SYNTHESIS AND CHARACTERIZATION OF LAYERED DOUBLE HYDROXIDE AS BIOCOMPATIBLE MATERIALS

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5. Report

5.1 Proposed Executive Summary

(Original proposal – 300 words)

Layered double hydroxides (LDHs), also called anionic clays, displays unique physical and chemical properties surprisingly close to the properties of clay minerals. Layered double hydroxides are group of inorganic materials as host compounds. LDHs are layered solids having positively charged layers and interlayer charge compensating anions. The chemical composition of LDHs can be represented by the general formula $[M^{II}_{(1-x)} M^{III} (OH)_2]^{x+} A^{z-}_{x/z} . yH_2O$ or $[M^{I} M_2^{III} (OH)_2]^{+} A^{z-}_{1/z} . yH_2O$ where M^{I}, M^{II} and M^{III} are mono, di- and trivalent cations, respectively, occupying octahedral positions in hydroxide layers, and A^{z-} is an interlayer charge-compensating anion.The continuous development of new drug delivery systems is driven by the need to maximize therapeutic activity while minimizing negative side effects. LDH is one class of drug delivery vehicle that has received more attention which can accommodate polar organic compounds between their layers and form a variety of intercalated compounds. Because the release of drugs is potentially controllable, these new materials have a great potential as a delivery host in the pharmaceutical field in preparing a **controlled release formulation**. Some layered double hydroxides have been studied as the host in novel drug delivery systems. The intercalation of the anticancer agent cytarabine and related compounds into γ-titanium phosphate has been reported (Danjo et al., 1997). Intercalation compounds of ternary layered inorganic materials such as synthetic mica (Na-TSM) with diclofenac sodium and their drug release characteristics have been investigated (Suzuki et al., 2001), and indomethacin has also been intercalated into synthetic mica (Yoshiteru et al., 1994).The interlayer anion exchangeable capability of layered double hydroxides meets the requirement of inorganic matrices for encapsulating functional biomolecules with negative charge in aqueous media. Choy et al. (1999, 2000) have reported that nucleoside monophospahtes and DNA can be intercalated into layered double hydroxides by anion exchange process, in an attempt to develop possible applications of bio-layered double hydroxide hybrids as gene of drug delivery carriers. It has also been reported (Hussein et al., 2002) that layered double hydroxides have been employed as hosts for the controlled release of a plant growth regulator, α-naphthaleneacetate.

5.2 Enhanced Executive Summary

(Abstract of the research)

The continuous development of new drug delivery systems is driven by the need to maximize therapeutic activity while minimizing negative side effects. Recently, more attention is given to LDHs containing drug molecules due to its unique properties such as enhanced dissolution property, increased thermal stability and control the drug release. LDH is one class of drug delivery vehicle that has received more attention because it can accommodate polar organic compounds between their layers and form a variety of intercalated compounds. Intercalation compounds with biologically active species could thus provide composites with ability to control the drug release. Hydrotalcite-like compounds based on Mg and Al hydroxycarbonates are the most suitable layered host because of their biocompatibility and because there are already used in their medicine as antiacid and antipepsin activity [4]. Because the release of drugs is potentially controllable, these new drug-inorganic composite have a great potential as a delivery host in the pharmaceutical field in preparing a controlled release formulation.

Layered double hydroxides (LDHs), also called anionic clays, displays unique physical and chemical properties surprisingly close to the properties of clay minerals. Layered double hydroxides are group of inorganic materials which can be used as biocompatible materials or as host compounds. LDHs are layered solids having positively charged layers and interlayer charge compensating anions. The chemical composition of LDHs can be represented by the general formula $[M^{II}_{(1-x)}\ M^{III}\ (OH)_2]^{x+}\ A^{z-}_{x/z}\ .\ yH_2O$ or $[M^{I}\ M_2^{III}\ (OH)_2]^{+}\ A^{z-}_{1/z}\ .\ yH_2O$ where M^{I}, M^{II} and M^{III} are mono, di- and trivalent cations, respectively, occupying octahedral positions in hydroxide layers, and A^{z-} is an interlayer charge-compensating anion.

