SYNTHESIS AND CHARACTERIZATION OF ZINC LAYERED HYDROXIDE INTERCALATED WITH 4-AMINOBENZOIC ACID AS SUNSCREEN FORMULATION

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ABSTRACT

The aims of this study were to synthesis and characterize zinc layered hydroxide intercalated with 4-aminobenzoic acid (ZAB) as a sunscreen formulation. ZAB was successfully synthesized from 4-aminobenzoic acid (4-AB) and zinc oxide (ZnO) precursor using direct method. The intercalation of compound was confirmed by using powder x-ray diffraction (PXRD) pattern with a basal spacing of 23.2 Å at lower 2θ angle. The result was supported by fourier transform infrared (FTIR) spectrum where the signal of carboxyl and amine functional groups were observed at 1518 and 1174 cm^{-1}, respectively. Thermogravimetric analysis and deferential thermal gravimetric (TGA/DTG) showed that ZAB material was more stable compared to pure 4-AB. Carbon composition in the material acquired from carbon, hydrogen, nitrogen and sulphur (CHNS) analysis was 19.2%. This composition is close to theoretical value of 21% of carbon presence in ZAB. Surface area of ZAB obtained from breuneur, emmet and teller (BET) analysis was 53.80 m^2/g much higher compared to 3.38 m^2/g of ZnO material which was caused by the modification of ZnO pore texture transformed into layered intercalation compound. Field emission scanning electron microscopy (FESEM) morphology of ZAB clearly showed that the material was flake-like shape with different sizes after intercalation process. Kinetics release study of anion from interlayer of ZAB fitted to pseudo-second order with 0.945 of correlation coefficient (r^2) exhibited the highest accumulated released of 4-AB anion was in pH 5.5 phosphate buffer solution. Cytotoxicity study demonstrated human dermal fibroblast (HDF) cells were exposed to ZAB concentration at below 25.0 µg/mL experienced less than 50% of cell viability reduction, indicating no cytotoxicity effect to HDF cells. In conclusion, ZAB material has been successfully synthesized and characterized. The implication of this study is to offer non-toxic formulated sunscreen that potential to improve pharmaceutical technology and medical care.

SINTESIS DAN PENCIRIAN ZINK HYDROKSIDA BERLAPIS DIINTERKALASI DENGAN ASID 4-AMINOBENZOIK SEBAGAI FORMULASI PERLINDUNG MATAHARI

ABSTRAK

Tujuan kajian ini adalah untuk mensintesis dan mencirikan zink hidroksida berlapis diinterkalasi dengan asid 4-aminobenzoik (ZAB) sebagai formulasi pelindung matahari. ZAB berjaya disintesis daripada asid 4-aminobenzoik (4-AB) dan pemula zink oksida (ZnO) dengan menggunakan kaedah terus. Interkalasi sebatian telah disahkan dengan menggunakan corak pembelauan serbuk sinar-X (PSSX) dengan jarak basal 23.2 Å di bawah sudut 2θ. Keputusan tersebut disokong oleh spektrum inframerah transformasi fourier (IMTF) di mana isyarat kumpulan berfungsi karboksil dan amina diperhatikan masing-masing pada 1518 dan 1174 cm^{-1}. Analisis termogravimetrik dan perbezaan termogravimetrik (ATG/PTG) menunjukkan bahawa sebatian ZAB adalah lebih stabil berbanding dengan 4-AB tulen. Komposisi karbon dalam sebatian yang diperolehi dari analisis karbon, hidrogen, nitrogen, sulphur (KHNS) ialah 19.2%. Komposisi ini adalah hampir kepada 21% nilai teoritikal kehadiran karbon dalam ZAB. Luas permukaan ZAB yang diperolehi daripada analisis breuneur, emmet dan teller (BET) ialah 53.80 m^2/g jauh lebih tinggi berbanding dengan 3.38 m^2/g bahan ZnO adalah kerana pengubahsuaian tekstur liang ZnO yang berubah menjadi sebatian interkalasi berlapis. Morfologi mikroskop elektron pengimbas pancaran medan (MEPPM) bagi ZAB jelas menunjukkan bahawa sebatian tersebut ialah berbentuk seperti empingan dengan saiz yang berbeza selepas proses interkalasi. Kajian kinetik pelepasan anion dari lapisan ZAB yang mematuhi tertib pseudo-kedua dengan nilai 0.945 bagi pekali korelasi (r^2) telah menunjukkan pelepasan anion 4-AB tertinggi terkumpul adalah dalam larutan penimbal fostat pH 5.5. Kajian sitotoksik telah menunjukkan sel-sel fibroblast derma manusia (FDM) yang terdedah kepada kepekatan ZAB di bawah 25.0 µg/mL mengalami pengurangan sel hidup kurang daripada 50% menunjukkan tiada kesan sitotoksik ke atas sel FDM. Kesimpulannya, sebatian ZAB telah berjaya disintesis dan diciri kan. Implikasi kajian ini ialah untuk menawarkan pelindung matahari yang diformulasi tanpa toksik berpotensi untuk meningkatkan teknologi farmaseutikal dan rawatan perubatan.

