STUDIES ON BENTONITE CLAY FROM THAILAND FOR ITS PHARMACEUTICAL APPLICATION
การศึกษาเพื่อประยุกต์ใช้ดินเบนทอไนต์ของไทยทางเภสัชกรรม

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ABSTRACT

Thai bentonites were studied for pharmaceutical application as suspending agent and cosmetic application as emulsifying agent. Samples of bentonite were washed and passed through sieve number 325 mesh and the yield was 95%. The swelling property of washed bentonites was improved by treating them with sodium carbonate. Two methods were used, by adding only sodium carbonate in method 1 and sodium carbonate with ammonium chloride and hydrochloric acid in method 2. The latter method gave better swelling property. Brightness of bentonite was studied and improved by using sodium dithionite. Rheology of treated bentonites was studied to compare with standard bentonite from United Kingdom. Both standard and treated bentonite suspensions had shown thixotropic property. Treated bentonite from method 2 had higher viscosity and thixotropy than the other one from method 1 and it was found that the quantity of sodium carbonate affected bentonite properties. Standard bentonite had much higher thixotropy and viscosity than treated bentonites. It was found that concentration, temperature, ageing and pH affected bentonite rheology. Bentonite was used as emulsifying agent in acne cream and as suspending agent in calamine lotion. Acne creams containing standard or treated bentonite were quite stable whereas in calamine lotion, the preparation containing standard bentonite was redispersed easier than the ones containing treated bentonite.

บทคัดย่อ

ทำการศึกษาดินเบนทอไนต์ของไทยเพื่อประยุกต์ใช้เป็นสารช่วยกระจายตัวในยาน้ำแขวนตะกอนทางเภสัชกรรมและสารอิมัลชันในผลิตภัณฑ์เครื่องสำอาง หลังจากการล้างดินเบนทอไนต์ผ่านตะแกรงขนาด 325 ช่อง ต่อความยาว 1 นิ้ว ซึ่งผลที่ได้คือ 95% และได้ทำการปรับปรุงคุณสมบัติการบวมน้ำของดินเบนทอไนต์ที่ล้างแล้วโดยใช้โซเดียมคาร์บอเนต 2 วิธี คือ วิธีการที่ 1 ใช้เฉพาะโซเดียมคาร์บอเนต และวิธีการที่ 2 ใช้โซเดียมคาร์บอเนตร่วมกับแอมโมเนียมคลอไรด์และกรดเกลือ พบว่าวิธีการที่ 2 ให้คุณสมบัติการบวมน้ำที่ดีกว่าวิธีการที่ 1 สำหรับคุณสมบัติความสว่างของเบนทอไนต์ได้มีการศึกษาและปรับปรุงให้ดีขึ้นโดยใช้โซเดียมไดไธโอไนต์ ส่วนการศึกษาคุณสมบัติการไหลของดินที่ปรับปรุงแล้วควบคู่กับดินเบนทอไนต์มาตรฐานจากประเทศอังกฤษ พบว่าทั้งดินมาตรฐานและดินที่ศึกษาแสดงคุณสมบัติธิโซโทรปี (การเปลี่ยนความหนืดตามเวลา) โดยดินเบนทอไนต์ที่ปรับปรุงด้วยวิธีการที่ 2 มีค่าความหนืดและค่าธิโซโทรปีสูงกว่าดินที่ได้จากวิธีการที่ 1 ปริมาณโซเดียมคาร์บอเนตที่ใช้มีผลต่อคุณสมบัติที่ได้ เบนทอไนต์มาตรฐานมีค่าธิโซโทรปีและความหนืดสูงกว่าเบนทอไนต์ที่ผ่านการปรับปรุง ความเข้มข้น อุณหภูมิ เวลา ความเป็นกรด-ด่าง มีผลต่อการไหลของเบนทอไนต์ การทดลองใช้เบนทอไนต์มาตรฐานและเบนทอไนต์ปรับปรุงคุณสมบัติเป็นสารช่วยทำอิมัลชันในครีมรักษาสิว สารช่วยกระจายตัวในคาลาไมน์โลชันผลปรากฏว่าครีมรักษาสิวที่ประกอบด้วยเบนทอไนต์มาตรฐาน และเบนทอไนต์ที่ปรับปรุงคุณสมบัติมีสภาพค่อนข้างคงตัว ขณะที่คาลาไมน์โลชันที่มีดินเบนทอไนต์มาตรฐานสามารถกระจายตัวได้ง่ายกว่าที่มีเบนทอไนต์ปรับปรุงคุณสมบัติ

