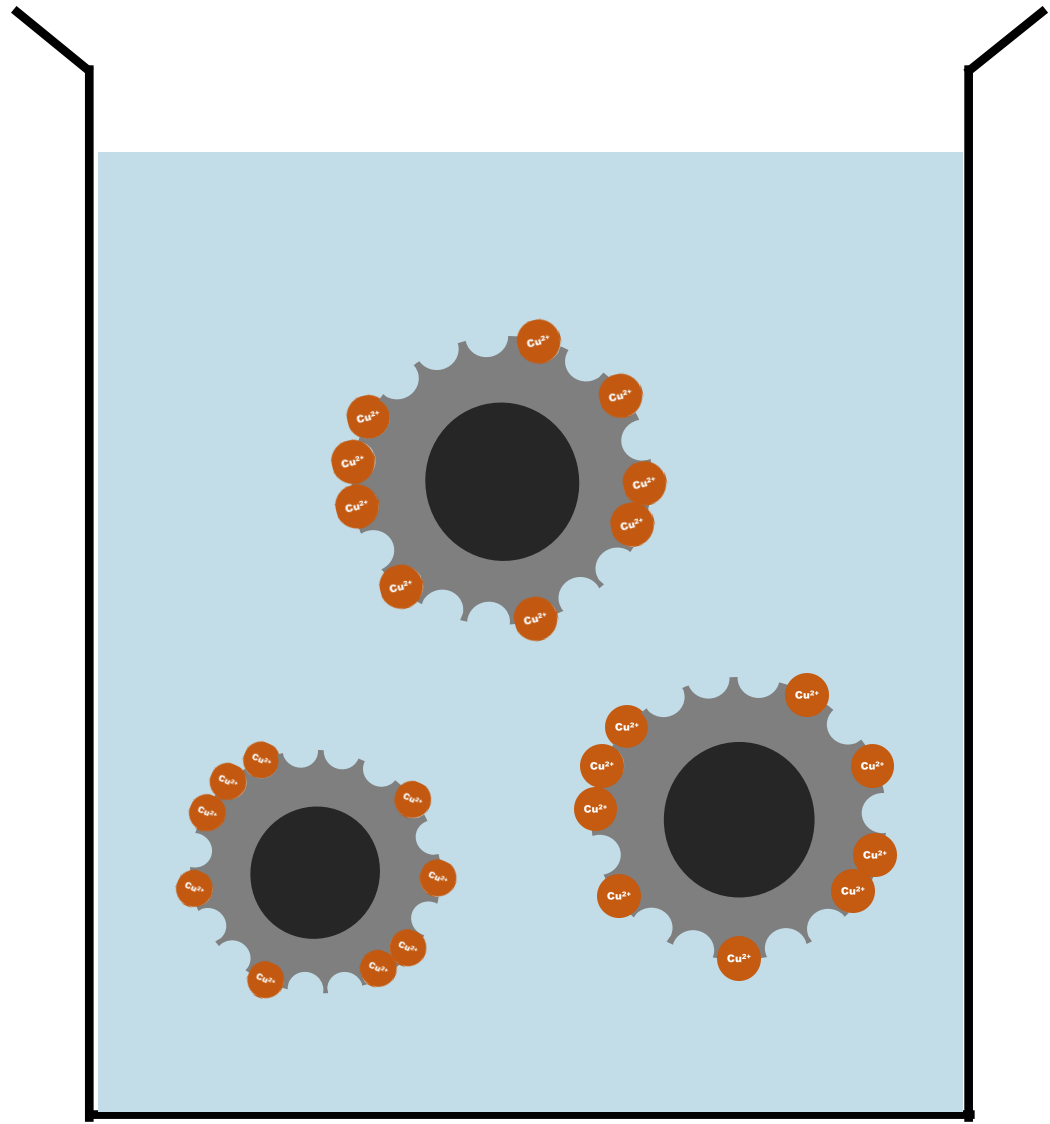


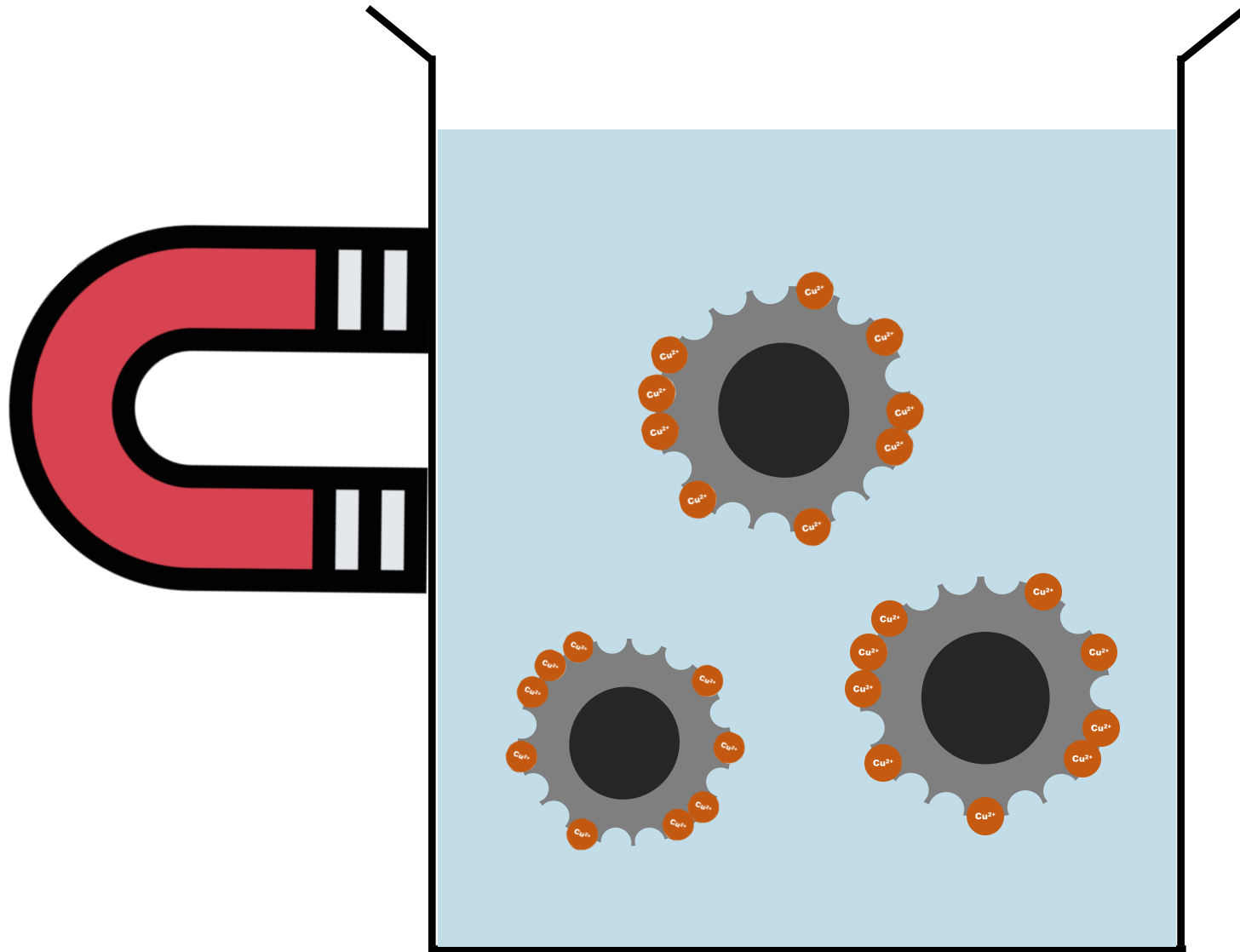


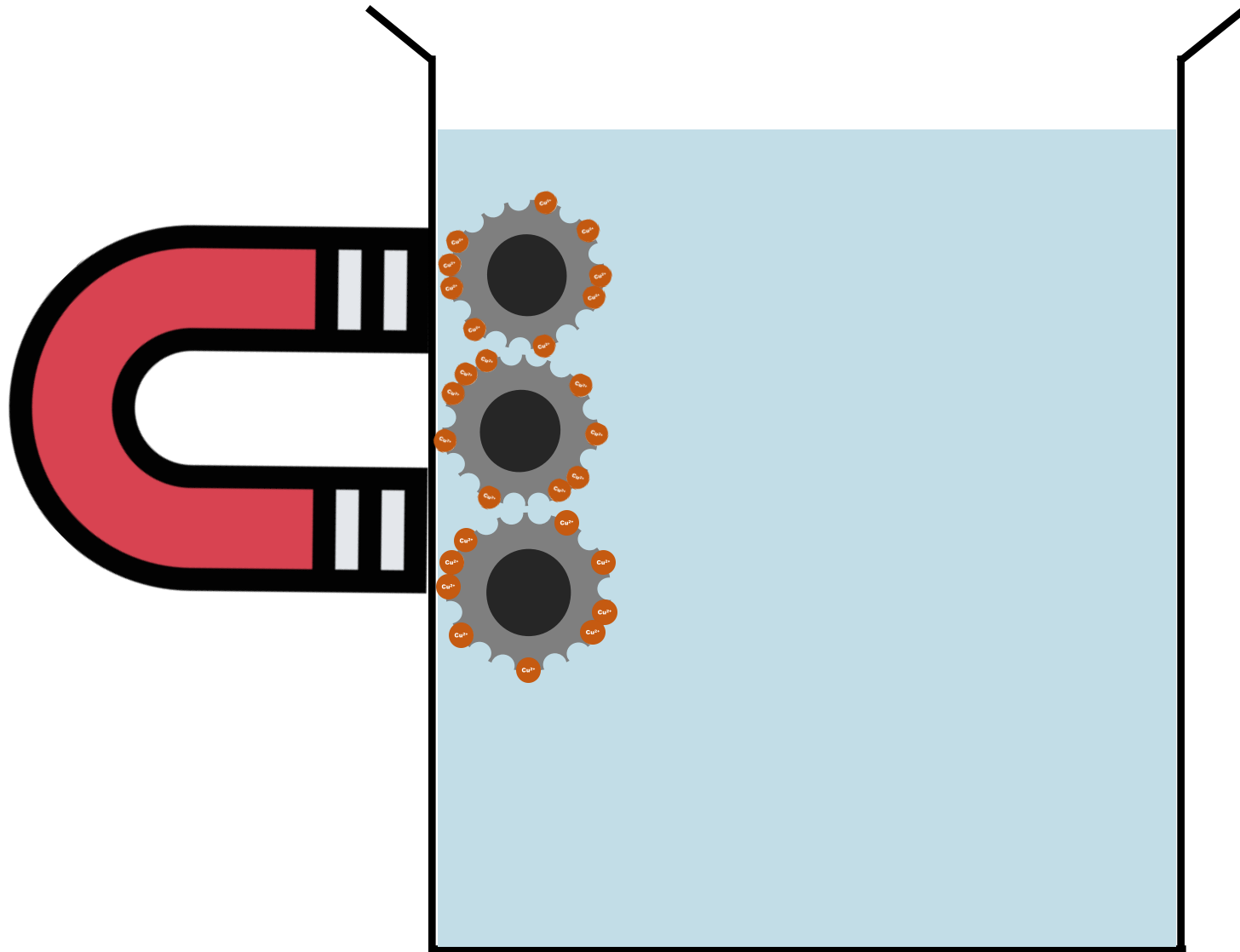


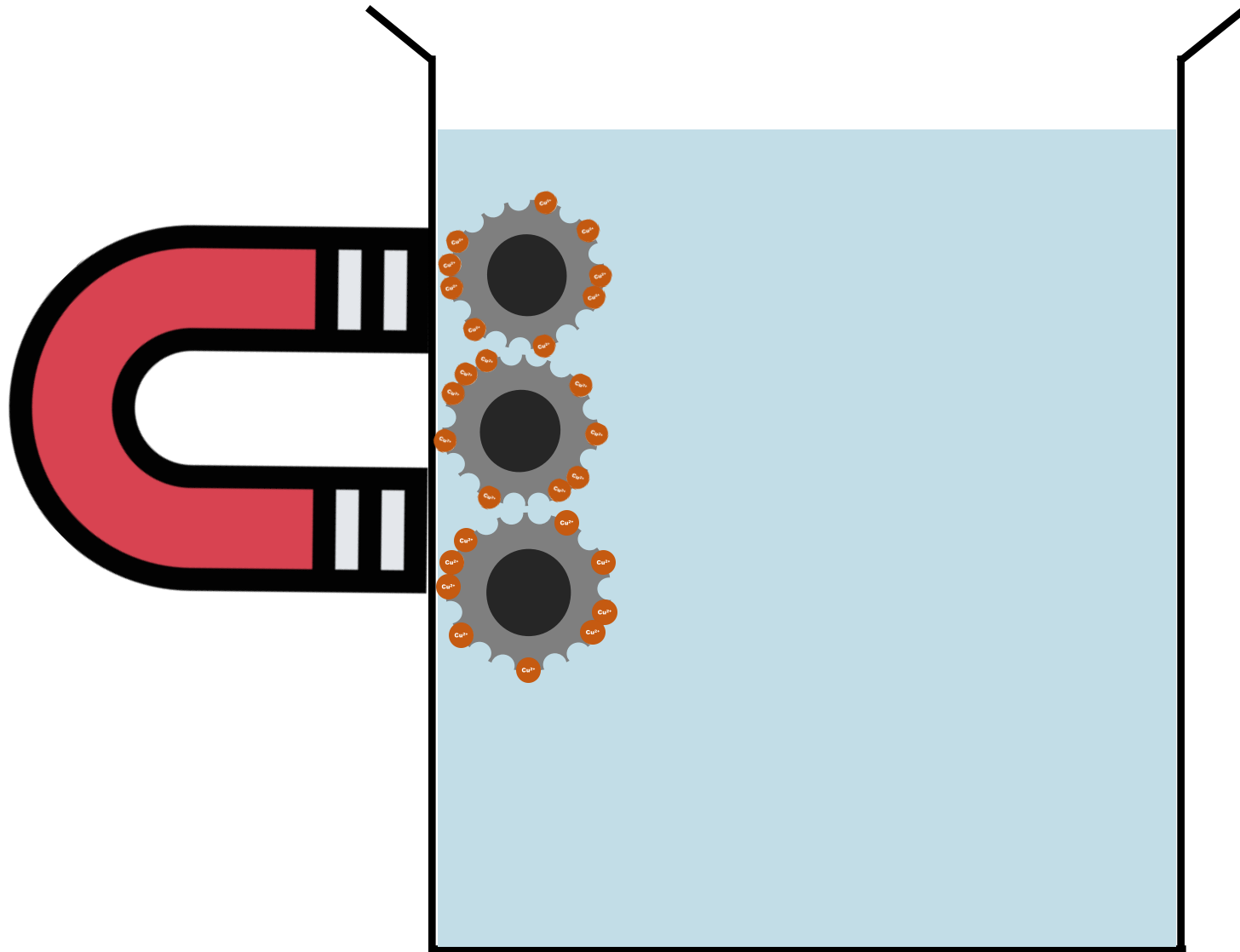


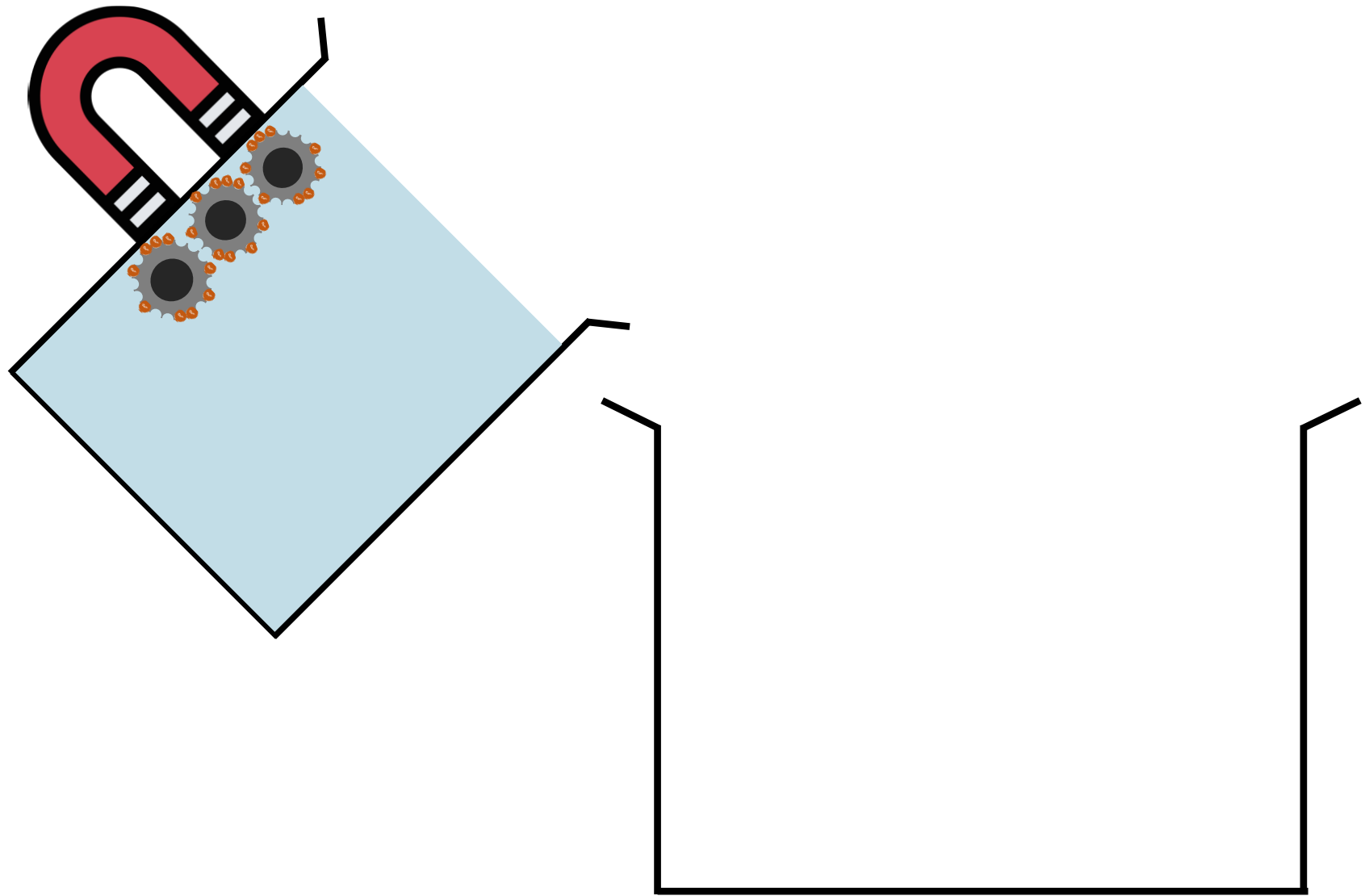


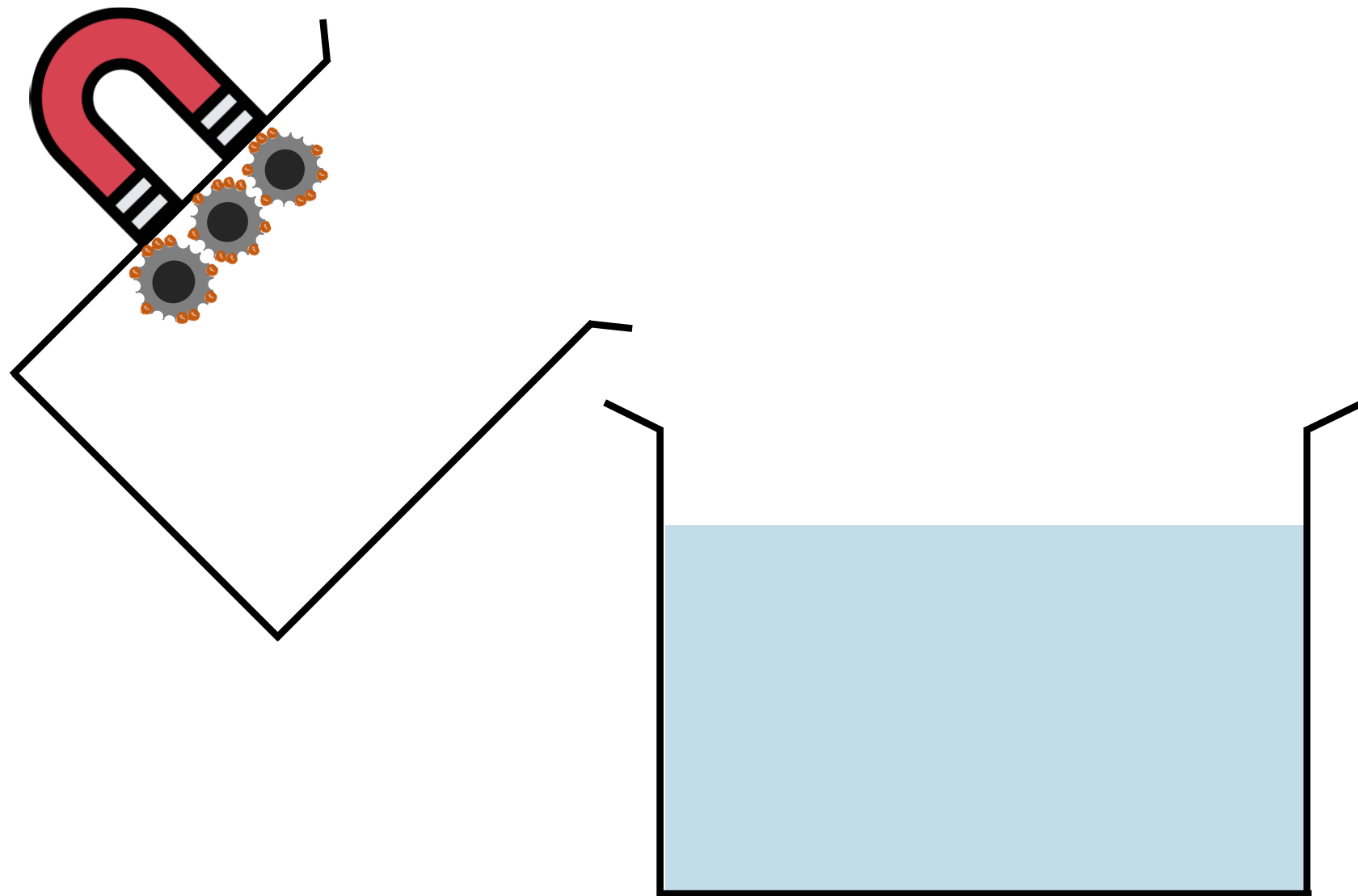


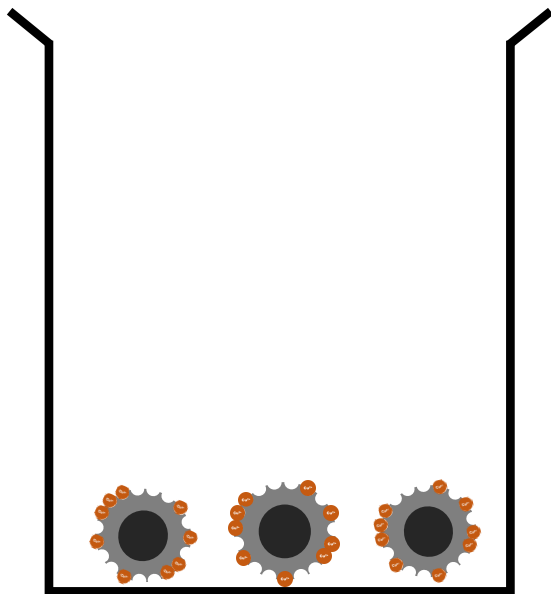




