

Drug delivery system based on inorganic layered materials

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ABSTRACT

The nanocarrier Layered Double Hydroxide (LDH) was used to intercalate the antioxidant molecule lipoic acid. The nanomaterial was isolated and characterized by a set of physical chemical techniques such as powder X-ray diffraction (XRD), elemental analysis, vibrational infrared spectroscopy (FTIR), thermal analysis, size and zeta potential. The XRD results show the intercalation of the molecule between the layers in a bilayer arrangement.

Keywords: layered double hydroxide, lipoic acid, nanomaterials, spectroscopy, intercalation.

1 INTRODUCTION

In recent years, studies on nanomaterials for drug delivery systems have been intensified in the nanotechnology field due to the improvement of solubility, stability against decomposition processes, and sustained release of biological species.¹ Layered Double Hydroxides (LDHs) are well known inorganic carriers which have been explored during the development of new materials for medicinal and pharmacological applications.² These inorganic materials are biocompatible and are known to have antacid activity.³ The solubility and chemical stability of guest species can be increased when intercalated between LDH layers.⁴ LDHs can support the release of intercalated bioactive species through ion exchange reactions and/or chemical processes mediated by changes in pH. In this study, synthetic routes and experimental parameters were determined for the confinement of the anionic form of lipoic acid (abbreviated Lip), a natural substance which displays antioxidant activity, and which can be used for the Alzheimer disease and Parkinson's treatment.

2 MATERIALS AND METHODS

The inorganic carriers containing the bioactive species were synthesized by the co-precipitation method, using molar ratios of $M^{2+}/Al^{3+} = 2$ and $Lip/Al^{3+} = 1$. Samples were labeled as $M_2AlLip.y$, where M can either mean Mg^{2+} or Zn^{2+} , and y denotes one of the following drying processes: (i) lyophilization (lyo) and (ii) room temperature with reduced pressure in a dessicator (des).

3 RESULTS AND DISCUSSION

XRD patterns of all isolated LDH-lipoate materials (Fig. 1) show the peaks regarding to the Layered Double Hydroxide structure and the intercalation of lipoate anions in the interlayer region. The peak $d_{(003)}$ which is related to the basal spacings of the layers was shifted from 0.78 nm for Mg_2AlCl to 2.26 nm for $Mg_2AlLipdes$, 2.19 nm for $Zn_2AlLip.lyo$, and 2.24 nm for $Zn_2AlLip.des$ indicating the expansion of the interlayer region. The materials prepared with Zn^{2+} exhibit a more organized stacking of the layers.

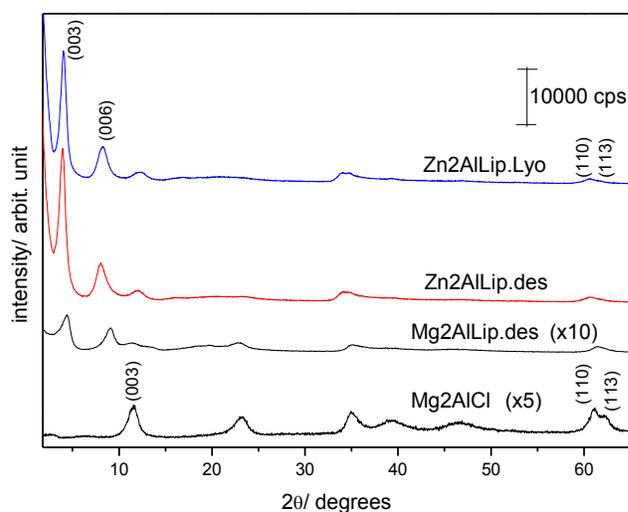


Figure 1: XRD patterns of powdered $Zn_2AlLip.Lyo$, $Zn_2AlLip.des$, and $Mg_2AlLip.des$ (from top to bottom).

Evaluating the XRD data by employing the Debye-Scherrer equation for the peak (003), we find that the mean crystallite size of the materials is 15.1 nm for $Mg_2AlLipdes$, 20.9 nm for $Zn_2AlLip.lyo$, and 22.2 nm for $Zn_2AlLip.des$.

From the estimated dimensions of lipoate (0.44 x 1.21 x 0.36 nm) and the XRD data, one can suggest an arrangement of a bilayer (Fig. 2) of the organic anion in the interlayer region.