INTRODUCTION

Bentonite, a colloidal hydrated aluminium silicate, is a very fine odourless powder, pale buff or cream to grayish in colour, free from grit and having slightly earthy taste. It is insoluble in water, swells to approximately twelve times of its volume when added to water and does not swell in organic solvent.[20] Bentonite is used in pharmaceutical preparations such as anti-inflammatory and antiseptic gel,[11] treating acne,[5] therapeutic dressing,[4] treatment of burns and skin lesions[12] and antacid.[3] Bentonite is used in cosmetic such as antiperspirants,[13] cosmetic makeup,[14] sunscreen,[15] hair conditioner,[7] shampoo,[2] cosmetic packs,[18, 19] cosmetic foundations[6, 17], skin creams and ointments[10]

Most of bentonite are imported with high price, although there are many sources of bentonite in Thailand but none of them have been investigated for pharmaceutical purposes. Therefore, it is interesting to study the development of Thai bentonite in order to be able to utilize domestic resource with lower cost.

In this study, two samples of Thai bentonite were investigated by comparing with United Kingdom bentonite on quality and possibility for pharmaceutical uses.

MATERIALS AND METHODS

Purification and preparation of bentonite

Purification of bentonite

Bentonite samples were dispersed in water to separate impurities such as mica and sand, then they were pumped into the hydrocyclone. Samples were obtained from dispersion by passing through sieve no. 325 mesh and dried at 70°C. They were then milled through sieve no. 100 mesh.

Improvement of brightness

Fifty g of washed bentonite containing 1.6% ferric oxide were dispersed in water using a low-speed mixer to form 5% w/w suspension and adjusted its pH to 2.8 with hydrochloric acid (HC1). Samples were treated separately with sodium dithionite in varying amount ranging from 0.1-0.6 g and heated at 60°C for 1 h and then centrifuged to separate the cakes of substantially iron-free bentonite from the aqueous medium. The cakes were washed with water, separated by centrifugation then dried at 70°C and milled through sieve no. 100 mesh.

Preparation of sodium bentonite

Two methods of preparation of sodium bentonite were selected to improve the swelling property of bentonite and two samples (sample 1 and 2) were used for each method of preparation.

Method 1

Fifty g of washed bentonite were treated separately with 500 ml of either 0.2-0.6% (w/v) of sodium carbonate solutions or 0.2-0.5% sodium hydroxide solutions. Divided portions of bentonite were added to alkali solutions and then the suspensions were homogenized for 5 min, stirred for 1 h while heating at 90°C. The products were allowed to stand for 24h, dried at 90°C and the dried powders were milled through sieve no. 100 mesh.

Method 2

The process was similar to method 1 but after heating at 90°C for 1 h while stirring, 0.6-2.7 g of 30% hydrochloric acid and 1.7-7.7 g of 20% ammonium chloride were added in varying quantities. The suspensions were allowed to stand undisturbed at room temperature for 24 h, then dried at 90°C and milled through sieve no. 100 mesh.

Preparation of treated bentonite

Ten kg of washed bentonite were added to 50 l of 0.4% (w/v) sodium carbonate solution at 90°C. The suspension was blended for 10 min and the temperature was kept at 70°C for 1 h, homogenized for 5 min and blended for 10 min, and then divided into 2 equal portions, each portion was blended for 10 min. The first portion was blended with 100 ml of 20% (w/v) NH_4Cl, dried at 60°C and milled through sieve no. 100 mesh. The second portion was blended with 15 ml of 50% HCl and 160 ml of 20% (w/v) NH_4Cl for 10 min, dried at 60°C and milled through sieve no. 100 mesh.

Investigation of properties

USP specifications of bentonite

Three samples of bentonite : washed bentonite, treated bentonite and standard bentonite were subjected to the following tests:

pH

Four g of bentonite were dispersed and mixed vigorously in 200 ml of water. The pH of each suspension should fall between 9.5-10.5.

