Versatile applications of hydroxyapatite-based composites

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Introduction

Hydroxyapatite is a well-known mineral from the apatite group, which is widely used, Currently, research is being conducted to improve its structure and parameters through appropriate modifications, including with metal ions, oxides, clays and organic substances.

Composites created in this way are gaining popularity due to the versatility of their potential applications. Composites are materials formed by combining two or more components. Such a compound often combines the best features of the substrates that were used for its synthesis. The unusual properties of hydroxyapatite make it a very good covering material, i.e. forming an outer layer. This creates many opportunities for potential modifications and the creation of new composites.

Hydroxyapatite

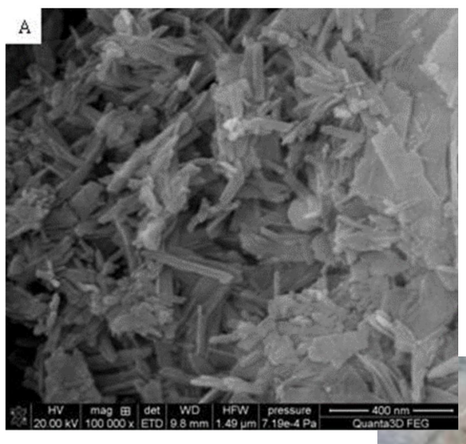
Source: Osuchukwu, Obinna Anayo, et al. "Synthesis techniques, characterization and mechanical properties of natural derived hydroxyapatite scaffolds for bone implants: a review." *SN Applied Sciences* 3.10 (2021): 1-23.

Hydroxyapatite/iron oxide composite

One of the more interesting modifications is a magnetic core (γ-Fe2O3 or Fe3O4). Such a composite gains better strength and adsorption properties. Studies show that the combination of hydroxyapatite with a magnetic core finds numerous applications as an adsorbent for metals, such as cadmium, nickel, cobalt and uranium. The composite also effectively binds anions, such as nitrates, citrates, among others. In addition, compounds of organic origin, such as humic acid, dyes, proteins and enzymes also readily sorb on its surface. It is worth mentioning that the good adsorption properties exhibited by the composite also enable its use in medicine, such as as a medium for transporting drugs and delivering them to a specific location in the human body.

Adsorbent for metals, ions and organic compounds

In medicine: drug delivery system, MRI, orthopedics.



Source: Biedrzycka, A.; Skwarek, E.; Osypiuk, D.; Cristóvao, B. Synthesis of Hydroxyapatite/Iron Oxide Composite and Comparison of Selected Structural, Surface, and Electrochemical Properties. *Materials* **2022**, *15*, 1139. https://doi.org/10.3390/ma15031139

Modification with metal ions

A frequently used solution in hydroxyapatite research is its modification with metal ions, such as calcium, silver, strontium, iron, or zinc. Such composites have proven to be good adsorbents for removing other ions from aqueous solutions, including uranium, chromium and lead.

Adsorbent of metals: U, Cr, Pb

Source: Sneha, Murugesan, and Nachiappan Meenakshi Sundaram. "Preparation and characterization of an iron oxide-hydroxyapatite nanocomposite for potential bone cancer therapy." *International Journal of Nanomedicine* 10.Suppl 1 (2015): 99.

White clay composite

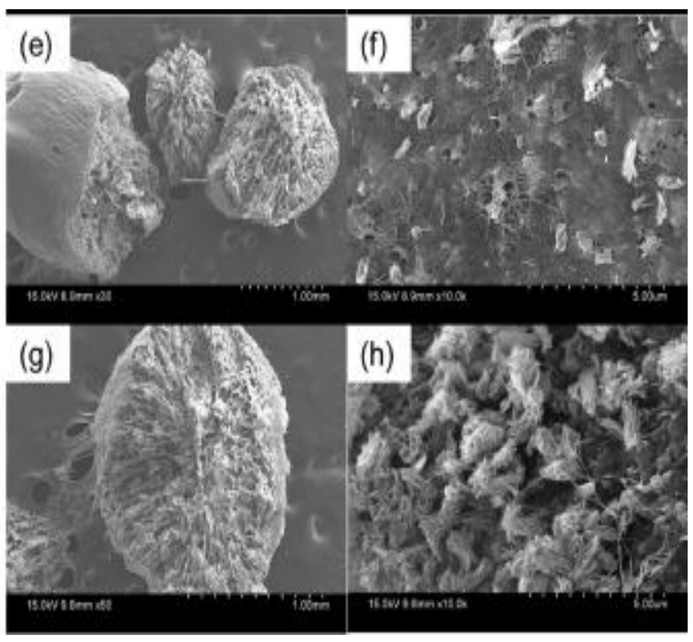
The combination of white clay and hydroxyapatite makes it possible to obtain a composite with satisfactory adsorption capacities for, among others, uranium, cadmium and nickel ions. Moreover, organic substances such as tetracyclines also undergo adsorption processes

