Kinetic Controlled Release Study of Salicylate Anion from Synthesized and Characterized of Ni/Al-salicylate- Layered Double Hydroxide Nanohybrid .

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الخلاصة

حضرت طبقات نيكل/ المنيوم ثنائية الهيدروكسيد المقحمة بأنيون الساليسلايت لانتاج المركبات النانوية الهجينة بطريقة التبادل الايوني المباشر بنسب مولية (R = 4). المادة النانوية الناتجة شخصت بواسطة تقنية طيف الاشعة تحت الحمراء (FTIR) وطيف حيود الاشعة السينية (XRD). تم دراسة تحررية الانيون العضوي الساليسلايت في الوسط المائي لأيونات هيدروجين فوسفات والكبريتات حيث وجد ان كمية الانيون العضوي المتحرر في الوسط الحاوي لايونات هيدروجين فوسفات اكبر من الكبريتات. حركية التحرر لأنيون الساليسلايت قدرت بمعادلات مختلفة من الرتبة الصفرية والاولى والثانية الكاذبة ولوحظ ان عملية التحرر تخضع لتفاعل المرتبة الثانية الكاذبة للانتشار.

Abstract

Synthesis of Ni/Al- layered double hydroxides intercalated with Salicylate Anion to obtaining nanohybrid compounds. The ion exchange method was used with molar ratio Ni/Al = 4. The resulted material was characterized by Fourier transform infrared spectra (FT-IR),XRD (X-ray diffraction),and the release profiles of the guest anion to hydrogen phosphate and sulphate aqueous media. The accumulated release in to hydrogen phosphate more than sulphate. Release kinetics of salicylate anion has been evaluated with various models such as zeroth order, first order and pseudo- second order. It is observed that the release profiles of salicylate Anion were governed by pseudo second order.

Keywords: *Salicylate Anion, Hydrogen Phosphate, Sulphate Aqueous Media FT-IR, XRD,*

Introduction

Salicylic acid (SA; from the Latin salix, willow tree, from the bark of which the substance is obtained) is a monohydroxybenzoic acid, a type of phenolic acid, and a beta hydroxy acid **Figure 1.** The formula of SA is $C_6H_4(OH)COOH$, where the OH group is ortho to the carboxyl group. SA is also known as 2-hydroxybenzenecarboxylic acid. SA is poorly soluble in water [1]. This colorless crystalline organic acid is extensively used in organic synthesis and functions as a plant hormone.

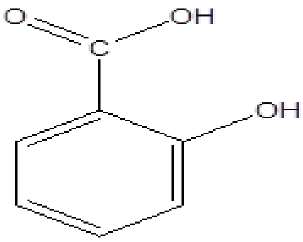

Fig. 1: Molecular Formula Of Salicylic Acid.

SA is a phenolic phytohormone and is found in plants. It plays a role in plant growth and development, photosynthesis, transpiration, ion uptake, and transport. SA also induces specific changes in leaf anatomy and chloroplast structure. SA is involved in endogenous signaling and mediates plant defense against pathogens [2]. SA has a role in resistance to pathogens by inducing production of pathogenesis-related proteins [3]. In addition, SA is involved in systemic acquired resistance, in which a pathogenic attack on one part of the plant induces resistance in other parts. The signal can also move to nearby plants through conversion of SA into methyl salicylate, a volatile ester [4].

Pollution of soil textured salicylate and other contaminants could lead to interaction and production of toxic substances that seep into groundwater; this entry of toxic substances into groundwater is considered an important factor that affects human health. To reduce this phenomenon, nanohybrid compounds such as layered double hydroxides (LDHs) have been prepared.

LDHs, which are also known as anionic or hydrotalcite-like clays, are a class of lamellar compounds that consist of positively charged brucite-like host layers and hydrated exchangeable anions located in the interlayer gallery for charge balance. The charge of the brucite-like layers increases from isomorphous substitution of divalent metal ions with trivalent metal ions [5]. The chemical composition of LDHs is expressed by the general formula $[M^{2+}{}_{1-x} M_x{}^{3+} (OH)_2]\cdot[A^{n-}{}_{x/n}\cdot mH_2O]$, where M^{2+} and M^{3+} represent metallic cations such as Mg^{2+}, Ca^{2+}, and Cu^{2+}. A^{n-} is an interlayer anion of charge n such as Cl^{1-}, $CO_3{}^{2-}$, $NO_3{}^{1-}$, $SO_4{}^{2-}$, or organic anions. The x value is equal to the molar ratio of $M^{2+}/[M^{2+} + M^{3+}]$. The crystal structure consists of positively charged brucite-like octahedral hydroxide basal layers, which are electrically neutralized by interlayer anions and water molecules that occupy interlayer spaces [6].