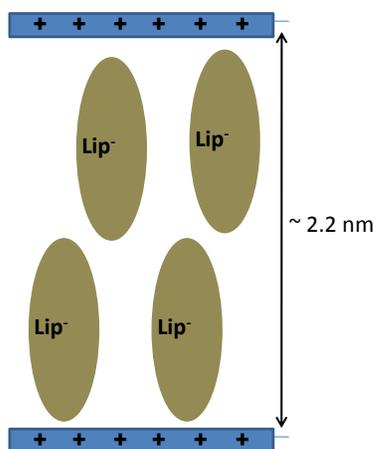


Figure 2: Schematic representation of the arrangement of lipoate anion into the interlayer region of the LDH.

FTIR spectra showed in Figure 3 display the bands of lipoate ion (Lip^-): CH_2 stretching ($\sim 2928 \text{ cm}^{-1}$), COO^- asymmetric stretching (1545 cm^{-1}), COO^- symmetric stretching (1408 cm^{-1}), S-C stretching (681 cm^{-1}) and S-S stretching (523 cm^{-1}).

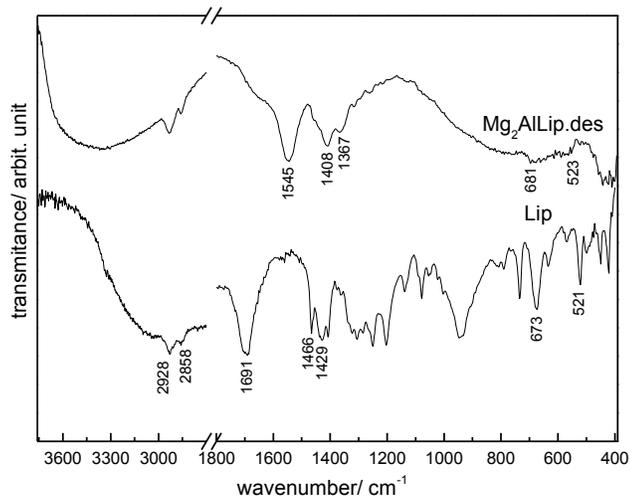


Figure 3: FT-IR spectra of lipoic acid and $\text{Mg}_2\text{AlLip.des}$ samples.

Unlike the dessicator process, the lyophilization process drastically changed the stability of the suspension in water, i.e. the Zeta potential of $\text{Zn}_2\text{AlLip.lyo}$ was $+ 28.2 \text{ mV}$, while that of $\text{Zn}_2\text{AlLip.des}$ was found -7.49 mV . Elemental analysis data of the hybrid materials showed that the different compositions of the layered materials used did not alter the organic content in the materials. The amount of lipoate ions (wt.%) in the isolated materials was roughly 39%.

The thermal decomposition (Fig. 4) of lipoic acid under air begins at $180 \text{ }^\circ\text{C}$, while for the hybrid materials that process starts at approximately $230 \text{ }^\circ\text{C}$. Hence, the thermal

stability of the immobilized species in the LDHs interlayer region was significantly improved. LDHs are potential carriers for lipoate storage and delivery.

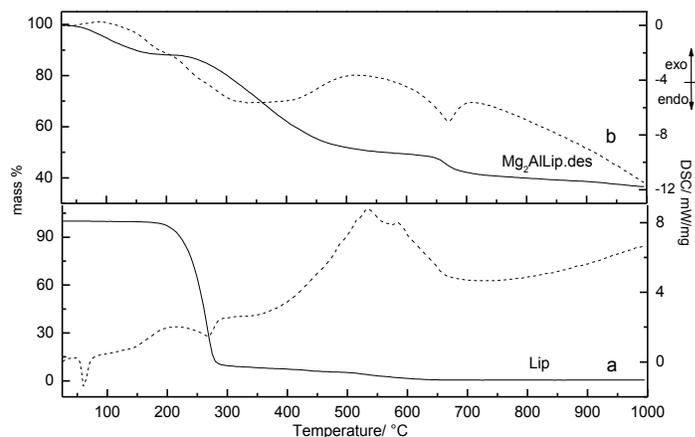


Figure 4: TGA-DTG of lipoic acid and $\text{Mg}_2\text{AlLip.des}$ samples.

CONCLUSION

The results of the PXRD, FT-IR, TGA/DTG and Elemental analysis suggest the presence of the organic compound in the LDH materials.

The data of PXRD showed that the materials prepared with Zn^{2+} increased the crystallinity of the obtained hybrids materials.

FT-IR shows the presence of the anion Lip^- by the bands related to the asymmetric and symmetric stretching of the carboxylate group at 1545 and 1408 cm^{-1} , respectively.

TGA-DTG data shows that the confinement of the organic species in LDH increases its thermal stability.

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