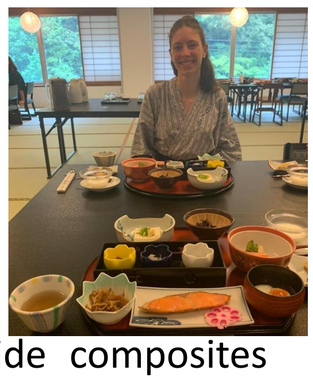
Micro/nano structures and colour tones of hematite nano-particles for beautiful red pigments:

Maëva GUILLOT (Sorbonne University, PCMAT)
Internship: 15th of April to 31st of August
JAPAN, Okayama University, department of Applied chemistry
Supervisor: *Professor FUJII Tatsuo,*
Tutor: *KEIJIRO Suga*



The laboratory is working on functional iron oxide composites materials.

Acknowledgements:

I would like to express my deep and sincere gratitude to my internship supervisor, Professor FUJII Tatsuo, for welcoming me in his laboratory during my stay in Japan. I also thank my tutor Suga KEIJIRO. I am extremely grateful to all my laboratory mates and all the persons I cannot name here. During this stay of 5 months, I have been granted with financial support, thus my thanks also go to the 2022 TAKENOKO grant, the iMAT program, the CROUS, and Sorbonne University, especially with the help of Ms. Marie-Laure LEBRUN . Last, I particularly want to express my deepest gratitude to Dr. Anne-Lise POQUET.

Subject:

The aim of this internship was to create very bright pigments based on hematite α-Fe_2O_3, a red pigment. For that matter, elements such as Aluminum or Silicon were added into the composition, in order to obtain a solid solution of elements (Fe: Si or Al). The influence of shape was also investigated.

Pigments were synthetized with the aim of using them as heat-resistant pigments on houses' walls or roofs, in particular to resist to high temperatures without using energies and to prevent the Global Warming.

Hematite through the ages:

Hematite is quite famous and has great potential. It was used since Paleolithic, first as a red pigment such as in the famous Lascaux and Chauvet caves in France.

Chauvet cave

In Japan, hematite is also part of the culture such as in Bizen wares for particular shades and it is also responsible of the Fukiya village red color. Through the years, it has been used in many fields like concretes and today it may be used in Li-ion batteries or for water splitting.

Methodological method:

To do so, pigments were synthetized through a precipitation method before being dry into the dryer machine, and before being fired into the furnace.

Then analysis were done with X-Ray diffractometer (XRD) to check the crystallographic phase and have crystallite size and lattice parameters, spectrophotometers with optical reflectance to obtain the bandgap and the reflection of samples, X-Ray Fluorescence to check the composition and Scanning Electron Microscopy to observe the shape of the pigments.

X-Ray diffractometer

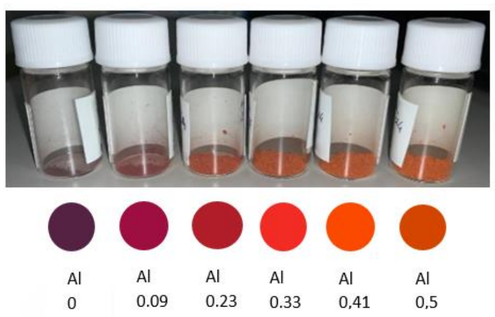
Optical reflectance spectrophotometer

X-Ray fluorescence device

Scanning Electron Microscope

Bizen ware

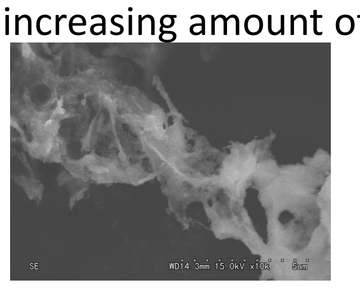
Fukiya village



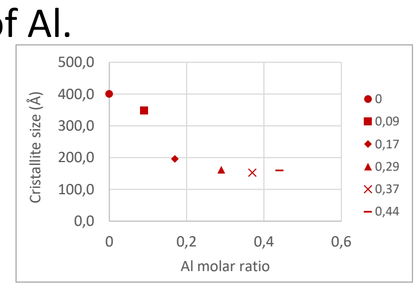
Hematite samples synthetized at 1000°C, containing Al