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LIST OF ABBREVIATIONS

4-AB	4-Aminobenzoic Acid
Å	Amstrong
ASAP	Accelerated Surface Area and Porosity
BET	Brenaeur-Emmet-Teller
BJH	Barret-Joyner-Halenda
CHNS	Carbon, Hydrogen, Nitrogen and Sulphur
FTIR	Fourier Transform Infrared Spectroscopy
HDF	Human Dermal Fibroblast
ICP-OES	Inductive Couple Plasma Optical Emission Spectrometry
KBr	Potassium Bromide
LDH	Layered Double Hydroxide
LHS	Layered Hydroxide Salt
MTT	3-[4,5-dimethylthiazol-2-yl]-2,5 diphenyltetrazolium bromide
NaCl	Sodium Chloride
PXRD	Powder X-Ray Diffraction
SEM	Scanning Electron Microscopy
TGA-DTG	Thermogravimetric and Differential Thermal Gravimetric Analyses
ZnO	Zinc Oxide
ZAB	Zinc Layered Hydroxide-4-Aminobenzoic Acid-Nanocomposite
ZLH	Zinc Layered Hydroxide

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Sunlight is very important for every living thing such as providing warmth, light and supporting life through photosynthesis in the plants. On the other hand, it also provides vitamin D to human skin for bones maintenance. Sunray consists of ultraviolet radiation, which can be divided into UV-A (320-340 nm), UV-B (290-320 nm), and UV-C (100-290 nm) (Kockler, Oelgemöller, Robertson, & Glass, 2012). An excessive exposure of UV radiations to the skin can cause premature skin ageing, sunburns, and development of skin cancer. Therefore, an application of sunscreen is needed to prevent these problems.

There are many types of sunscreen in the pharmaceuticals and personal products (PCPs) that are sold in the market. Sunscreen is used to protect our skin by reflecting or absorbing the UV radiation from the sun. Many sunscreens that are available in the market are essential products to prevent UV radiation to reach the skin. Sunscreen consists of UV filter that acts as an absorber and reflector of UV radiation, thus, protecting the skin from severe risk. Nowadays, UV filters are not only focused on the sunscreen itself but also present in other cosmetic products such as lipstick, skin care, and hair products (Klimová, Hojerová & Beránková, 2015; Donglikar & Deore, 2016).

Even though sunscreen is good as skin protector from UV radiation, however, using a high concentration of the sunscreen can cause toxicity to the body since UV filter can be absorbed by the epithelial cell then goes to the internal organ in the human body. Therefore, encapsulated of UV filter with the layered double hydroxide is important to prevent this happening. In this research, we discover the potential of zinc layered hydroxide-4-aminobenzoic acid (ZAB) used as a sunscreen application. The study of the resulting material also has been studied in order to investigate the toxicity of 4-AB released from ZLH inorganic layer to human dermal fibroblast cell (HDF).

1.1.1 Sunscreen

According to Salvador and Chisvert (2005), sunscreen cosmetic can be defined as a cosmetic product containing UV-filters in its formulation to protect skin from the solar deleterious UV-light, avoiding from the sun, and minimizing radiation light that can damage human health. Topical sunscreen has active organic and inorganic ingredients filter with the functions to absorb and scatter UV radiation from the sun. The organic filter usually contains an aromatic ring, which acts to absorb radiation in the UV wavelength while inorganic filter (ZnO and TiO) function as a physical barrier between skin and UV radiation (Osmond-McLeod et al., 2016).