By contrast, the plant body requires only a small amount of hormones (salicylate) for physiological functions. Insufficient and excessive hormone supplies are harmful to the plant body [7]. For reliable supply, developing a controlled delivery system for hormones is necessary. In this regard, LDH could be an excellent candidate matrix because of its high anion exchange capacity and biocompatibility.

This study deals with the synthesis and controlled release of salicylate–LDH for advanced drug delivery. The salicylate–LDH hybrid system can potentially relieve adverse properties. In addition, controlled release of salicylate from LDH operates like clockwork.

Experimental

Materials

Sodium Salicylate (HOC_6H_4COONa) and Sodium hydroxide pellets were obtained fromHiMedia Laboratories. $Al(NO_3)_3.9H_2O$ (98%) was obtained from xinbao nice chemical.NaOH and $Ni(NO_3)_2.6H_2O$ (98%) were obtained from xilong chemical. All chemicals were of analytical grade and used without further purification.

Preparation of Ni-Al –NO_3- LDHs

Ni/Al-LDHs with nominal Ni^{2+}/Al^{3+} molar ratio of (4), was prepared by hydrothermal reaction at 70 °C. The Ni-Al-NO_3-LDHs have been prepared by co-precipitation method[8,9] fromNi and Al nitrate. Amixed aqueous solution containing 0.1M (1.45g) Ni(II) and 0.025M (0.468 g) Al(III) , was titrated drop wise with NaOH (2M) solution. The pH was adjusted to 10.5 and the mixture was magnetically stirred at 70˚C for 18h. The suspension was transferred into a 500 ml stainless Teflon-lined autoclave and heated at appropriate temperature for 24h, and then left to room temperature. The resulting green precipitate was isolated by filter paper, washed four times with deionized water, and then dried at 70 °C.

Prepration of Ni/Al-Salicylate-LDHs by Ion-Exchange Method

The green precipitate of Ni-Al-NO_3-LDHs with (molar ratio 4) was dispersed in 50 ml deionized water and then drop wise with 100 ppm Sodium Salicylate. The mixture was magnetically stirred at 70°C for 18 h, and then filtered, washed with deionizedwater four timesto remove the excess amount of nitrate ion and then driedat 70°C for 24 h.

Results And Discussion

FT-IR Spectra

The bands in the spectrum of sample Ni-Al-NO_3-LDHs, also shown in Fig. 2 , it is due to the ν(OH) of the layered double hydroxid mode in the 3558 cm^{-1}[10]. The band 1380cm^{-1} is due to the intercalation of the counter anion (NO_3^-). The bands between 426-700 cm^{-1} are due to ν(Ni-O) and ν(Al-O) [11]. The FT-IR spectrum ofSodium Salicylate shown in Figure 2, has been recorded to be compared with those of the solids prepared. The band at 1587 cm^{-1} can be ascribed to the ν (C=O) mode of the carboxylates group, while that for the hydroxyl group is recorded atbroad3444 cm^{-1} [12]. The bands between 1450-1500 $cm^{-1}$are due to the ν (C-C) stretching modes of the aromatic rings. The bands in the spectrum of sample Ni-Al-Salicylate-LDHs, also shown in figure 2, the new bands due to the ν(OH) of the layered double hydroxide mode in the 3512 cm^{-1} [13]. The band at 1593 cm^{-1} can be ascribed to the ν(C=O) mode of the carboxylate group. Upon comparing FT-IR spectra of the hybrids with those of Sodium Salicylate, it is clear that the intercalation reactions are successfully completed without any denaturation of the drug molecules [14].

