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An Overview on (LDHs)

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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Minireview Article

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ABSTRACT

Layered Double Hydroxides are inorganic solid minerals with brucite-like structures. They are non-silicate minerals seen in the soil very rare in amount [1]. LDHs have brucite-like layers with an excess positive charge on their surface. The excess charges are balanced by anions that are present in the interlayer. Generally, LDHs are also known as Hydrotalcite-like compounds because Hydrotalcite is one of the LDHs seen commonly in soil. Due to their higher anion exchange capacity, they are also known by the name anionic clay. In nature, they generally occur as a clay mineral, but sometimes as the metabolic by-product of micro-organisms. Even humans can manufacture it at a low cost of production.

Keywords: Layered double hydroxide; octahedral sheets; trivalent cation; chloride anions.

1. INTRODUCTION

1.1 Formation of Layered Double Hydroxide in Soil

The formation of LDHs in the soil is a three-step process.

a. Divalent cations present in the soil form octahedral units with hydroxyl ions.
b. These octahedral units form octahedral sheets through octahedral side sharing.
c. Trivalent cations in the soil isomorphically substitute the divalent cations in the sheets.

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d. The formed excess positive charge though this substitution is balanced by anions present in the interlayer.

This LDHs structure is having some structural similarities with phyllosilicates clay minerals in soil but in the same time having many differences.

2. HYDROXIDE SHEET COMPONENTS

The trioctahedral sheets of the LDHs mainly contain two types of metallic cations. One is divalent (M^{2+}) and another is a trivalent (M^{3+}) cation. As it contains two types of cations they are known by the name Layered Double Hydroxide [2-4]. The stability of the LDHs is mainly determined by the ratio of divalent to trivalent cation. For stable LDHs, the ratio should be between 1 to 5. The LDhs have an amorphous structure when the ratio more than 5 and the LDHs structure easily district when the ratio less than one [5-8,9].

Ionic radius is the most limiting factor for the formation of the LDHs, the divalent cation should have an ionic radius of 0.62 to 0.69 A°, and the trivalent should have 0.65 to 0.80 A° [10]. Because of this reason, all the metallic cations present in the soil cannot form the LDHs structure. Fig. 2 shows the d-block elements which can form the LDHs.

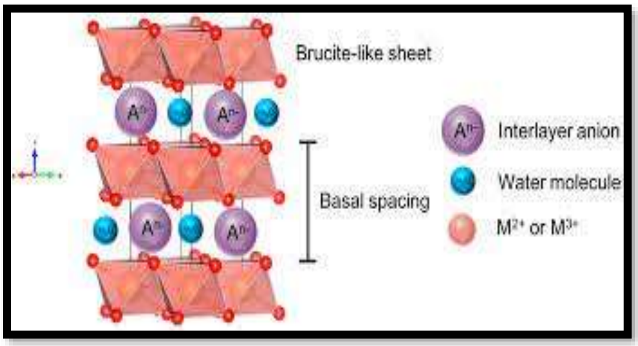

Fig. 1 .Layered double hydroxide

Table 1 .Phyllosilicates clay minerals characterization

Phyllosilicates	Layered Double Hydroxide
Seen excessively in soil	Found rarely in soil
Isomorphous substitution results in negative charge development	Isomorphous substitution results in positive charge development
Tetrahedral and octahedral sheet arrangements can be seen	Only octahedral sheets can be seen
Having higher Cation Exchange Capacity	Having higher Anion Exchange Capacity