Adsorbent for metals: Cd, Ni, U

Hydroxyapatite with graphene oxide and chitosan

The material showed satisfactory results in the sorption processes of dyes and copper ions. SEM images of the composite show numerous pores, which are associated with the presence of active centers that contribute to greater adsorption.

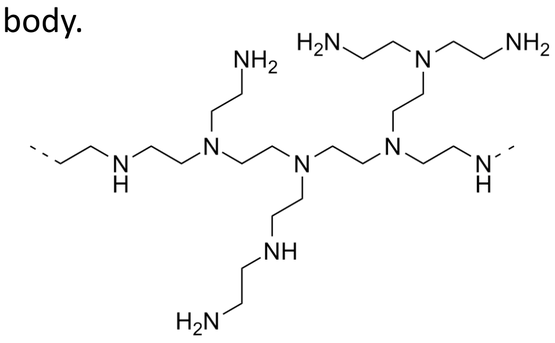
Adsorbent of dyes and Cu



Source: Hoa, N.V.; Minh, N.C.; Cuong, H.N.; Dat, P.A.; Nam, P.V.; Viet, P.H.T.; Phuong, P.T.D.; Trung, T.S. Highly Porous Hydroxyapatite/Graphene Oxide/Chitosan Beads as an Efficient Adsorbent for Dyes and Heavy Metal Ions Removal. *Molecules* **2021**, *26*, 6127. https://doi.org/10.3390/molecules26206127

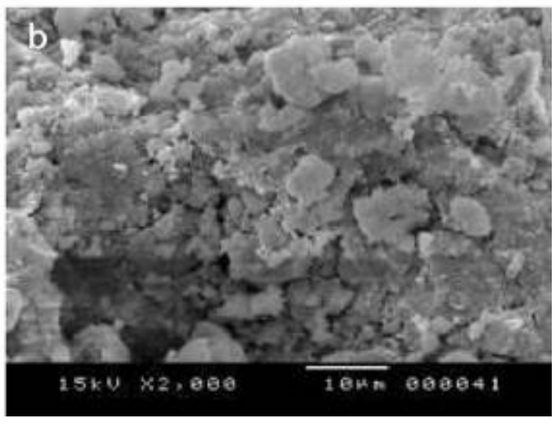
Polyethyleneimine

Also could be an organic component of apatite material modification. Such a composite could potentially be used as a medium to transport drugs inside the body.



Hydroxyapatite and sodium alginate

This organic substance is extracted from algae. It is commonly used as a food additive for its gelling and stabilizing properties, and its designation is E401. It can be found on the packaging of sauces, syrups, beverages, jams and candies . Studies have shown that in combination with hydroxyapatite, it is a good cadmium ion binding material.



Source: Guesmi, Youssef & Agougui, Hassen & Lafi, Ridha & Jabli, Mahjoub & Amor, Hafiane. (2017). Synthesis of Hydroxyapatite-Sodium alginate via a co-precipitation technique for efficient adsorption of Methylene Blue dye. Journal of Molecular Liquids. 249. 10.1016/j.molliq.2017.11.113.

Summary

Hydroxyapatite has gained immense popularity among scientists. Science now poses many application challenges. Of great importance are issues touching environmental protection and care, as well as improving and facilitating access to medical solutions. An opportunity to improve the quality of life and the services provided could be hydroxyapatite-based composites. Preliminary studies show that they are versatile materials with many advantages with a good chance for potential future use.

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