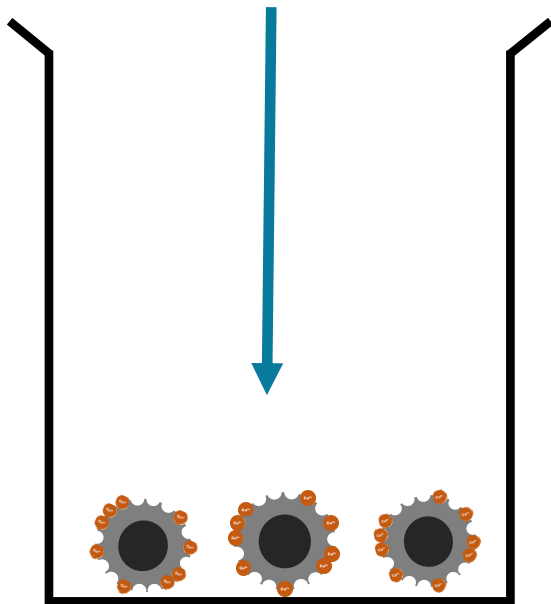




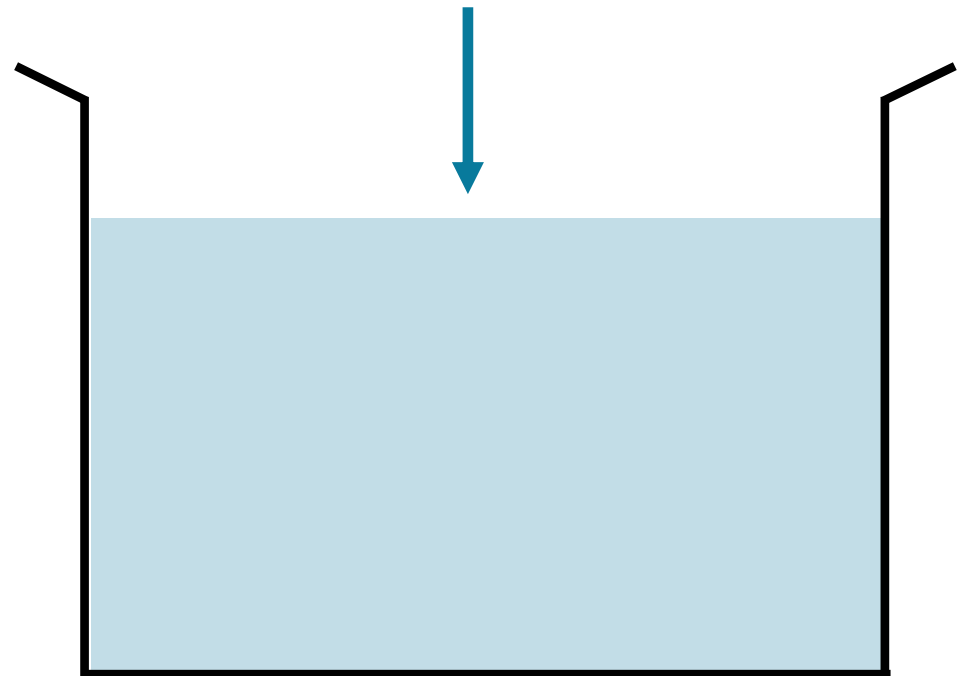




**Nanoparticles
with copper ions**



Water



What are the objectives of our project?

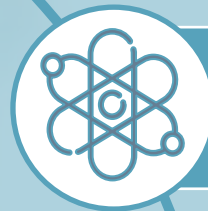
Reduce the number of cases of heavy metal ion poisoning

