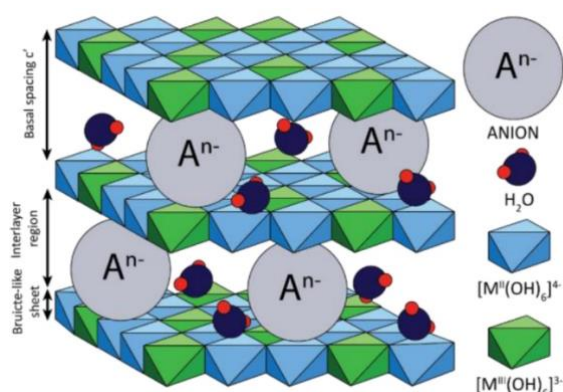


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## DESCRIPTION OF HYDROTALCITE SYNTHESIS

An atom like hydrogen is composed of a nucleus (composed of only 1 proton bearing 1 positive charge) surrounded by an electronic cloud (composed of only 1 electron bearing 1 negative charge), the right balance of negative and positive charges being responsible of the *electric neutrality of the atom*. In the world of minerals (crystallized structures) composed of 5744 identified and referenced mineral species<sup>1</sup>, one can find hydrotalcite (abbreviated as Htc) which is a member of the large Layered Double Hydroxide (LDH) family. Htc, is quite common in nature since it is composed of common chemical elements found in the earth crust such as magnesium, aluminum, oxygen, hydrogen and carbon. In nature, one can find it's nickel analogue called takovite. Such chemical elements initially in solution in water (rivers, groundwater) usually precipitate where they meet (like confluence for rivers). Carbon (the major building block of life) is the only element on earth that can exist in tree forms: solid (graphite), gas (CO<sub>2</sub>) and liquid (when CO<sub>2</sub> dissolves with water and solubilizes into carbonic acid (H<sub>2</sub>CO<sub>3</sub>) and thus can be incorporated into minerals in the form of carbonates<sup>2</sup>). Hydrotalcite belongs to the carbonate family since it is an association of a carbonate (A = CO<sub>3</sub> with n = 2, see figure below) and Metal hydroxides layers (with M = Mg and Al). To make it simple, the balance between di-cations (M<sup>II</sup> such as Mg<sup>2+</sup> bearing 2 positive charges) and tri-cations (M<sup>III</sup> such as Al<sup>3+</sup> bearing 3 positive charges) creates an excess of positive charges in the layers which is balanced by anions A<sup>n-</sup> (such as carbonate bearing 2 negative charges) located between the layers, the right mixture of both charges being responsible of the *electric neutrality of the crystal structure*.



Such minerals can be very easily prepared by chemists using mineral synthesis that offers the unique opportunity to replace some elements by others (such as magnesium by nickel for example). Thus, chemists can make even larger the LDH family by preparing new crystalline materials and combining elements that never met in nature. Such has been done in the CleanHME project by preparing new nanostructured LDHs whose formula is for example:

$\text{Ni}_6\text{Al}_2\text{CO}_3(\text{OH})_{16} - 4 \text{H}_2\text{O}$ . It is the exact copy of takovite but in our case the crystals are very small (nanostructured).

From a practical point of view, LDH are prepared by a very simple co-precipitation method which consist in the mixing of the appropriate amounts of reactants dissolved in water. To make it simple, nickel, copper and aluminum hydrated salts ( $\text{NiCl}_2$ ,  $\text{CuCl}_2$  and  $\text{AlCl}_3$ ) are dissolved in water<sup>3</sup> and form solution A. Solution B is prepared by dissolving in water the other components of the synthesis like sodium hydroxide and sodium carbonate. Then, under stirring, solution A is poured dropwise on solution B and the green suspension obtained is eventually heated at  $65^\circ\text{C}$  overnight. Finally, the solid obtained is washed, oven dried and milled as a green powder.

On earth, any solid material has to be crystallized (regular organization of atoms) or amorphous (no organization). Such is the case for quartz (crystallized silica)<sup>3</sup> and obsidian (amorphous silica)<sup>4</sup>. Our new LDHs (**A**, see figure below) have been specially designed to be able, after several treatments<sup>5</sup>, to generate magnetic *crystalline* metallic phase supported on an *amorphous* mineral structure (**C**), such active metallic phase being able to “catch” hydrogen and to force hydrogen to react via a LENR path. The activating treatment comprises *a minima* a heating phase followed by a reduction step under hydrogen, both steps being able to transform green nickel cations ( $\text{Ni}^{2+}$ ) into black nickel metal nanoparticles (see figure below).

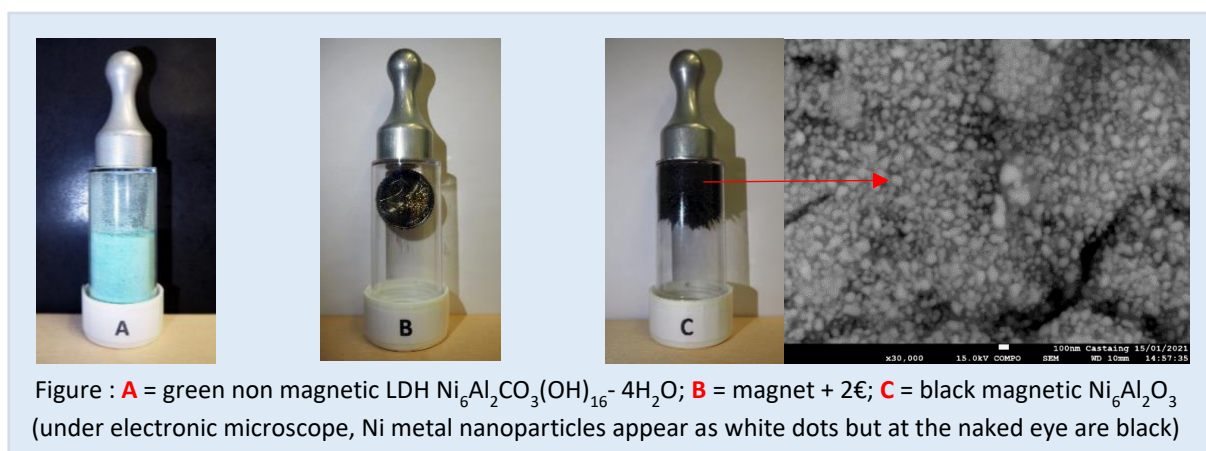


Figure : **A** = green non magnetic LDH  $\text{Ni}_6\text{Al}_2\text{CO}_3(\text{OH})_{16} - 4\text{H}_2\text{O}$ ; **B** = magnet + 2€; **C** = black magnetic  $\text{Ni}_6\text{Al}_2\text{O}_3$  (under electronic microscope, Ni metal nanoparticles appear as white dots but at the naked eye are black)

#### References:

- 1) Warr et al, **2021**; [doi:10.1180/mgm.2021.43](https://doi.org/10.1180/mgm.2021.43)
- 2) A similar phenomena happens for calcite (calcium carbonate,  $\text{CaCO}_3$ ) in the case of the formation of stalactites.
- 3) These salts are, like NaCl (our common cooking salt), very soluble in water and give a transparent solution after some time of stirring at room temperature.
- 3) [Quartz - Wikipedia](https://en.wikipedia.org/wiki/Quartz)
- 4) [Obsidian - Wikipedia](https://en.wikipedia.org/wiki/Obsidian)
- 5) confidential; in collaboration with Jean Paul Biberian and Mathieu Valat.