Potencial of Salicylic-Acid-Bentonite Clay Nanocomposite as Drug Delivery System and its Characterization of Physichochemical Properties

Ida Ayu Gede Widihati[1], Nyoman Adiputra[2], Ida Bagus Putra Manuaba[3], Putu Wayan Sutirtayasa[4]

[1, 3]Chemistry Departement, Faculty of Mathematic & Natural Sciences, Udayana University, Bukit Jimbaran Campus, Badung Bali, 80237

[2, 4]Faculty of Medical, Udayana University, Sudirman Campuss, Denpasar Bali, 80232

Abstract: ***Synthesis of salicylic acid-bentonite clay nanocomposite by varying the contact time and concentration of salicylic acid has been carried out. The aim of this research is to produce new nanomaterial that has anti-inflammatory activity. The physicochemical properties of this nanocomposite are characterized by X-ray diffraction (XRD), Fourier-Transformation Infrared Spectrofotometry (FTIR), particle size and zeta potential analyzer while the specific surface area, were conducted by Brunauer, Emmet, dan Teller (BET) method. Based on the characterizations it was concluded that the introducing of salicylic acid with different concentration did not give any effect to the crystalinity of the bentonite indicating that the structure of nanocomposite is intercalated. The change of interlayer space as caused by intercalate concentration increasing respectively 16, 95Å; 16,40Å; 16,63Å. Characterization of SA-BC nanocomposite by FTIR showed new specific bands indicated intercalation until atomic scale. Band at 1554 cm^{-1} attributed to vibration of C=C from benzene group. Bands at 1462,04 cm^{-1} and 1384,89 cm^{-1} indicated anti symetry and simmtry stretching vibration of –COO- group of salicylic acid. Bands at 1228,66 cm^{-1} and 1109,07 cm^{-1} showed vibration of =COO and bending O-H of salicylic acid. Bands at 528,50 cm^{-1} ,464,84 cm^{-1} and 792,74 cm^{-1} indicated tetrahedral structure of Si-O-Al , Si-O-Mg, and Fe(III)-OH-Mg respectively. Increasing of zeta potential is caused by intercalation salicylic acid into interlayer of bentonite clay. Zeta potential value of SA-BC nanocomposite 1,2,3 are -21,3 mV; -24,3 mV;-23,1 mV; -21,9 mV respectively. The change of particle size from bentonite into SA-BC nanocomposite 1,2,3 respectively are 2211,8 nm; 777,4 nm; 2574,6 nm; and 2007,1 nm. Decrease of specific surface area is caused by salicylic acid bonded at interlayer and edge surface of bentonite clay. The value of bentonite and SA-BC nanocomposite respectively are 74,79 ; 63,28; 30,77; 17,64 m^2/g.***

Keywords: nanocomposite, bentonite, clay, salicylic acid, anti-inflammatory.

1. Introduction

Salicylic acid is a hydroxy benzoic acid belonging to a class of non-steroidal anti-inflammatory drugs (NSAIDs) that has properties as antiinflammatory, antiseptic, antiradical, analgesic, antirheumatic, antioxidant, and anticarcinogenic. Salicylic acid is widely used almost everywhere in the world either orally or topically. This substance is the oldest keratolitik materials that have been used for more than 100 years.[(1,2)]

Until now salicylic acid is still used in the treatment of verruca, callus, psoriasis, seborrheic dermatitis on the scalp, and ichtiosis. Its use is increasingly developed as a peeling agent in skin aging therapy, melasma, postinflammatory hyperpegmentation, and acne.[(3,4,5)]

The use of salicylic acid topically and orally often leads to systemic toxicity because salicylic acid is a strong acid. In general, the use of topical therapy is relatively safer and has minimal side effects compared to oral administration route, but topical therapy has the potential for systemic toxicity, teratogenic effects, and drug interactions due to systemic absorption to be aware of.

In this study, efforts will be made to reduce the toxicity of salicylic acid by modifying it with bentonite clay through salicylic acid intercalation into interlayer space of clay to form nanometer-dimensional composites. The use of nano technology in the pharmacy aims to overcome some problems such as low solubility, often need fat to dissolve, easily aggregated into big particles making it difficult to absorb on the body, and not easily absorbed and digested so that the healing process becomes longer. In the past ten years, the use of clay mineral nanocomposites and biopolymers in the pharmaceutical field has been growing rapidly. This nanocomposite material combines properties into two components, organic and inorganic such as swelling, water uptake, mechanical characteristics, thermal properties, rheology and bioadhesion.[(9,12)]

The clay of bentonite contains approximately 85% of montmorillonite minerals. The soil has features such as palpable, soft, waxy, pale with white, light green, gray, pink in fresh appearance and if it has darkish brown[(11)]. Clay is a material belonging to a class of nanoparticles having a layered structure in which each layer has a negative charge which can be neutralized by cations such as Na^+, K^+, Ca^{2+}, Mg^{2+}, etc. that occupy interlayer space. Clay has modifiable properties because the cations located in interlayer space are easily replaced by other ions.[(23)]

