

CHAPTER 6. Conclusions

By performing the present study, final conclusions and further work can be defined, presented as follows.

From literature review:

- Hydration mechanisms for cement phases are really complex, as well as sensitive to conditions changes, and they are not completely defined.
- Literature works related to mechanistic studies present limited and uncompleted explanations, particularly in how hydration and retention mechanisms may be altered in presence of trace pollutants.
- Further research must be done to extend literature works related to oxyanions behaviour, especially vanadium, in cementitious materials.

From hydrated C_3S samples manufacture process:

- Reproducibility of the manufacture process has been accepted to obtain homogeneous and comparable samples, mainly by TGA and SEM analysis.
- Saving samples in plastic bags and inside desiccator is appropriate to avoid contact with CO_2 . Despite not having a total carbonate absence, the percentage is low enough to make it acceptable.
- For future work, it is recommended to perform vanadium retention tests with $CaCO_3$ as substrate in order to know its behaviour and detecting possible deviations caused in analysis performed in the present study.

From vanadium retention experiment on commercial portlandite:

- Total vanadium retention from the system is achieved at 120 minutes, considering a ratio $L/S=200$, 500 and 1000 ppm of vanadium, $pH \approx 12$ and $T^\circ = 24 \pm ^\circ C$.
- Vanadium retained from the solution precipitates as $Ca_3(VO_4)_2$.
- The retention curve is not characteristic of adsorption experiments.
- For future work, it is recommended to analyse precipitated solids, as done in coprecipitation tests, for confirming the presence of $Ca_3(VO_4)_2$.

From vanadium and *insitu* portlandite coprecipitation experiment:

- Total vanadium retention from the system is achieved at 150 minutes, considering a ratio $L/S=200$, 1000 ppm of vanadium, $pH \approx 12$ and $T^\circ = 24 \pm ^\circ C$.
- *Insitu* portlandite formation from CaO and water is altered with vanadium presence in solution. It decreases total amount of portlandite synthesised.
- CaO retains vanadium from solution making it precipitate as $Ca_3(VO_4)_2$ i $Ca_2V_2O_7$.
- The retention curve is not characteristic of adsorption experiments.

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- TGA analysis allow the identification of a compound losing mass at $\sim 150^{\circ}\text{C}$, which might linked to the dehydration of a hydrous calcium vanadate ($x\text{CaO}\cdot y\text{V}_2\text{O}_5\cdot n\text{H}_2\text{O}$). DRX analysis would confirm this hypothesis.
 - For future work, it is recommended to perform once again the experiment in order to rule out errors in pH values and also confirming how ill-identified processes affect this parameter.

From vanadium retention experiment on CSH (hydrated C_3S pastes):

- More than 80% of vanadium has been retained, considering $\text{L/S}=200$, 1000 ppm of vanadium, $\text{pH}\approx 12$ and $T^{\circ}=24\pm^{\circ}\text{C}$.
- Due to its superficial charge, colloidal CSH nanoparticles retain vanadium by adsorbing hydrogenvanadate oxyanions (HVO_4^{2-}). Consequently, total precipitation in form of $\text{Ca}_3(\text{VO}_4)_2$ is avoided.
- Contrary to previous experiments, equilibrium state is reached later (>8 h) and CSH retention curve presents a smoother curve characteristic of adsorption experiments.
- For future work, more than 8 h experiment should be carried out for determining the real equilibrium time and the maximum retention achieved.
- For future work, it is recommended to analyse precipitated solids, as done in coprecipitation tests.

Other remarks and proposals:

- Research in this line should be continued but expanding to the trace elements retention like molybdenum (Mo), antimony (Sb) and Arsenic (As).
- The present work could be performed on the remaining cement phases: C_2S , C_3A and C_4AF .
- Such experimental work should not be stopped because it can lead to important contributions in performing sustainable cementitious materials by adding SCMs.