In order to provide a broad spectrum to the user, the ratio between protection of UV-A range and UV-B range must be less than three and the critical wavelength must exceed than or equal to 370 nm based on the European guidelines in 2006 (Couteau, Diarra, & Coiffard, 2016).

According to Nohynek & Schaefer (2001), an ideal sunscreen should have these criteria:

i. UV filter is safe to use on skin (nonirritant, nonphototoxic, and nonsensitising)
ii. Photostable in order to avoid degradation of the product
iii. Cover and protect the skin (does not penetrate to avoid systemic exposure to the substance)
iv. Suited for formulation in cosmetic preparations (water resistant, tasteless, odourless, and colourless)

Sunscreen is usually categorized into two types namely are organic and inorganic UV filter, which acts as an absorber and scatter UV radiations from the sun. The organic UV-filter can be classified into different derivatives such as cinnamates derivatives, dibenzoylmethanes derivatives, para-aminobenzoic acid (PABA) and its derivatives, triaminotriazine derivatives, and others. Besides that, inorganic UV filters that are commonly used are zinc oxide (ZnO) and titanium oxide (TiO_2) (Kockler et al., 2012). The organic UV filters composed have single, multiple aromatic structures, conjugated with carbon-carbon double bonds, and carbonyl moieties enable it to impair the transmission of the photons from the UV radiations (Stiefel & Schwack, 2014).

Sun Protection Factor (SPF) plays an important role to exploit the effectiveness of the sunscreen. In 1962, Dr. Franz Greiter introduced an SPF testing system in order to determine the efficiency of the sunscreen products (Stiefel & Schwack, 2014). According to Osterwalder, Sohn & Herzog (2014), SPF is the ratio of minimum erythema dose that is produced on the skin (the minimal erythema dose (MED)) as shown in the following equation:

$$SPF = \frac{MED_{protected}}{MED_{unprotected}} \tag{1.1}$$

Sunscreen that is mostly available in the market is oil and emulsion that contain organic and inorganic compound filtering the UV rays from the sun (Couteau et al., 2016) . Pharmaceutical and personal care products (PPCPs) listed the sunscreen as important products to prevent skin cancer (Tsoumachidou, Velegraki, & Poulios, 2016).

1.1.2 4-Aminobenzoic Acid (4-AB)

4-aminobenzoic acid (4-AB) is an aminobenzoic acid derivative that is commonly used as a sunscreen component (Li, Tang, Zhou & Wang, 2016). The molecular structure of 4-AB is presented in Figure 1.1. The structure consists of a benzene ring, which is substituted with an amino and carboxylic group. Prominently, 4-AB acts as the UV-B absorber to prevent UV-B rays from penetrating the skin (Stiefel & Schwack, 2014). However, the use of 4-AB was banned when several reports stated that it can cause allergic contact dermatitis, photo allergic dermatitis, and therefore, it is being substituted with other derivatives (Cursino, da Costa Gardolinski & Wypych, 2010).

4-AB was used to filter UV from the sun because of their ability to absorb rays in the UV-B region. Therefore 4-AB is one of perfect compounds to act as UV filter in the sunscreen formulation (Poon, Kang, & Chien, 2015). All organic UV filter including 4-AB has aromatic moieties where the resonance structure plays an important role to stabilize the excited state in order to absorb the radiation (Osterwalder et al., 2014).

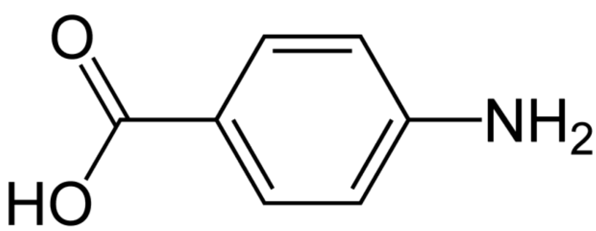

Figure 1.1. Molecular Structure of 4-Aminobenzoic Acid.

UV absorbance maxima (λ_{max}) for 4-AB is 290 nm and this UV filter has electron-releasing group (NR_2) as shown in Figure 1.2. This (NR_2) is substituted with an electron-accepting group, which is the carboxyl group (COOR). This substitution allows the delocalization electron more efficient and this delocalization happens when the energy of the ultraviolet absorption is around 290 nm (Shaath, 2010).