Removal of heavy metal ions from contaminated water

Use of an inexpensive and effective process

Reduce chemical pollution

Index



Introduction



Materials and methods



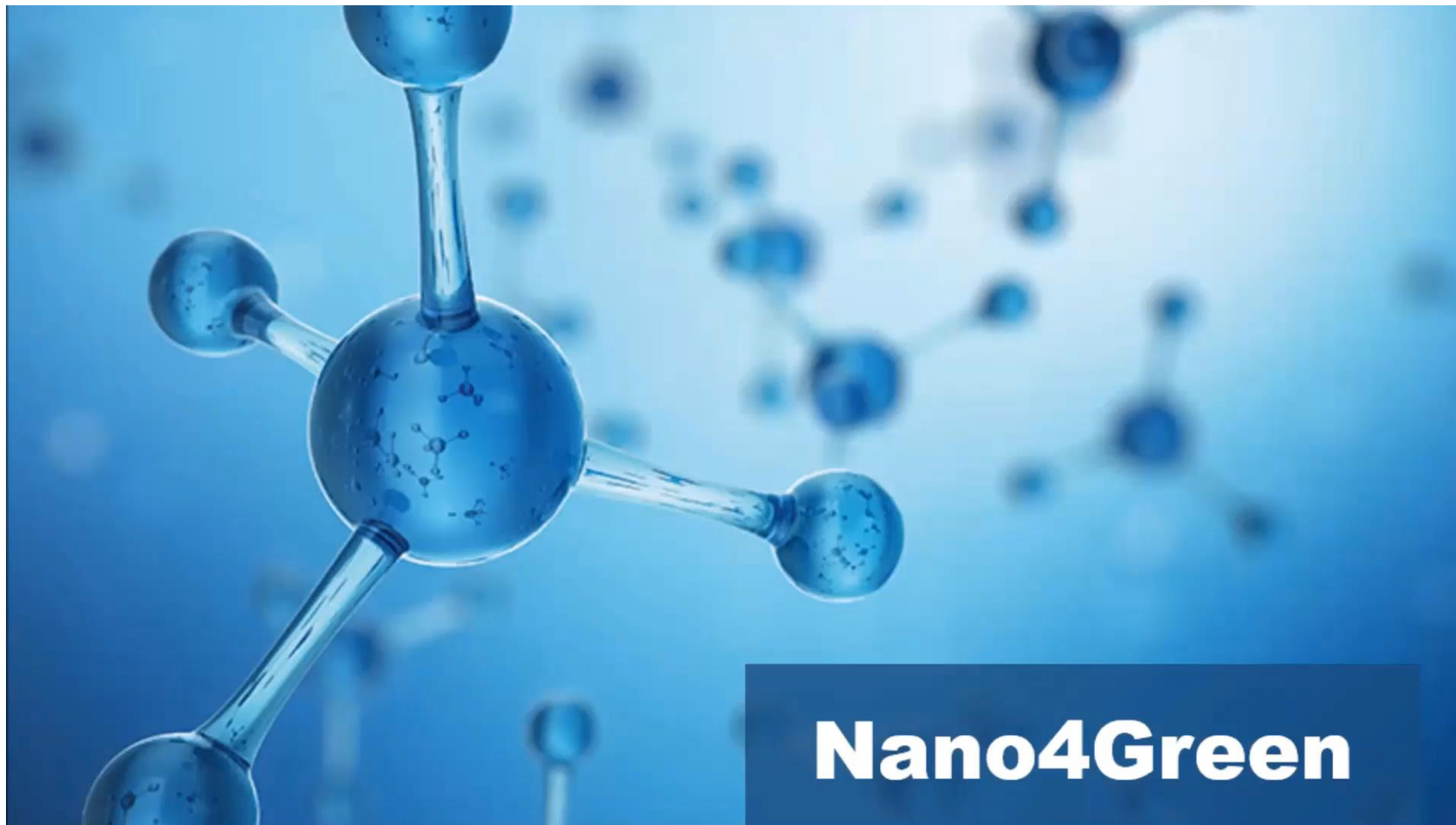
Results and discussions



Bibliographic references

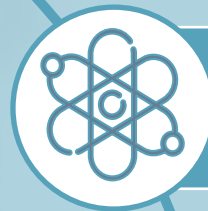


Materials and methods



Video 2: Materials and methods used

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Introduction



Materials and methods



Results and discussions



Bibliographic references



Results and discussions

Zetasizer

Infrared
Spectroscopy

Scanning Electron
Microscope (SEM)

Atomic absorption
spectroscopy with
flame

Zetasizer



Figure 2: Zetasizer results
(Fe_3O_4)



Figure 3: Zetasizer results
($\text{Fe}_3\text{O}_4 @ \text{SiO}_2 - 1x$)



Figure 4: Zetasizer results
($\text{Fe}_3\text{O}_4 @ \text{SiO}_2 - 2x$)