Lawsone (Law) [2-hydroxy-1,4-naphtaquinone] is a red orange dye present in the leaves of *henna* plant. Human have used *henna* extracts containing lawsone as hair and skin pigments for many years. Lawsone strongly absorbs UV light and aqueous extracts can be effective sunless tanning sunscreens. Nowadays, lawsone is becoming more and more popular due to its profound effect on human health. In the present study, lawsone was selected as biological active species and intercalated into Zn and Al layered double hydroxides by both co-precipitation and ion exchange techniques. The study focuses on the intercalation structure through characterizations of intercalation compound by using Powder X-ray diffraction (PXRD), Fourier transform infrared (FTIR) and TG-DTA analysis.

5.3 Introduction

Background

Layered Double Hydroxides

Clays can be divided into two broads groups, namely cationic clays, which nature prefer and anionic clays, which is less common. Clays can be prepared synthetically or chemically to enhance certain desirable properties. Clay minerals are composing of infinite layers of metal or non-metal oxides and hydroxides stacked on top of each other. For cationic clays, the charges of interlayer cations neutralize the negatively charge sheets. However, anionic clays have positively charged metal oxide or hydroxide layers with anions located at interstitial position. Layered double hydroxides can be grouped as anionic clay. They are rarely found in nature and it's containing exchangeable anions. The mineral consisting mainly Mg^{2+}, Al^{3+} and CO_3^{2-}, in which the metal ions forming the sheets or layers and CO_3^{2-} as interstitial anion.

Historical Background

Layer double hydroxides (LDHs) were first discovered in Sweden around 1842 (Cavani *et al.*, 1991). It occurs in nature foliated and contorted plates or fibrous masses. The first reports of synthetic layered double hydroxides appeared in the 1930's when Feitknecht produced small quantities by reacting dilute aqueous metal salt solutions with base. After appropriate aging, washing and drying solids were obtained which had the distinctive X-ray powder patters of hydrotalcite. Layer double hydroxide (LDHs) exhibit anion-exchange properties, i.e. anions in the interlayer may be exchanged with the other ones. They can be employed for preparation of compound intercalated with various anions or removal of anions from solutions.

Structure of layered double hydroxides

Layered double hydroxides (LDHs) or anionic clays have been of interest to researchers of different discipline in chemistry due to their many applications specially as adsorbents, ion-exchangers, catalysts precursors and more recently in pharmaceutics for drug release control. LDHs are minerals and synthetic materials that consist of layered structure with positive charge brucite-type ($Mg\,(OH)_2$) layers of mixed metal hydroxides. In brucite, magnesium atoms are coordinated to hydroxyl groups in an octahedral geometry resulting in layers that interact with each other by weak forces. Exchangeable anions are located in the interlayer spaces to balance the positive charge of the layers.

Layer double hydroxides (LDHs) have a general formulation of $[M^{+2}_{1-x}\,M^{+3}_{x}\,(OH)_2]^{+x}$ $(A^{m-})_{x/m}.nH_2O$, where M^{+3} and M^{+2} represent metal atoms arranged octahedrically within the structure and A^{m-} represents a general anion such as Cl^-, OH^-, CO_3^{-2}, etc. Trivalent metal atoms have substituted some divalent metal atoms, which creates positively charged layers. The generation of an organic-inorganic hybrid material is accomplished by incorporating an organic anion in the interlayer space of the layered inorganic matrix by a typical ion-exchange mechanism between the anion sited, which is free to move, and the organic anion. It is also possible to exchange not only organic but also inorganic anions, as well as complexes at varied oxidation states.

The layer surfaces of LDHs are structurally similar to Kaolinite ($Al_2Si_2O_5$), in which it is a dioctahedral layered alminosilicate, consists of aluminum atoms coordinated