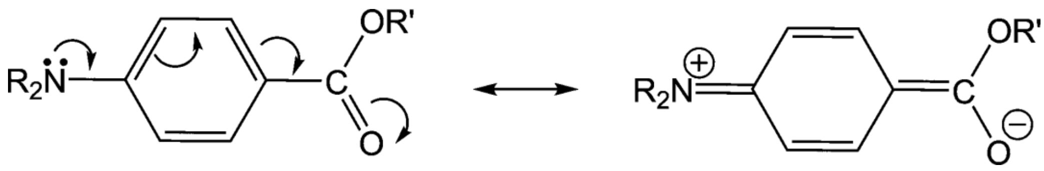

Figure 1.2. The Electron Delocalization in a 4-AB Molecule. Adapted from (Shaath, 2010)

1.1.3 Zinc Oxide

Zinc oxide has a wide-band gap property (~ 3.4 eV) and large excitonic binding energy of 60 meV at room temperature. Due to their optical band gap in the UV region, ZnO has a potential to act as an effective UV absorber (Osmond-McLeod et al., 2016) . This unique property of ZnO exists in three crystalline forms, which are hexagonal wurtzite, cubic zinc-blende structure, and a rarely-observed cubic rock-salt (NaCl-type) (Figure 1.3). Among those crystalline structures, hexagonal wurtzite is the most thermodynamically stable structure (Moezzi, McDonagh & Cortie, 2012). ZnO has been used in many applications such as batteries, piezoelectric, UV-detectors, photocatalysts, coating for papers, pigments in paints, and sunscreen (Kołodziejczak-

Radzimska & Jesionowski, 2014). In the sunscreen formulation, ZnO is one of the broad-spectrum UV absorbers for both UV-A and UV-B range.

Besides that, ZnO does not cause skin irritation because there are no conformations of carcinogenicity, genotoxicity, and reproductive toxicity in the humans (Moezzi, McDonagh & Cortie, 2012). In addition, based on Food and Drug Administration (FDA) approval, there is no concentration limit for ZnO in the sunscreen in Australia and Japan (Osterwalder et al., 2014).

ZnO is considered as a non-toxic compound where it does not irritate the skin and eye. A combination of nanoscale ZnO and TiO (less than 100 nm) with sunscreen brings a wide range spectrum physical sunblock (Monteiro-Riviere et al., 2011). Their unique characteristic such as low skin permeability, high photostability, and the ability to maintain photoprotection for a long period is the main reason to be used in the sunscreen (Kullavanijaya & Lim, 2005).

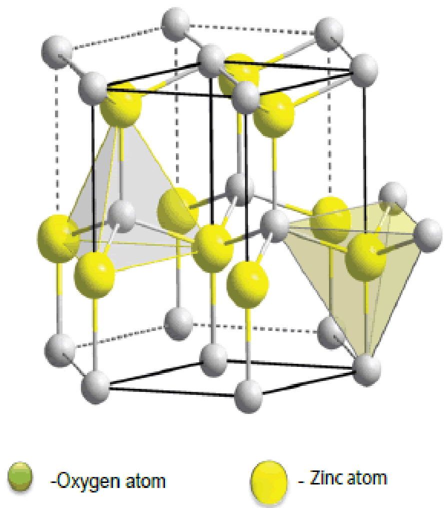

Figure 1.3. The Crystal Structure (Wurzite) of Zinc Oxide. Adapted from (Samanta, 2017)

1.1.4 Nanocomposite

Nanomaterial is a multiphase solid material, which can be divided into three dimensions including zero dimension (chains and clusters), one dimension (thin films), two dimensions (nanofibres, nanowires and others), and three dimensions (nanoparticles and quantum dots) (Nersisyan et al., 2017).

This material particles size is in the range of 1 to 100 nm in one or more external dimensions (Lu et al., 2015). Recently, nanocomposite brings a lot of attention in many application such as agriculture (Maruyama et al., 2016), medicine (Barahuie, Hussein, Fakurazi & Zainal, 2014), biosensor, cosmetics, mechanical industries (Kot et al., 2016) and many more.