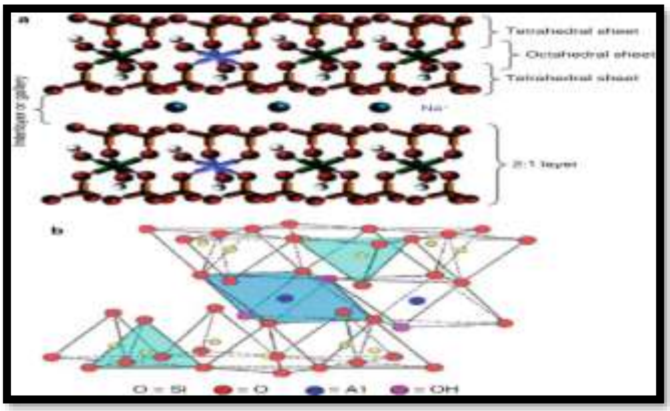

Fig. 2 .Phyllosilicate clay mineral

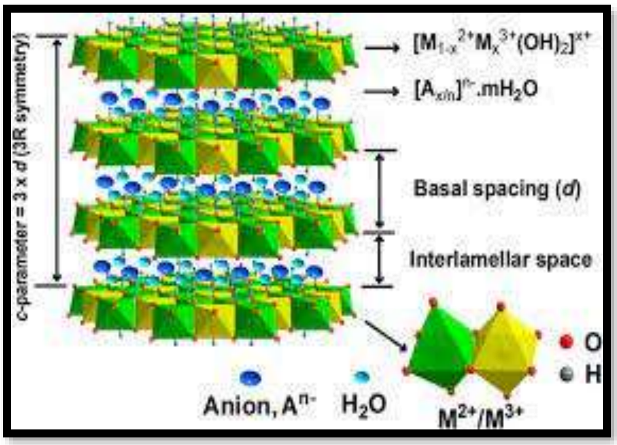

Fig. 3. Layered double hydroxide

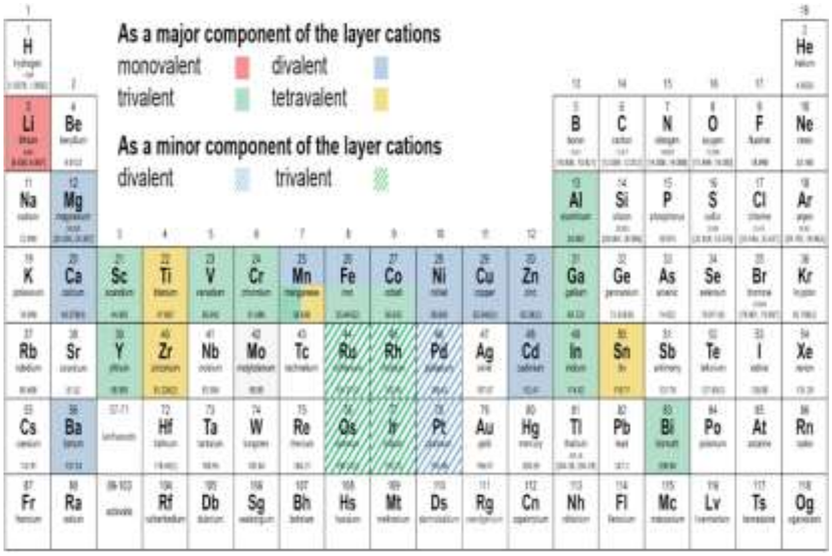

Fig. 4 .LDHs forming cations

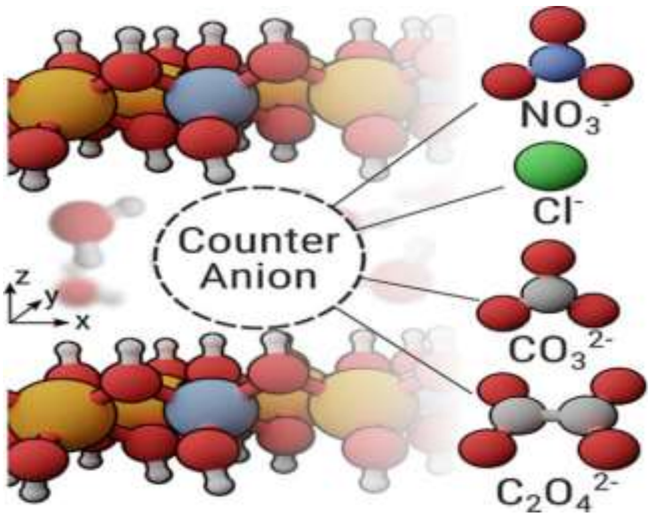

Fig. 5. Inter layer anion

3. INTERLAYER COMPOSITIONS

Interlayers of the naturally forming LDHs usually have carbonate, nitrate, hydroxyl ion, sulfate, and chloride anions. But when it is artificially synthesized it can be intercalated with any type of anion based on the inter-layer composition. Anions in the interlayer are usually held by van der Wall's force, electrostatic force, or through a Hydrogen bond. These intercalated anions can often easily have exchanged with other anions so LDHs have high anion exchange capacity.

3.1 General Properties of LDHs

- Having a hardness of 2 in mho scale
- Low density 1.06 g/cm^3
- High anion exchange capacity of 200-400 cmol/kg
- High surface area of $200m^2/g$
- Basal spacing ranges from 7-18A°
- Interlayer space depends on the type of the anion and the extent of anion hydration
- Thermal stability depends on the type of metal cations on the layers
- Having positive zeta potential
- Iso electric point is highly basic

3.2 Methods of Synthesis LDHs

a. Anion exchange method – indirect method
b. Co-precipitation method – the direct method, is the most widely used
c. Reconstructed method – memory-based method

3.3 Uses of Ldhs in Sustainable Agriculture

- Can be used as slow-release fertilizer especially NO_3^- -N and $P_2O_5^{3-}$
- Can be used to reduce the toxicity of heavy metals in water bodies and soil.
- By uptake of nitrate nitrogen and phosphate into the interlayer proper reduction of leaching loss of nutrients and improve nutrient use efficiency.
- In pesticide, herbicide contaminated soil its application helps to reduce the mobility of anionic part of the synthetic material by proper intercalation in the interlayer.
- Even can be used to deliver plant growth hormone and other agrochemicals like pesticides, insecticides *etc.*

4. CONCLUSION

Many of the issues in the agricultural sector are thought to be solved by layered double hydroxides, a new generation of green material. They are regarded as the most effective material for increasing the effectiveness of nutrient usage since they may be used as slow-release fertilizers and to absorb nutrients in polluted soils. They may be utilized even in heavy metal-contaminated soil. The mobility of heavy metals is therefore decreased, which lowers their toxicity. This happens when they are adsorbed on the surface through various sorts of bonds.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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