Zetasizer

	Particle size (d.nm)	PdI	Zeta potencial (mV)
1x	71.53	0.515	211.2
2x	202.9	0.267	275.9

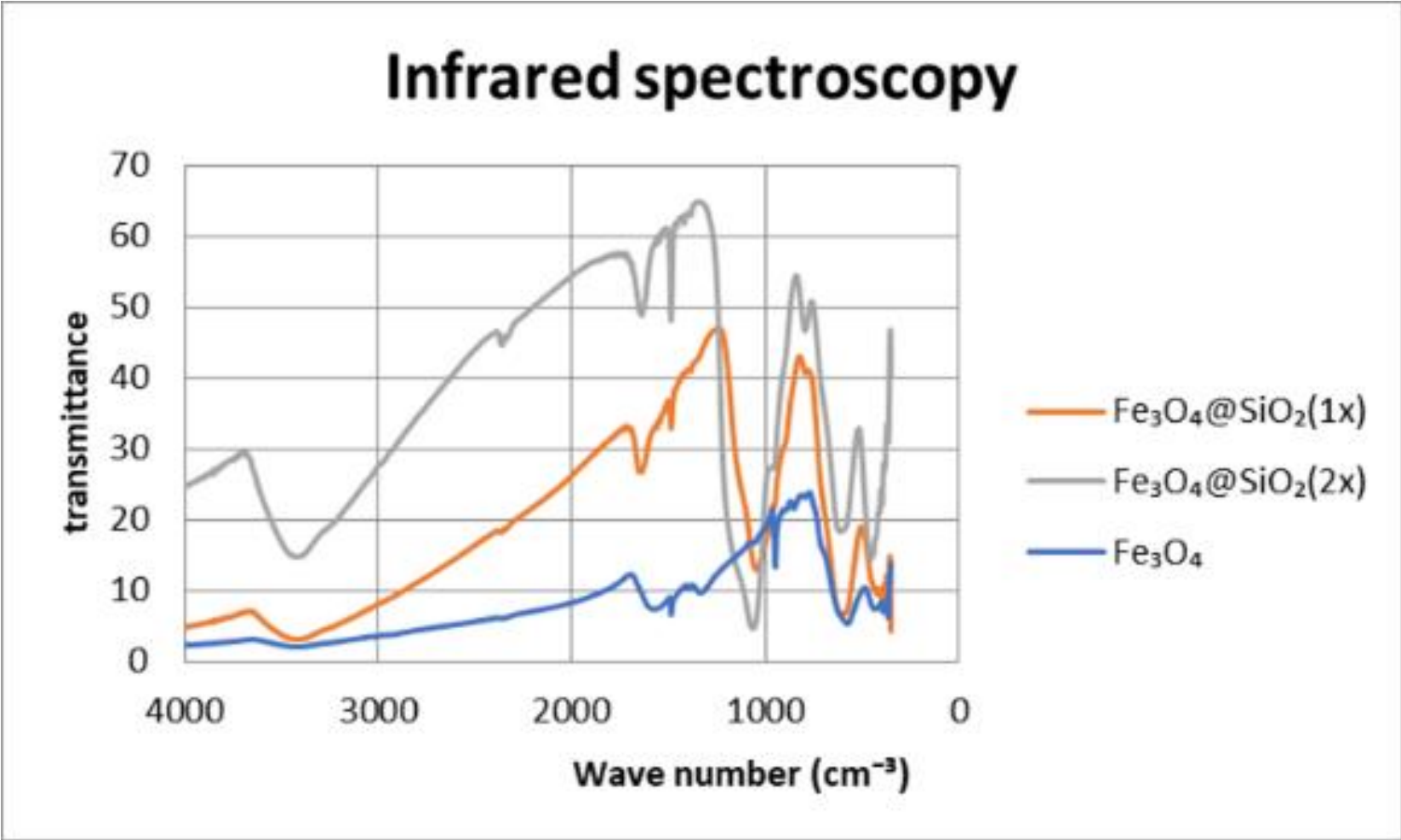
d.nm – diameter value in nanometers

PdI – polydispersity index

Zeta Potential - potential difference between the phase limits between solids and liquids. It is a measure of the electrical charge of particles that are suspended in liquid.

Table 2: Comparison of Zetasizer results
(Fe₃O₄@SiO₂ - 1x and 2x)

Infrared Spectroscopy



Graph 1: Results of Infrared Spectroscopy

Scanning Electron Microscope (SEM)