The unique features of nanomaterial are it shield reactive organic filters against the chemical degradation by protecting them inside the interlayers and it also improve the properties such as the thermal stability, chemical resistance, flame retardancy, electric conductivity, decrease gas, water and hydrocarbon permeability, mechanical properties (strength, modulus and dimensional stability), and reinforcement (Khan, Saeed, & Khan, 2017; Jeevanandam et al., 2018). The application of nanomaterial is widely used in many sectors such as pigments, coatings, photocatalysts, sunscreens, and semiconductors (Jeevanandam et al., 2018). One of the prominent nanocomposites is layered material hydroxide.

1.1.4.1 Layered Material Hydroxide

Back in the century, hydrotalcite compounds or anionic clay is a hydroxycarbonate of magnesium and aluminium, which occurs in nature in foliated and contorted plates and fibrous masses. This compound was first discovered in Sweden in the 1842 and have a fine structure and easily crushed into a white powder that is identical to talc structure (Cavani, Trifiro & Vaccari, 1991).

Based on Hoyo in 2007, layered double hydroxide (LDH) is named by Feitknecht since he discovered and synthesized a large number of the compound with a hydrotalcite-like structure. Originally, it was named as “Doppelschichtstrukturen”, which give a definition of double sheet structure where the material is composed of intercalated hydroxide layers (Figure 1.4). It is also known as anionic clay because it exhibits unique chemical and physical properties which is similar to clay mineral (Cavani et al., 1991). Layered material hydroxide is divided into layered double hydroxide (LDH) and layered hydroxide salt (LHS) and both of layered material have different of structure and physiochemical (Rojas et al., 2015).

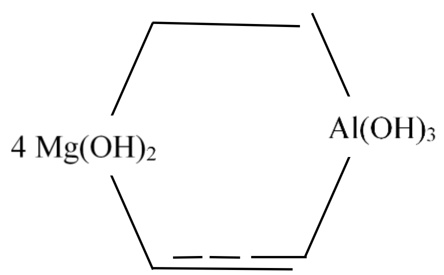

Figure 1.4. The Structure of Doppelschichtstrukturen. Adapted from (Cavani et al., 1991)

1.1.4.2 Layered Double Hydroxide

LDH attracts interest in many areas and one of the most interesting properties of LDH is their unique molecular structure. General formula for LDH can present as $[M^{2+}_{1-x} M^{3+}_{x} (OH)_2] (A^{n-})_{x/n}.yH_2O$ where known as anionic clays consists of brucite layer with positive charges based on the isomorphic divalent of metals (Mg^{2+}, Zn^{2+}, Ni^{2+}, Mn^{2+}, Co^{2+}) or trivalent metal ionic ions (Al^{3+}, Fe^{3+}, Cr^{3+}, Co^{3+}) replacement in the interlayer of galleries as shown in Figure 1.5. These unbalanced charges are restored by intercalating the anions in the hydrated interlayer regions (Barahuie et al., 2014; Rojas et al., 2015). This two-dimensional (2D) interlayer is supported by van der Waals forces for the neutral layers and electrostatic forces for the charged anion. On top of that, the bonds in the layers are covalent bond and they have the capability to maintain the anion with electric charges, which are reconcilable with the interlayers (Mishra, Dash, & Pandey, 2018).

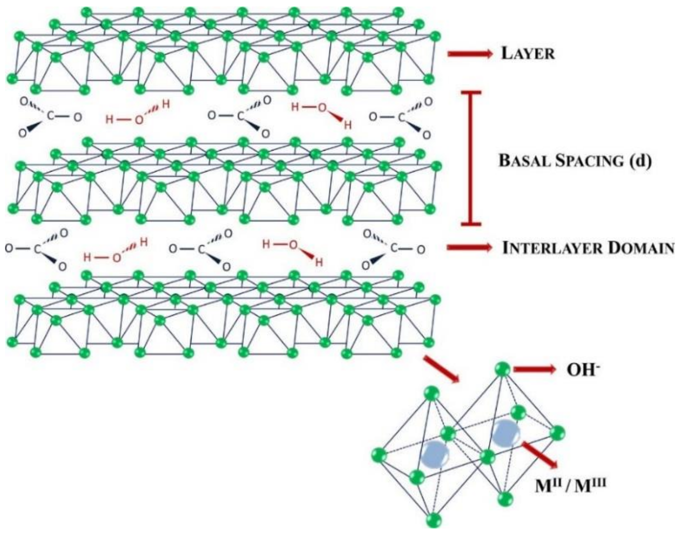

Figure 1.5. Layered Double Hydroxide (LDH) Structure. Adapted from (Benício et al., 2015)