2. Equipment

The bentonite clay used was obtained from center of Java, as the main ingredient. The chemicals used for proanalysis are the production of MERCK. In this study also used demineral water to make intercalate solution, clay and composite suspensions. The salicylic acid bentonite clay composite (SA-BC) was synthesized by sol gel method through intercalated intercalation into interlayer space of bentonite clay. Intercalator is made by reacting 0.0125 M with FeCl3 and 0.025 M salicylic acid . Intrument XRD used is Rigaku Miniflex 600 with operating condition 40 kW 15 Ma, FTIR Spectrofotometer used is IR Prestige-21 from Shimadzu, specific surface area analysis is done by BET method using Micrometric Type Tristar II, 3020, determining zeta potential and particle size using Horiba Nanoparticle Analyzer S2-100.

3. Experimental

Synthesis of bentonite-salicylic acid clay nanocomposite. A total of 30 g of pre-prepared bentonite clays are suspended into 600 ml of a solution containing Fe (III) 0.0176 M and 0.025 M salicylic acid, then stirred with a magnetic stirrer for 24 hours, then filtered with a vacuum filter, and washed with ion free water repeatedly until all of the Cl ions lost are indicated by a negative test against $AgNO_3$ solution. The filtration result was dried in an oven at a temperature of 110-120 ° C for 24 hours[(10)] . Furthermore, the resulting material was crushed and sieved using a 106 µm sieve. To obtain the best composite, the intercalated concentrations of Fe (III) and salicylic acid were made twice, and three times the initial concentration. Characterization of physico chemical properties of nanocomposite was performed with XRD, FTIR, PSA, zeta potential and N_2 gas adsorption analytical method (BET) for specific surface area analysis.

4. Results and Discussions

XRD characterization

From the result of X-ray diffraction analysis for natural bentonite clay obtained high intensity at 2θ = 5.45 deg and d_{001} spasing value = 16,19Å, the magnitude is the identity of bentonite clay. The results of this identification show that the natural clay used is a bentonite clay which also contains several other mineral components shown by several difractogram peaks at different in 2ϴ angles. Fig 1. Shows the XRD pattern of bentonite and salicylic acid-bentonite clay nanocomposite. The difractogram of salicylic acid-bentonite clay nanocomposite showed a characteristic peak due to the regular layers structure. From the presented images it can be explained that there is no significant difference of difractogram from some of the resulting composites. Increasing of intercalant concentration did not change peak of difractogram. The peaks that are characteristic of bentonite still exist, but undergo a change in intensity. Changes in the distance between layers of clay due to salicylic acid intercalation are presented in the following table 1.

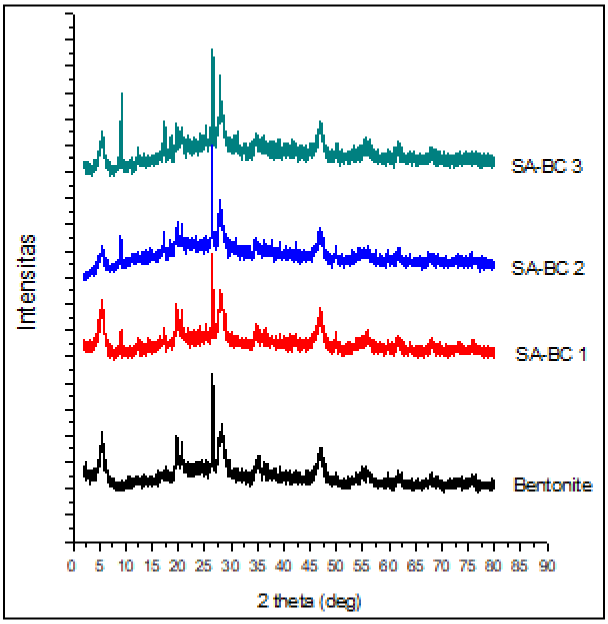


Figure 1: XRD pattern of bentonite clay and SA-BC nanocomposite

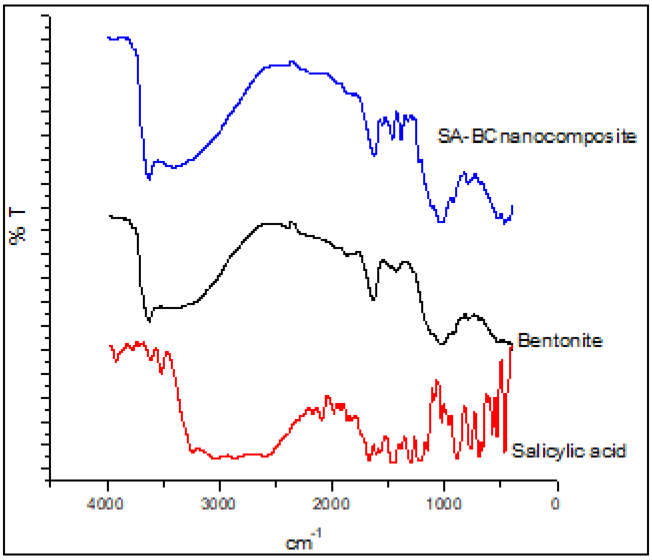
Table 1: *d-spacing* bentonite and salicylic acid-bentonite clay (SA-BC) nanocomposite