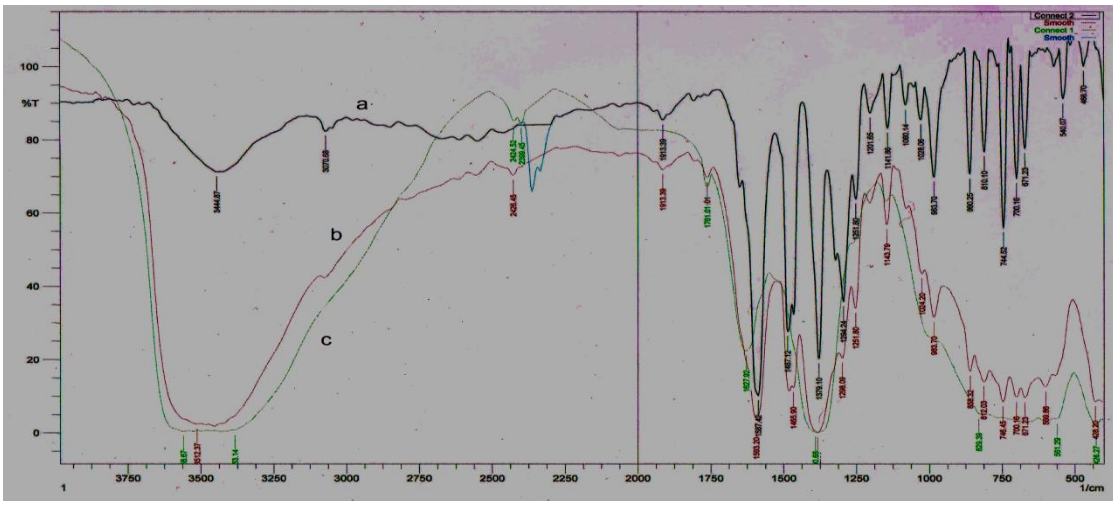

Fig. 2: The FT-IR Spectra for (a): Sodium Salicylate, (b): Ni- Al- Sal- LDHs, and (c): Ni- Al- NO_3- LDHs.

Powder X-Ray Diffraction .

Powder X-ray diffraction patterns of the solid obtained that indicate after hydrothermal treatment at 70 C°.A Ni-Al-NO_3-LDHs nanohybrid has been formed fig.(3)for sample Ni-Al-NO_3-LDHs R=4 ion-exchange the basal reflections are recorded at 0.906 nm (003), 0.502 nm (006), and 0.290nm (009), respectively and particle dimension (d_{003}) is 2.718 nm. On the other hand , the basal reflections of sample Ni-Al-Sal-LDH is 1.430 nm (003), 0.705nm (006), and

0.385 nm (009), particle dimension (d_{003}) is 4.290 nm . Compared to values of (003), (006), and (009) between patterns of Ni-Al-NO_3-LDHs, and Ni-Al-Sal-LDHs, we find values of (003) diffraction line increase with presence drug as well as (006) and (009), intercalation of drug leads to a significant increase in the interlayer space [15,16].

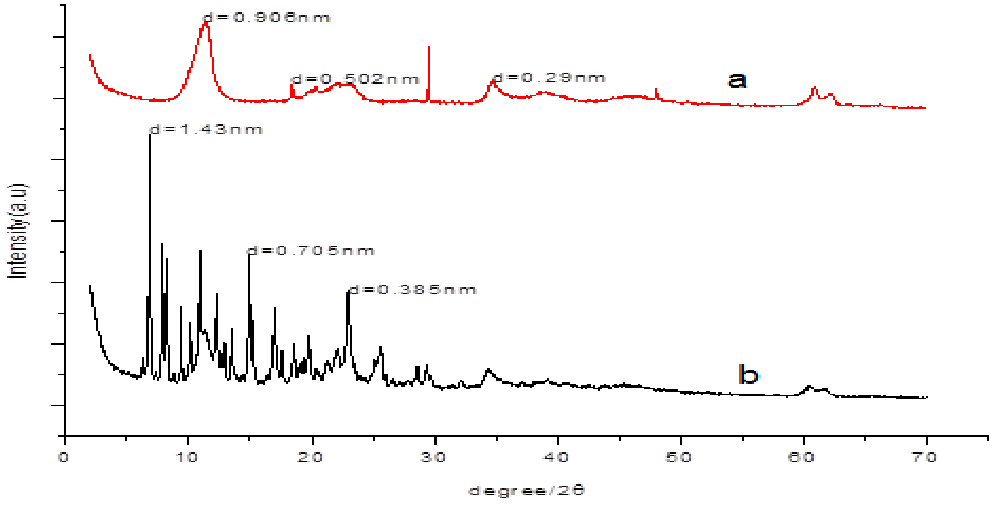

Fig. 3: X-Ray Powder Diffraction Patterns (a) Ni-Al-NO_3-LDH (b) Ni-Al- Salicylate-LDH

Release Study of Salicylate into Aqueous Solution

The drug release properties of Sodium salicylate from the nanohybridinterlamellae in to two aqueous media using (0.5 , 0.005) M of Na_2HPO_4 and Na_2SO_4 have been conducted. **Figure 4** show the release profiles of drug in to both aqueous solutions. The effects of various aqueous systems on the release of salicylate anion were evaluated according to the maximum accumulated release and can be written as follows :

Hydrogen Phosphate > Sulphate.