Gel formation

Six g of bentonite were mixed with 300 mg of magnesium oxide. Divided portions were added to 200 ml of water in a 500-ml blender and blended for 5 min. And the mixture (100 ml) were transferred to a 100-ml graduated cylinder and allowed to stand for 24 h. The supernatant liquid appeared on the surface should not be more than 2 ml.

Swelling power

Two g of bentonite were sprinkled to 100 ml of water in a 100 ml glass-stoppered cylinder. Before adding another portion, each portion was allowed to settle. The mass at the bottom should gradually swell until it occupied an apparent volume of not less than 24 ml at the end of a 2-h period.

Fineness of powder

Two g of bentonite were sprinkled to 20 ml of water allowed to swell in a mortar and dispersed with water to 100 ml. The suspension was poured through a standard sieve no. 200 mesh and the sieve was throughly washed with water. No grit should be felt when fingers were rubbed over the wire mesh of the sieve.

Microbial limit

Bentonite should meet the requirements of the test for absence of *Escherichia coli.*

BP specification of bentonite

It is similar to USP specification except for alkalinity which should fall between

9-10.5 and arsenic limit of 8 ppm.

IR Spectrophotometry

Samples of raw bentonite, washed bentonite and standard bentonite were subjected to IR-spectrophotometer for identification purpose.

Mineralogical and chemical examination

X-ray diffraction and chemical analysis were done for characterization of bentonite. Bentonite was dispersed in water and centrifuged at 800 rpm for half an hour. Bentonite from the surface of cake was smeared on slide and allowed to air-dry at room temperature. X-ray diffraction patterns were then recorded.

Determination of brightness

Samples were dried at 105°C and milled for 6 min. The brightness of washed bentonite, treated bentonite and standard bentonite were assessed by comparing with barium sulphate using Elrepho Reflectance Photometer.

Methylene Blue Index

Bentonite was dried at 105°C for 24 h. Slurries were prepared by using 2 g of sample in 300 ml of distilled water. The pH of the slurries were adjusted to 2.5-3.8 range while stirring with acid, and after the last addition of acid the mixture was stirred continuously for 10 to 15 min. The slurries were again tested for pH, and if necessary, acid was further added to restore the same pH range. During the titration of the slurries with methylene blue, a drop of each slurry was removed and placed on the edge of each filter paper, the end point was indicated by formation of a light blue halo around the drop. Each end point was confirmed by stirring for 2 min and retested.

The methylene blue index was calculated by using the following formula[8]:

$$MBI = EV\ 100/W$$

where

MBI = methylene blue index for each bentonite in meg/100 g clay
E = milliequivalents (mE) of methylene blue per ml
V = ml of methylene blue solution required for the titration
W = g of dried bentonite.

Particle size distribution

Particle size distribution of bentonite was determined by using Shimadzu centrifugal particle size analyzer SA-CP_2. Bentonite was dispersed in water to have a concentration of 2%. Calgon (sodium hexametaphosphate) was used as a dispersing agent in the concentration of 0.1%. The suspensions were dispersed for 6 min by magnetic stirrer before being subjected to the apparatus. Calgon of 0.1% concentration was used as reference for zero adjustment.

Rheological studies

Magma of each bentonite was prepared by sprinkling the bentonite on the required amount of water at room temperature and blended by Silverson homogenizer. To exclude the effect of preparation techniques, stock magma was prepared for using in the same experiment. Each 200 ml of magma was transferred to 6 cm-diameter container and allowed to stand undisturbed before measurement. The viscosity of bentonite magmas were measured by a Brookfield Digital Viscometer Model DV-II. The shear rates (0.3, 0.6, 1.5, 3, 6, 12, 30 and 60 rpm) were changed manually, without stopping the spindle. Before each measurement, magma containers were allowed to stand at a constant temperature in water bath for not less than 15 min. Equal time interval is required in each changed shear rate. Rheogram and factors affecting viscosity such as temperature, concentration, pH and ageing time were recorded.