The intercalation properties of the 2D layered material or nanocomposite bring an achievement to develop a lot of applications in the industries and environment such as anion-exchanger, catalysis, delamination, and many more (Hussein, Rahman, Sarijo & Zainal, 2012). Besides that, the properties of this layered material include having a large surface area, good anionic exchange capacities, and able to regain their own structure after undergoing reconstruction. It also has better storage lifetime and a well-controlled release property of the loaded drugs (Bi, Zhang & Dou, 2014). For example, it can be as a carrier system for delivering anions sunscreen in a controlled manner to reduce toxicity to the skin (Hoyo, 2007).

LDH can exist as a natural or synthetic compound, which can be readily synthesized in the laboratory. Their unique properties such as the brucite-like inorganic layers and exchangeable anions and water molecules in the interlayers are widely used in many application such as in water treatment (de Oliveira & Wypych, 2016), herbicides (Hussein, Hashim, Yahaya & Zainal, 2010), medicine (Hussein, Al Ali, Zainal & Hakim, 2011) and many more.

1.1.4.3 Layered Hydroxide Salt

Layered hydroxide salt (LHS) are anionic clays that consist of positively charged layers, which are separated by anions and water molecules (de Oliveira & Wypych, 2016). General formula for LHS is $M^{2+}(OH)_{2-x}(A^{m-})_{x-m}.NH_2O$ where M^{2+} is a divalent metal cations, M^{2+} (Ca^{2+}, Cu^{2+}, Zn^{2+}, Mg^{2+}) and A^{m-} are the interlayer anion (Cl^-, Br^-, CO_3^{2-}

and etc) (Bi et al., 2014). LDH provides tissues and cells friendlily by-products (H_2O, Mg^{2+}, Al^{3+}, Zn^{2+}) under physiological conditions (pH = 7.4 or less).

There are two types of layered hydroxide salts (LHS), which are type I and type II that were categorized based on their structural modifications. Type I LHS is the exchanged of hydroxyls by monovalent and divalent anions if there is a presence of divalent cations in the brucite structure. Type II is a part of octahedral sites, which can be eliminated and be split into two tetrahedral sites where it filled the upper and lower part of the vacancy. The tetrahedrons might contain anionic (Type IIa) (Figure 1.6 (B)) or neutral species (Type IIb) where it attached to the central atom (Tavares, Vaiss, Wypych, & Leitão, 2015).

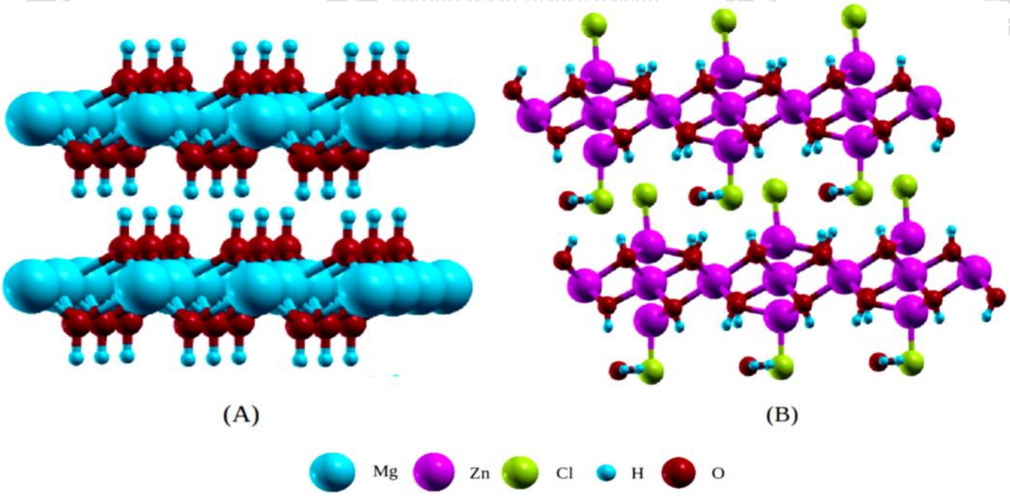

Figure 1.6. Side View of (A) The Brucite Structure and (B) the $Zn_5(OH)_8(NO_3)2{\bullet}2H_2O$ Structure, a Type-IIa LHS. Adapted from (Tavares et al., 2015)