Table 1: Percentage Release , Rate Constant (K), Half life ($t_{1/2}$) and Correlation Coefficients (r^2) Obtained From Fitting Of The Release Data of (Sal) From Ni-Al-Sal-LDH Nanohybrids In To Various Aqueous Solution (Ni/Al=4-Ion Exchange).

Aqueous Solution	Conc.(Mol) L^{-1})	Max. Release%	Max. Time(Min)	Zeroth Order	First Order	Pseudo Second Ord.	Other Parameters For Pseudo Second Ord.	
					r^2		$K\times10^4$ L. $mg^{-1}.min^{-1}$	$t_{0.5}$(min)
Na_2HPO_4	0.5	98	2850	0.792	0.891	0.999	1.9	32.5
	0.005	94	2850	0.817	0.966	0.994	13	4.55
Na_2SO_4	0.5	87	2850	0.744	0.884	0.997	15	4.8
	0.005	86.5	2850	0.817	0.876	0.986	18	3.6

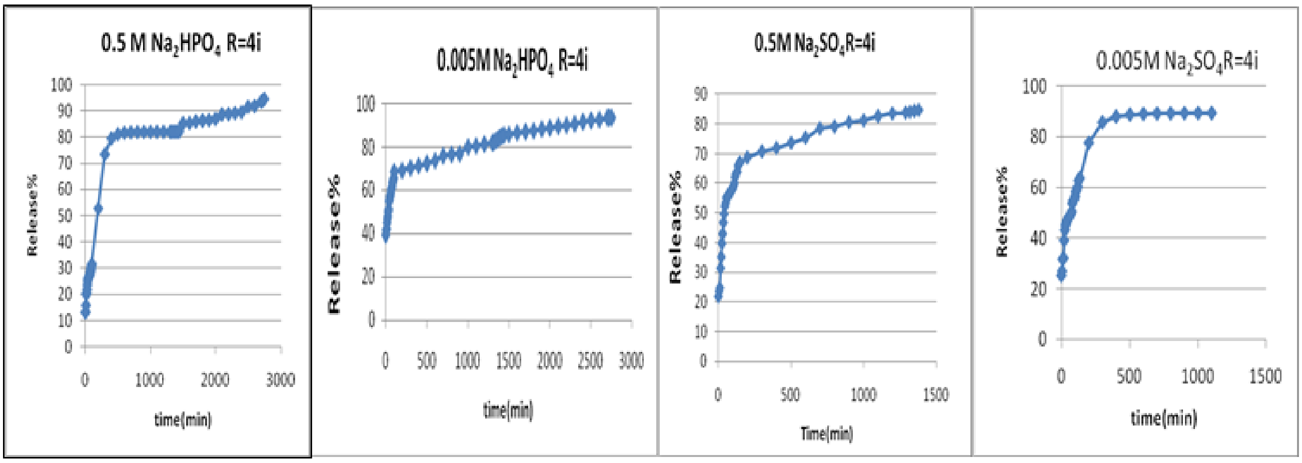

Fig. 4: Release Profiles Of (Salicylate Anion) From The Interlamellae of Ni-Al-Sal-LDHs, R=4 Nanohybrid In To Two Aqueous Systems With Concentrations Were Containing Anions Of Hydrogen Phosphate And Sulphate.

Finally, according to the release profiles and the amount of salicylate anion (Sal)R=4 intercalated, it is observed that the compound is more convenient. The results indicate that the amount of salicylate anion intercalated depends on the structure and layer charge, it can be seen that the compounds [17].

Release Kinetics

In order to explore the release mechanism, we applied three kinetics were previously mentioned to fit the release kinetic data **Figure 5** and calculated the corresponding linear correlation coefficients (r^2) from the **Table 1**. compared with the Zeroth order and first order, while pseudo second order kinetic model which is the more fitted model for the release of salicylate which is reflected by the obviously higher linear correlation coefficient of r^2 as in **Table 1**. It is given that the salicylate molecule is suffered much immobilized when it diffused through the inter particle in the case of Ni/Al-LDHs .