No	Sampel	2-theta (2θ)	d-spacing (Å)
1.	Bentonit	5,45	16,19
2.	SA-BC 1	5,21	16,95
3.	SA-BC 2	5,37	16,40
4.	SA-BC 3	5,31	16,63

From the list of peak data presented in table 1, it can be seen that there is a change of distance between layers (d-spacing) due to salicylic acid intercalation into the clay layer bentonit. The largest interlayer spacing was obtained from the first intercalate concentration. Less substantial spacing changes are likely due to the horizontal intercalate position against the clay layer or salicylic acid intercalated not only into the interlayer space of the bentonite clay but also bound to the edge surface of the bentonite particles.

With the occurrence of colloid flocculation of the results of difractogram and peak list analysis, it can be concluded that the composite structure of clay bentonit-salsilat acid formed is intercalated form (an intercalated form) which is indicated by the persistence of peaks that become characteristic of bentonite clay.

FTIR Characterization of salicylic Acid-Bentonite Clay Nanocomposite



Comparing FTIR spectra between Bentonite clay and Salicylic acid-bentonite, clay composite will show the appearance of new peaks not previously seen in bentonite clay but appearing on the composite spectra of SA-BC composite.. These peaks indicate the characteristic vibrations of salicylic acid, such as the 1554 cm^{-1} wave number which is the C = C vibration of the benzene group, band at 1462,04 cm^{-1} and 1384,89 cm^{-1} show the vibration of stretching anti symmetry and symmetry of the group -COO- salicylic acid. Band at 1228,66 cm^{-1} shows vibration = COO and band at 1109,07 cm^{-1} shows vibration of O-H bending from salicylic acid. The characterization of this composite by using FTIR spectrophotometer proves that the interaction of salicylic acid into interlayer space of bentonite clay has reached atomic scale and involves hydrogen bonding in it [12]. The vibration bands at wave numbers 528.50 cm^{-1} and 464,84cm^{-1} show the tetrahedral structure model of Si-O-Al and Si-O-Mg, the vibrations at 792,74 cm^{-1} are owned by Fe(III) -OH-Mg that indicates bentonite containing Mg and Fe(III)

Zeta potential and particle size characterization of salicylic acid-bentonite clay nanocomposite

Table 5.3: Zeta Potential and particle size of SA-BC Composite

Composite	zeta Potensial (mV)	Partikel size (nm)
Bentonite	-21,3	2211,8
SA-BC_1	-24,3	777,4
SA-BC_2	-23,1	2574,6
SA-BC_3	-21,9	2007,1

From the table above it can be seen that bentonite clay has a lower zeta potential than the composite formed. Clay minerals including bentonite have uniform negative electromatic potentials on the surface. When dissolved in water, dissolved ions will accumulate at the boundary of the clay and water interface. The ion counter present in the liquid phase deligns the mineral surface potential systematically until the potential becomes constant in most of the solution. Decrease of potential usually occurs at a distance of 5-200 nm, which is affected by the electrolyte of the solution [11,14,24]. In this study the particle size obtained from nanocomposites varies according to the concentration of intercalates used. It was found that the particle size approximating the nanoparticle group was obtained from the 0.0176 M Fe (III) intercalate concentration; 0.025M salicylic acid with contact time for 24 hours.

Characterization of Surface Area of Bentonite-Salicylic Acid Nanocomposite Clay

Measurement of surface area of solids as specific surface area usually use BET method (Brunauer, Emmet, and Teller) based on gas adsorption by solid surface. The result of measurement of surface area of bentonite and composite formed is presented in table 5.4.

Table 5.4: Specific surface area of bentonit and SA-BC nanocomposite

Sampel	Specific Surface Area (m^2/ g)
Bentonite	74,79 ± 0,89
SABC 1	63,29 ± 0,78
SABC 2	30,77± 0,41
SABC 3	17,64± 0,41

From the result of characterization of surface area by using BET method above can be explained that salicylic acid intercalation into interlayer of clay bentonite causes surface area of bentonite clay to decrease. This is because salicylic acid is bonded to the surface of bentonite clay and also to interlayer clay space, thereby reducing the contribution between layers to the surface area.

5. Conclusion

The synthesis of bentonite-salicylic acid nanocomposite was successful by intercalation method. Based on the characterizations it was concluded that the introducing of salicylic acid with different concentration did not give any effect to the crystalinity of the bentonite indicating that the structure of nanocomposite is intercalated. The data of the zeta potential, the particle size as well as the specific surface of 24,3 mV, 777.4 nm. and 63.29 m^2/ g respectively indicate a great potential of the nanocomposites as drug delivery system.

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