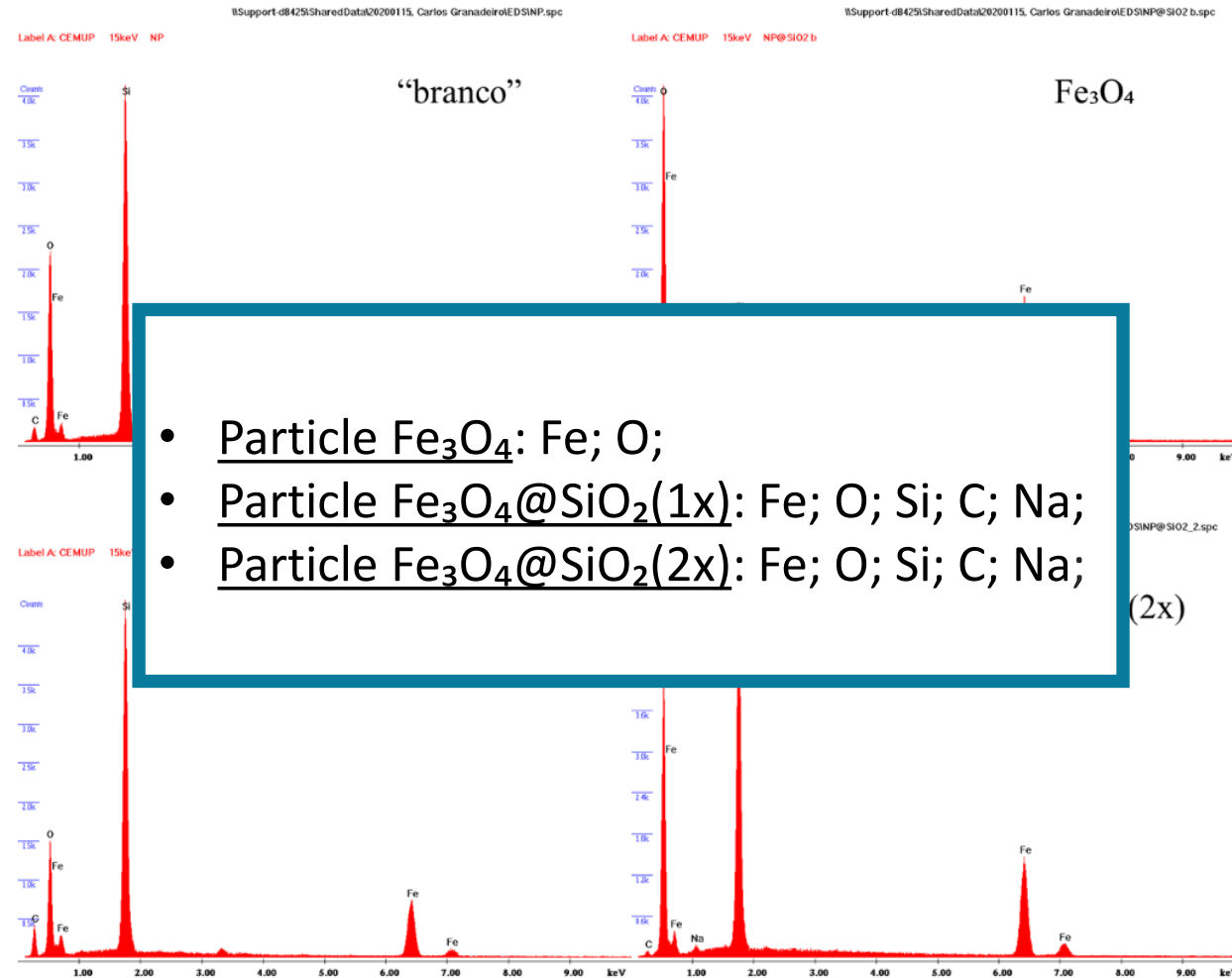


Figure 5: Result of Scanning Electron Microscope (SEM)

Scanning Electron Microscope (SEM)