Thus, the release profiles were fitted by zero order, first-order and Ho's pseudo-second-order equation[19] (in " 1 ", "2 ", "3") respectively, which is normally used to describe the dissolution, phenomena:

$$\mathbf{X = Kt + C \;\ldots\ldots\ldots\ldots\ldots\ldots\; (1)}$$

$$\mathbf{-\ln(1 - X) = Kt + C \;\ldots\ldots\ldots\ldots\ldots\ldots\; (2)}$$

$$\mathbf{t/Ct = 1/K_2Cf^2 + (1/Cf)t \;\ldots\ldots\ldots\ldots\ldots\ldots(3)}$$

(X) is the release percentage of salicylate anion at time t (min) and C is a constant. K is a rate constant, Ct the concentration of (Sal) at time t, Cf the final concentration of (Sal).

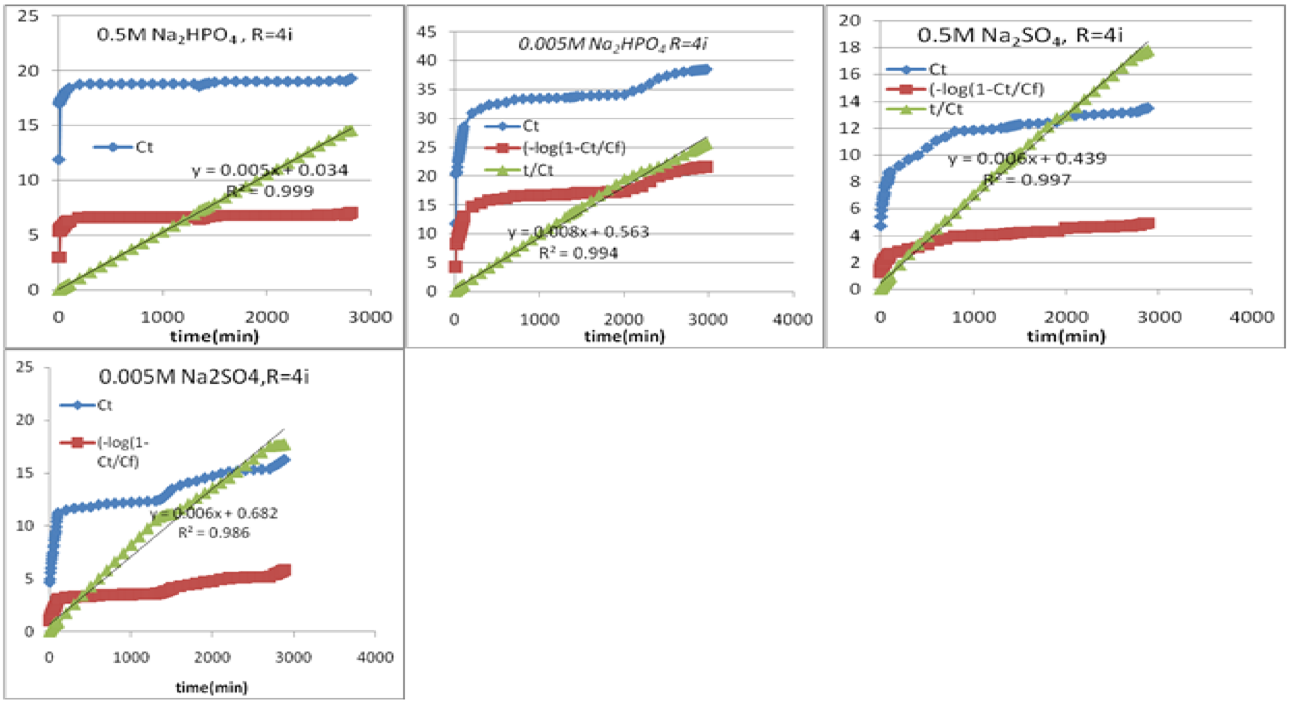

Fig. 5: Fitting Of The Data To The Zeroth , First And Pseudo-Second Order Kinetics For Salicylate Anion Released In To Different Aqueous Solution (Ni/Al=4 Ion-Exchange).

The release of salicylate anion from the inorganic LDH interlamellae involved dissolution of the nanocomposite as well as diffusion of the intercalated anion. The dissolution phenomena take place by ion-exchange process between the intercalated anions and the incoming anion such as hydrogen phosphate and sulphate anions in the aqueous solution can be better described by pseudo-second order kinetics because the mechanism of release has been interpreted on the basis of the ion-exchange process between the drug anion intercalated in the lamella host hydrogen phosphate, or sulphate anions in aqueous solution i.e. depending on two factors : incoming and outgoing anion. In addition, the dissolution time will represent the total time of how long the molecule spends outside the interlamellae host as well as the pseudo-second order model will represent the dissolution as well as diffusion phenomena [17,18].

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