Viscosity, rheogram and shearing time determination

The bentonite magmas were sheared at shear rate of 6, 12, 30 and 60 rpm for up-curve and 30, 12 and 6 rpm for down-curve in experiment 1, and experiment 2 was carried on shear rate of 0.3, 0.6, 1.5, 3, 6, 12,30 and 60 rpm for up-curve and 30, 12, 3, 1.5, 0.6 and 0.3 for down-curve. The shear stress was recorded. The shearing time versus viscosity was determined at a constant shear rate (6 and 60 rpm) which was carried out for the determination of change in viscosity.

Factors affecting viscosity

The concentration factor was determined at 3-6% (w/w) and temperature factor was determined at 30 ± 1, 40 ± 1, 50 ± 1 and 60 ± 1 °C. The magmas were stored for 8 weeks, then the viscosities of magmas were measured and recorded. Two hundred ml of 5% bentonite magmas were adjusted to pH 7, 8 and 9 with HCl and to pH 10 and 11 with NaOH. The viscosity of each sample was then determined.

Possibilities of using bentonite as suspending and emulsifying agent

Bentonite as a stabilizer in acne cream

Studies on factors affecting stabilizing property of bentonite in acne cream were recorded by using 2 types of packaging i.e. glass vial and aluminium tube. In glass vial, light and temperature factors were studied. At room temperature, vial of the acne creams were kept in dark and in light condition. Variations of temperature were done by keeping the acne cream in refrigerator, at 25°C and at 44°C and these temperature variations were performed with the cream in aluminium tube packing.

Bentonite as suspending agent in calamine lotion

Factor affecting suspending property of bentonite in calamine lotion was studied by comparing in three parameters : sedimentation volume, caking and viscosity with the products prepared by using standard bentonite. Viscosities of calamine lotion were determined by using Brookfield Digital Viscometer, halipath was used by moving upward and downward with shear rate of 12 rpm after 3, 6 and 9 weeks. The numbers of T-bar spindles used were D,E,F respectively.

RESULTS

Amounts of bentonite passing through sieves

Ten kg of raw bentonite clay sample 1 was washed through a series of sieves and the amounts of bentonite passed through the sieves according to their size ranges were 663, 218, 95 and 8,600 g at the size fraction (mesh) +100, −100+250, −250+325 and under 325, respectively. It can be concluded that, total yield of bentonite clay (sample 1) passed sieve no. 325 mesh was 9.576 kg. In sample 2, the amount of 30 kg bentonite clay passed through sieve no. 325 mesh yielded 28.5 kg.

USP specifications of bentonite

The results of USP specification of washed bentonite, treated bentonite and standard bentonite were shown in Table 1. Treated bentonite and standard bentonite passed standard fineness test. Treated bentonite had no *Escherichia coli.* For the arsenic content, standard bentonite and washed bentonite had been found to contain arsenic 0.46 ppm and 0.11 ppm, respectively

Effect of ammonium chloride

Effect of ammonium chloride on properties of 50 g treated bentonite, using 500 ml of 0.3% (w/v) sodium carbonate and 0.9 g of 30% HCl was studied on swelling power, gel formation and pH. It was found that the amount of ammonium chloride used affected properties of treated bentonite, the more quantity of ammonium chloride used the better quality of swelling and gelling in treated bentonite. Beyond the optimum quantity of ammonium chloride used, i.e. 2.6 g 20% ammonium chloride solution, the quality of treated bentonite decreased.

IR-spectrophotometry

IR-spectrophotometry can be used for the identification of bentonite. Spectra of the raw and washed bentonite were similar to that of standard bentonite.

X-ray diffraction

X-ray diffraction pattern was shown that 2Θ values of treated bentonite and of standard bentonite were 7° and 6.5°, respectively and it was shown that standard bentonite and treated bentonite contain montmorillonite because 2Θ values of the two bentonite were in the range of 7.2°-5.42° which are the 2Θ values of montmorillonite.[16]

Chemical analysis

Chemical compositions of standard and treated bentonite were analysed. It was found that treated bentonite contained more silica than standard bentonite and silica content could greatly diminish plasticity of clay. The amount of ferric oxide corresponded to the colour of bentonite, standard bentonite containing more ferric oxide than treated bentonite and was darker than the treated bentonite.

Brightness of bentonite

Percentages of brightness of washed bentonite and standard bentonite were 79% and 61.6%, respectively (Table 2). These values indicated that washed bentonite was brighter than standard bentonite. The colour of washed bentonite was pale-yellow while standard bentonite was pale-brown.