1.1.4.4 Zinc Layered Hydroxide

ZLH is one of the examples of layered hydroxide salt (LHS) and has a general formula of $Zn^{2+} (OH)_{2-x} (A^{m-})_{x-m}.nH_2O$ (Hussein et al., 2011). It is a composition of inorganic layers with octahedral coordinated zinc cation in which quarter of the site is an empty octahedral site that provides more space and storing for unstable chiral biomolecules (Hoyo, 2007; Hussein et al., 2012). There are charge balancing ion and easily exchange with various anion between the interlayer galleries of the ZLH and a maximal unoccupied space at one quarter of the tetrahedral site of the ZLH. Therefore, the tetrahedral coordination is completed when the interlayer anions are weakly bound to the tetrahedral Zn^{2+} ion and make it easily exchanged with most of the inorganic and organic anions (Soltani, Nabipour, & Nasab, 2018).

ZLH exhibits a brucite-like structure as shown in Figure 1.7. This structure can undergo other changes either by i) cation isomorphic substitution in a layer or ii) partial replacement of hydroxide group or a favourable water molecule. The difference is their interlayers of galleries were composed of only one type of metal cation (Zn^{2+}, Mg^{2+}, La^{2+}, Ni^{2+}) (Barahuie et al., 2014). Therefore, this unique characteristics have been used as carrier for many application as shown in Table 1.1.

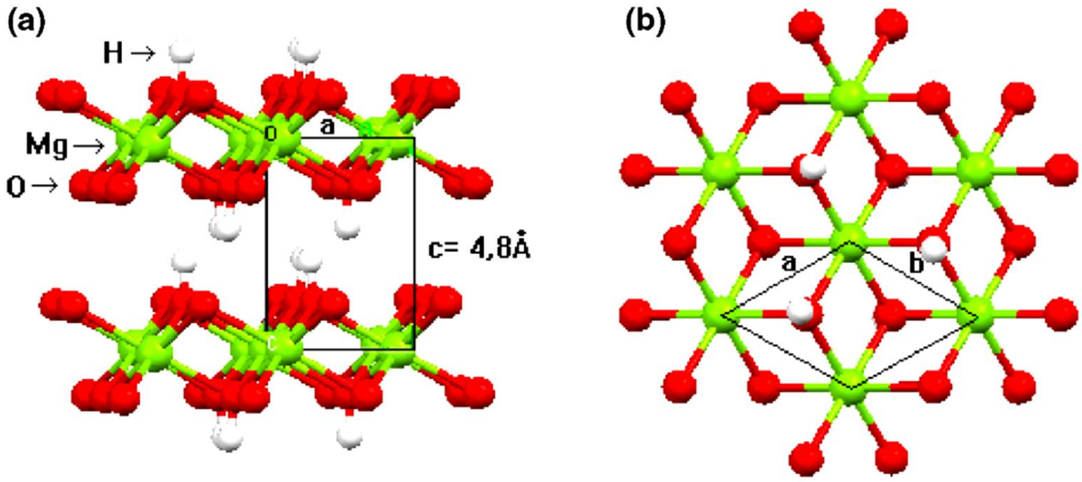

Figure 1.7. Schematic Representation of Brucite Structure (A) Side and (B) Top View of the Layer. Adapted from (Arizaga, Satyanarayana & Wypych, 2007)

Table 1.1

Previous Work on the ZLH-Drug Intercalation

Researchers	Previous study
Mohsin et al., 2013	Synthesis of (cinnamate-zinc layered hydroxide) intercalation compound for sunscreen application
Hussein et al., 2010	Synthesis and characterization of [4-(2,4-dichlorophenoxybutyrate)-zinc layered hydroxide] nanohybrid
Ahmad, Ahmed, Anwar, Sheraz & Sikorski, 2016	Synthesis and characteristics of valeric acid-zinc layered hydroxide intercalation material for insect pheromone controlled release formulation
Barahuei et al., 2014	Anticancer nanodelivery system with controlled release property based on protocatechuate-zinc layered hydroxide nanohybrid