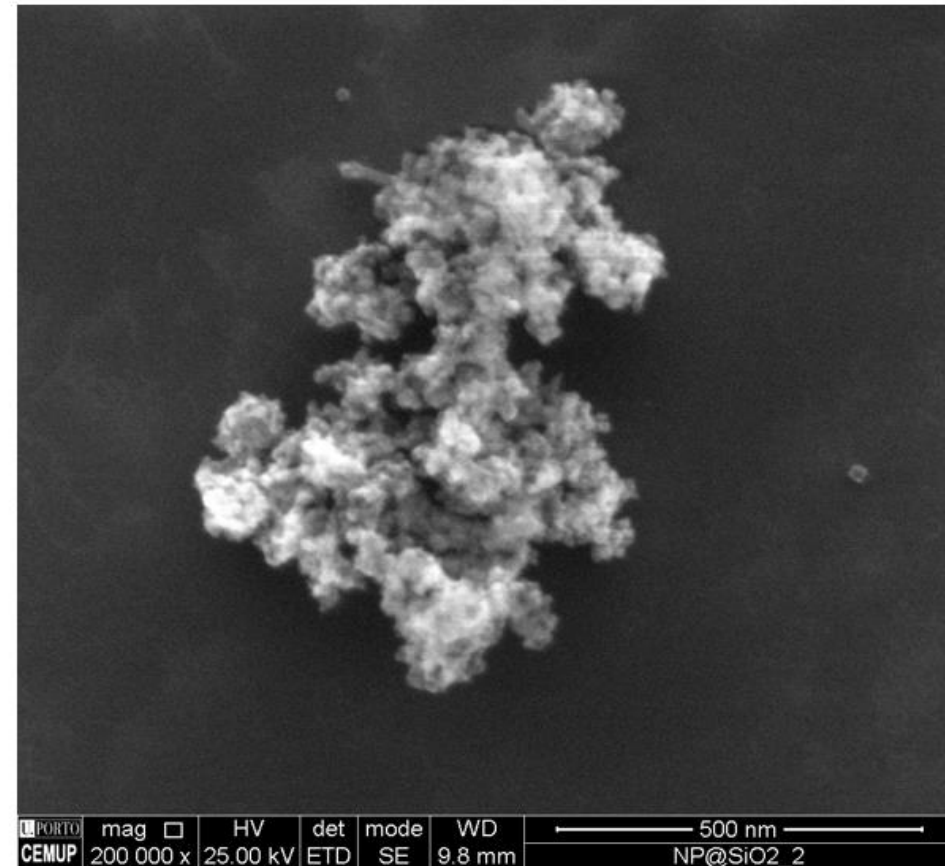
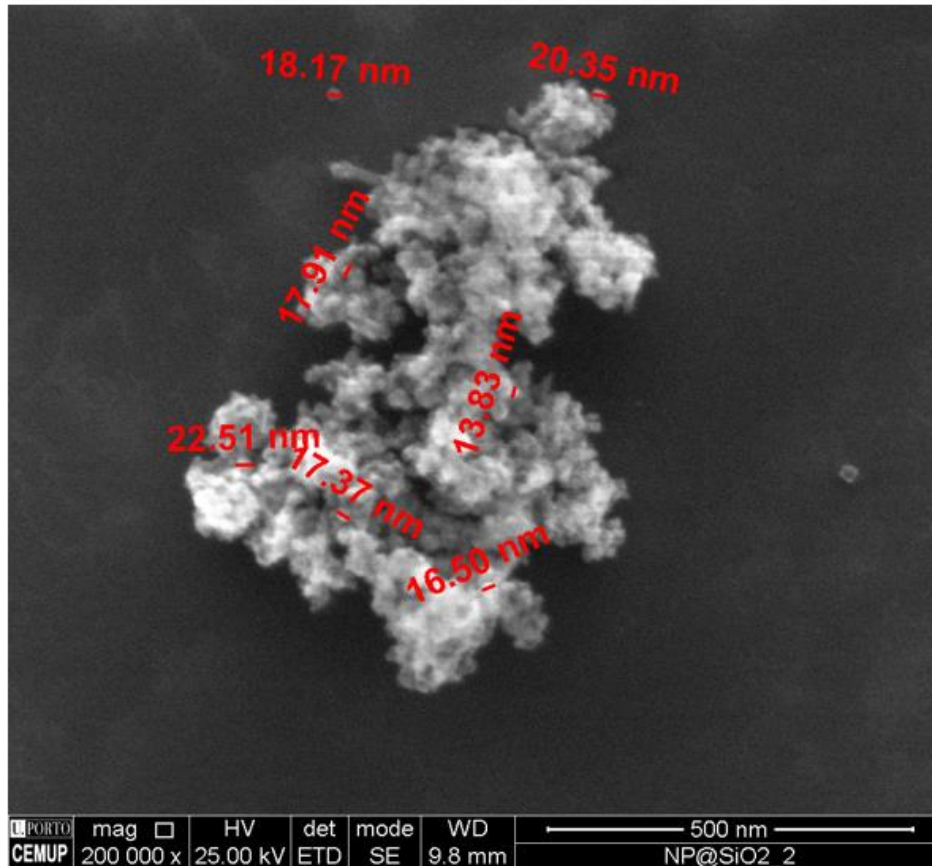
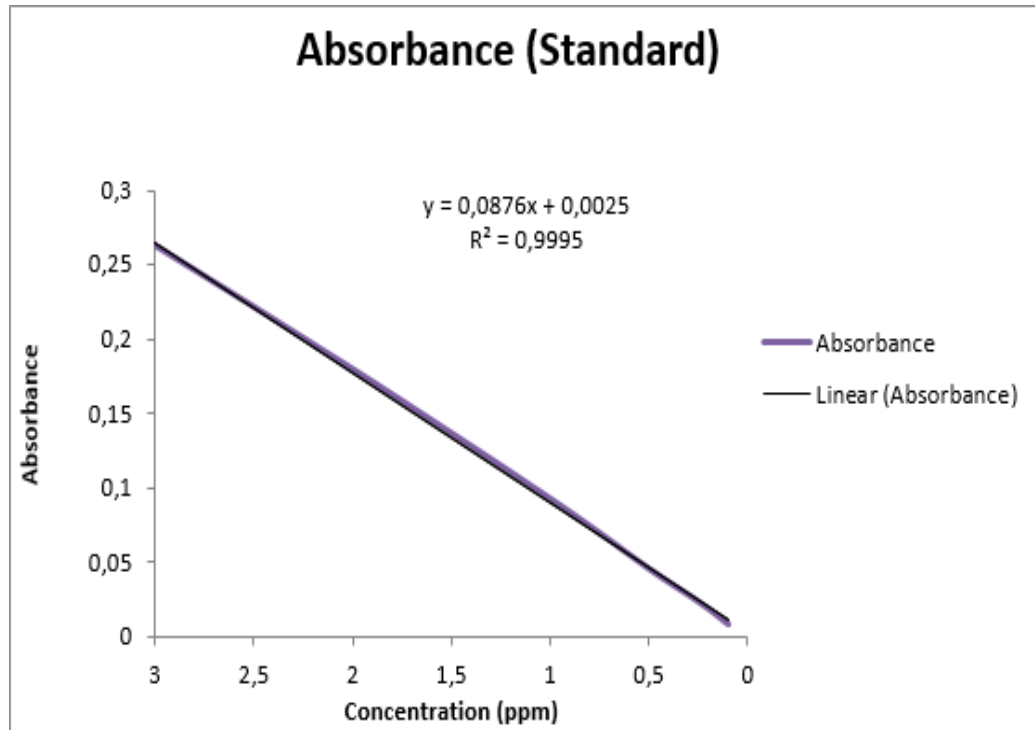
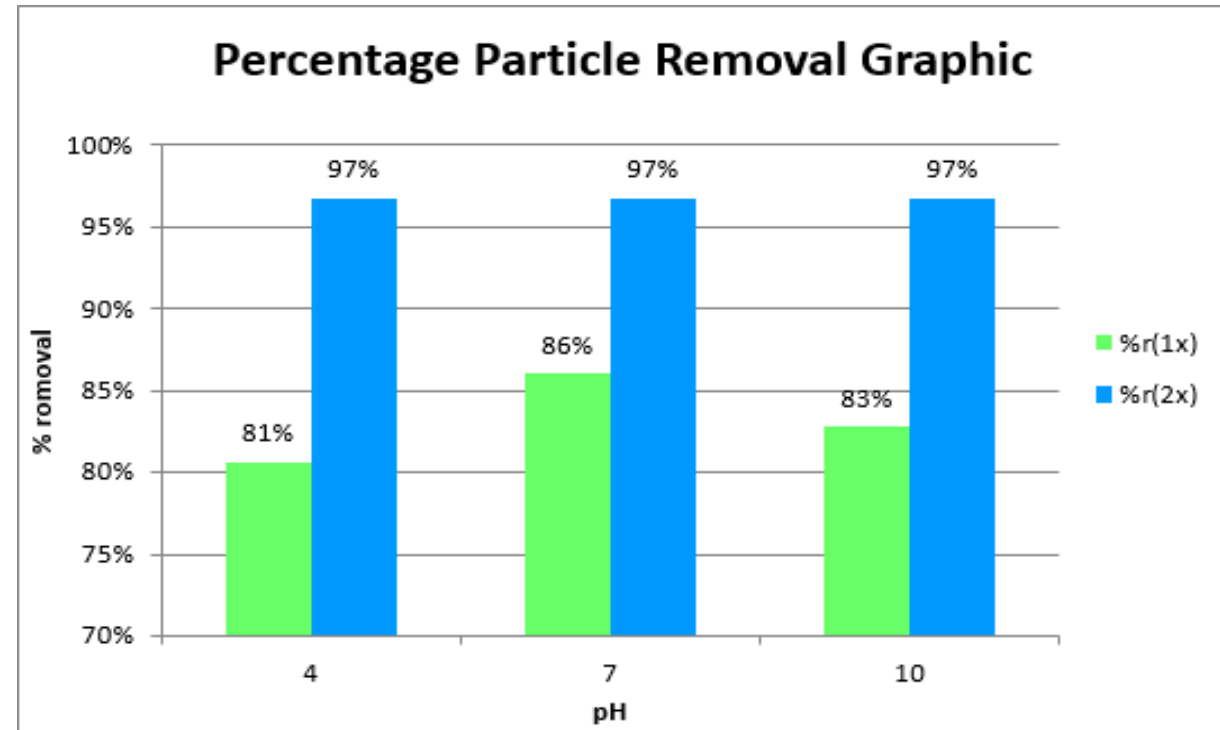


Figure 8: Result of SEM -Fe₃O₄@SiO₂(2x)

Atomic absorption spectroscopy with flame



Graphic 2: Results

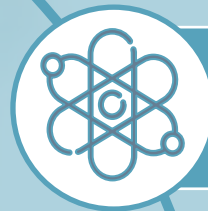


Graphic 3: Results

Conclusion

The results we obtained indicate that this work is highly promising as a future application to remove heavy metal ions from contaminated waters, since the developed adsorbent has quick and easy synthesis, low costs and its application proved to be efficient.

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Bibliographic references



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