Brightness of treated bentonite by method 1 was different from that of method 2. As the percentage of alkali increased in samples prepared by methods 1 and 2, the brightness decreased slightly. Using 0.3%, 0.5%, 10.6% (w/v) of sodium carbonate solution the brightness of treated bentonite by method 1 decreased in order of 71.5, 69.5, 68.5%, respectively whereas by method 2 were 76.5, 74.5, 74.5% respectively, (Table 2). Treated bentonite by method 2 was brighter than that of method 1 at the same amount of alkali used.

Methylene blue index

Methylene blue index of standard, washed and treated bentonite (samples $A_{1S0.3}$ and $A_{2S0.3}$ were 58, 50, 65 and 60 meq/100 g bentonite, respectively. It was indicated that washed bentonite had low cation exchange capacity than treated bentonite, treating bentonite with sodium carbonate improved this property.

Particle size distribution

Percent cumulative oversize of standard and treated bentonite at each mean diameter were shown that the percent cumulative oversize of standard bentonite was higher than treated bentonite. Particle size distribution of standard bentonite was higher than treated bentonite.

Rheological behaviour

Effect of shear rate : Shear stress of 4% and 5% of standard and treated bentonite at each shear rate and rheograms were shown in Figure 1.

Viscosity change at constant shear rate : Viscosity of 4% and 5% standard and treated bentonite at constant shear rate were shown in Figure 2. They showed decreasing in viscosity of bentonite suspension as a function of time.

Effect of concentration : Viscosity of 3%, 4%, 5% and 6% standard and treated bentonite at $25 \pm 1°C$ and $30 \pm 1°C$ were shown that the higher bentonite concentration was, the higher the viscosity of bentonite became.

Effect of temperature : Viscosity of 4% and 5% standard and treated bentonite at 30, 40, 50 and 60°C were shown that the higher the temperature was, the lower the viscosity of bentonite became.

Effect of ageing : Viscosity of 4% and 5% standard and treated bentonite during storage for 8 weeks were shown that viscosity increased during 8 weeks storage.

Effect of pH : The pH effect on viscosity of each sample, both standard and treated bentonite magma was shown that the standard had viscosity value higher than the others at pH range of 7-10 and more change in viscosity value with pH. Treated bentonite B_{2L1} and B_{2L2} had similar curve, and change less in viscosity value with pH than the standard. Therefore, treated bentonite $A_{2S0.6}$ B_{2L1} and B_{2L2} had wider pH range for application. An increase in electrolyte concentration (HCl, NaOH) caused greater change of viscosity except at pH 8-9. However the quantity of counter ion for adjusting pH and the nature of bentonite might have influence on the effect of pH.[19] Therefore the change in viscosity by pH was not clear cut.

Stabilizing property

Standard and treated bentonite were treated for their stabilizing properties in acne cream. The results were shown in Table 3.

Suspending property

Standard and treated bentonite were tested for suspending property in the formula of calamine lotions, the results were shown in Table 4.

DISCUSSION AND SUGGESTION

Discussion

Only particle size under sieve number 325 mesh (44 microns) was used throughout this experiment because this size conforms to USP specification and the proportion of this size is high, which indicates high yield value.

From Table 1 it was found that washed bentonite did not conform to USP specification because it was calcium bentonite that made its swelling power and gel formation to be very low whereas the standard sodium bentonite could pass USP specification. Therefore it can be assumed that the properties of treated bentonite were better than that of washed bentonite. In the latter, calcium bentonite has been changed to sodium bentonite by treating with sodium carbonate or sodium hydroxide. It was also found that the method and amount of alkali used affected the quality of bentonite. Bentonite prepared from sodium carbonate was better than the one from sodium hydroxide, and the optimum quantity of sodium carbonate used gave the best quality of bentonite.

From Table 2 improvement of brightness was done by using sodium dithionite. Brightness of washed bentonite was previously 79% but after bleaching with sodium dithionite the brightnesses were improved to be 85%. It had been shown that the more sodium dithionite used, the more brightness obtained. However, the amount of sodium dithionite should be kept a minimum in order to avoid its toxicity. Other conditions effecting brightness were pH and bleaching temperature.