Results analysis:

Al was the first element added to the composition of hematite. There, fibrous particles were obtained thanks to P-CNF. When synthetized at 800°C and 1000°C, the crystallite size of pigments and the lattice parameters were decreasing with the increasing amount of Al.

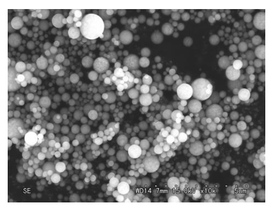


Fibrous particles of hematite



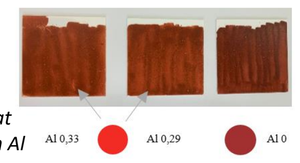
In both cases, by following the Vegard's law, pigments proved to be a solid solution of Fe and Al respectively until 0,29 Al and 0,41 Al. The lightest and brightest samples were also obtained for this two compositions. Then they were tested into paintings and it appeared that 0,29/0,33 Al samples synthetized at 800°C had a quite good reflection into visible light and even a better reflection into infra-red, which shows the heat-resistance of this pigment. 0,41 Al pigment synthetized at 1000°C did not show such great values, especially with a quite dark painting, but the aspect of the painting was very glassy which was very satisfying. The temperature of synthesis was influencing the bandgap in a more significant way.

The impact of shape for Al samples was then studied by synthetizing pigments through the ultrasonic spray pyrolysis method. Here spherical particles were obtained. It was found that spherical particles were bigger, less pure and reflect light less than the fibrous particles. The color was also more tarnish. So spherical particles were not promising at all for heat-resistant pigments.



Spherical particles of hematite

Si was the second element added to the composition. Nonetheless, no solid solution could be proved here. The color was not the lightest. The fact remains that reflectance in visible light was the highest, and 0,1 Si sample had the best values regarding the application into paintings.



Paintings at 800°C with Al

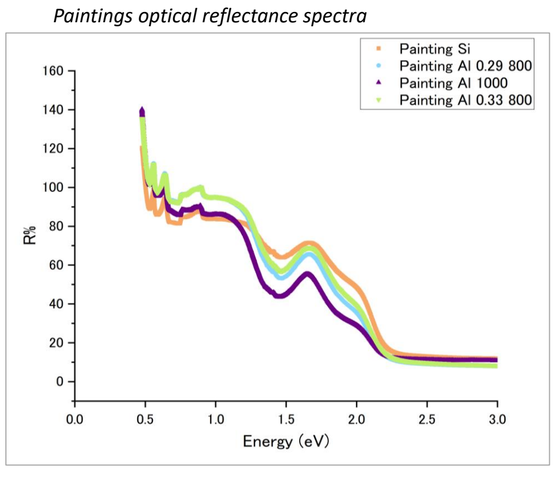
Painting at 1000°C with Al

Painting at 800°C with Si

Conclusion

Finally, the most promising sample with the aim of having heat-resistant pigments is hematite with 0,29 Al/ 0,33 Al synthetized at 800°C. Even though the reflectance for visible light is not the highest, for infra-red it is so. Nonetheless, 0,1 Si-hematite painting is also promising.

Paintings optical reflectance spectra



As far as my point of view is concerned, I have really appreciated this internship. It was the longest I experienced and I was fully autonomous. Responsibility and interest in the subject are requested. If so, the supervisor will also show interest in your work. Moreover, this internship was an incredible human experience. I recommend master 1 student and futures' one to have an experience in another country. In any cases, working abroad, discovering a new culture and living on your own is a great experience .