1.2 Problem Statement

The depletion of ozone layer causes harmful effects to the living thing on the Earth especially to human due to the exposure to the UV rays. This causes many adverse effects such as melanoma, skin cancer, and carcinogenic. Hence, sunscreen was designed as an important element to protect our skin from harmful effects of the ultraviolet (UV) radiation from the sun. However, the safety of using sunscreen is always questionable, for example, organic UV filter used in a high concentration can cause irritant, contact allergies, non-immunological phototoxic contact reactions, and photoallergic reactions to the skin (Kullavanijaya & Lim, 2005; Cursino, da Silva Lisboa, dos Santos Pyrrho, de Sousa & Wypych, 2013). Based on Malaysian National Cancer Registry Report 2007-2011, skin cancer is one of common cases for about 2.7%. On top of that, according to World Health Organization, skin cancer is one of most common cancer with 1.04 million cases. This problem need to take precaution before it leads to many cases.

Kockler et al., (2012) reported that 4-AB exhibits a good photostability profile, however, it can cause high irritation to the skin. Besides that, 4-AB was investigated under Hg/Xe lamp that imitate UV-B radiation wavelength (λ=290) nm and photodegradation occurred when it was exposed to it. When 4-AB penetrates to the skin, it increase the risk of contact or photocontact dermatitis. Therefore, it was no longer used in the sunscreen products (Nash & Tanner, 2014).

Inorganic UV filter such as zinc oxide (ZnO) and titanium oxide (TiO_2) that are commonly used to reflect and absorb both UV-A and UV-B radiations from entering the epithelial skin cell can cause cytotoxicity in the cultured human bronchial epithelial cells, oxidative stress, and membrane damage (Lu et al., 2015; Bahadar, Maqbool, Niaz, & Abdollahi, 2016). This is one of the concerns and many studies have addressed these issues. Furthermore, their bulk form results in an unpleasant look in the cosmetic application. As a result, micronized ZnO and TiO_2 were introduced in order to produce more transparent, less vicious, and easily blends onto the skin (Newman, Stotland & Ellis, 2009).

Therefore, many studies are currently trying to identify the mechanism to apply sunscreen on the skin in order to overcome these issues. One of the mechanisms is controlled release system by using incorporation of the organic materials in the interlayer galleries of inorganic layered materials to avoid direct contact of sunscreen to human skin. In this work, synthesis of intercalation of 4-AB into zinc layered hydroxide using ZnO as a precursor has been explored, which can be employed as a new promising host delivery system for controlled release of sunscreen delivery.

1.3 Significant of the Study

In this research, encapsulated 4-AB with zinc layered hydroxide (ZLH) can increase photostability and decrease degradation of 4-AB. Besides that, it acts as a carrier that potentially to control 4-AB delivery, reducing the concentration of 4-AB release to the skin. Hence, it gives sufficient amount of 4-AB to the skin in preventing contact dermatitis. Besides that, it also potentially offers a safe drug delivery to the target site of the skin.

Encapsulate active sunscreen between the interlayer galleries of the layered hydroxide and anion exchange properties of the nanocomposite is one of the methods used to overcome photodegradation and higher concentration release of 4-AB problem. The layered material hydroxide is the most suitable material for this research because it has good anion exchange capacities and high surface area, facility synthesis and easy storage with high stability (Hoyo, 2007; Bi et al., 2014). Besides that, the particle size of the material is in micro size (10-50 nm) resulting better performance in scattering visible light compared to the non-micronized form (200-500 nm) in cosmetic and pharmaceutical application (Kullavanijaya & Lim, 2005).

1.4 Objectives of the Study

The objectives of this study are:

i. To synthesize the ZLH-4-aminobenzoic acid (ZAB) using direct method of ZnO and 4-AB.

ii. To study the physiochemical properties of ZLH-4-aminobenzoic acid (ZAB) nanocomposite by using powder x-ray diffraction (PXRD), Fourier transform infrared (FTIR), accelerated surface area and porosimetry system (ASAP), thermogravimetry analyses (TGA), inductively coupled plasma (ICP), carbon, hydrogen, nitrogen and sulphur (CHNS), and elemental analyser (EA), field emission scanning electron microscope (FESEM), and ultraviolet-visible (UV-vis).

iii. To study the controlled release of 4-AB from the inorganic layer of ZAB compound in different types of aqueous media such as deionized water, NaCl, and pH 5.5 phosphate buffer.

iv. To study the cytotoxicity effect of ZAB on human dermal fibroblast.