The rheograms in Figure 1 of standard and treated bentonites showed time-dependent non-newtonian behaviour. From Figure 1 yield value of standard bentonite and treated bentonite $A_{1S0.3}$, $A_{2S0.3}$, $A_{2S0.6}$ were 23, 0.5, 13.4 and 12.4, respectively. From Figure 5 yield value of standard bentonite and treated bentonite $A_{2S0.6}$, B_{2L2}, were 21.6, 6, 6 and 6, respectively. Standard bentonite showed higher yield value than treated bentonite.

Thixotropic coefficient of standard bentonite was higher than that of treated bentonites. Treated bentonites gave different results and the treated bentonite sample B_{2L1} (Figure 2) gave higher thixotropic coefficient than the other treated bentonite samples.

From Table 3, standard and treated bentonites used in acne cream gave different colour of the preparations. Preparation using standard bentonite was gray while the other using treated bentonite was pale-yellow. All preparations showed no creaming. The result indicated no effect of light on the stability of these preparations. Storage temperature had an effect on colour of the preparations, i.e. the colour became a little darker at higher temperature. However, refrigeration was the best condition for storage of these preparations.

Packaging had an effect on the product especially bentonite sample $A_{2S0.3}$ prepared by method 2. In glass packing, no effect occurred but in aluminium tube at 44°C, the colour of the product prepared by using bentonite B, changed to black with bad smell. Aluminium tube could react with the product, therefore glass container is recommended for packaging of this acne cream formula.

From Table 4 sedimentation volume of standard and treated bentonite were equal in formula 1 but were different in formula 2, but the difference were very little. Sedimentation volume of all products were satisfactory. The redispersion of products prepared by using standard bentonite were easier than the product prepared by using treated bentonite both in formula 1 and formula 2. The viscosities of all products prepared from both standard and treated bentonites increased according to time of storage and distance from the surface to the bottom which T-bar halipath penetrated downward. The products also showed thixotropy at the same position when the T-bar moved downward and returned upward.

Suggestion

1. Choosing of the appropriate sample of bentonite is very important. It must be done first before studying in order to get the one having properties complying with the purposes of utilization.

2. Washing process governs bentonite properties. The smaller the size is, the better the quality of bentonite is obtained.

3. Amounts of sodium carbonate used should be as little as possible on improving bentonite and giving requirement properties.

4. Method of preparation and instruments used affect the properties of bentonite. Therefore, controlling method of preparation and choosing high efficiency of instrument must be done.

5. Pharmaceutical application based on conformation of USP specification of bentonite. Our treated bentonite should have high thixotropy for the use as a suspending agent.

6. Thai bentonite is showing tendency to be able to use in pharmaceutics but deeply study of improving bentonite properties should be done.

7. Zeta potential measurement may be useful to differentiate sodium bentonite from calcium bentonite.

CONCLUSIONS

1. Two samples of Thai bentonite clay were investigated by comparing with standard bentonite from the United Kingdom. Samples of bentonite were washed and passed through sieve no, 325 mesh and the yield was 95%.

2. Samples of Thai bentonite were brighter than that of standard, i.e. their colors were pale-yellow while standard bentonite was pale-brown. For the improvement of brightness, sodium dithionite in varying quantities was used.

3. Washed bentonite had low swelling and gelling properties which did not comply with the USP specifications so improvement of these properties were necessary. Sodium carbonate and sodium hydroxide were used and it has been found that these two alkalies could improve bentonite properties. Sodium carbonate gave better result than sodium hydroxide.

4. Two methods were used to treat bentonite samples, in method 1 only sodium carbonate was used whereas in method 2 sodium carbonate together with ammonium chloride and hydrochloric acid were employed. Bentonite treated by method 2 had better quality and met USP specification than bentonite treated by method 1. Ammonium chloride gave better swelling and gelling properties if optimal quantity being added.

5. Both standard and treated bentonites show thixotropic properties. Standard bentonite showed much more thixotropic property than treated bentonites. Different hysteresis loops were observed among treated bentonite and the least degree of thixotropic was found in treated bentonite using in method 1.

6. It has also been found that concentration, temperature and ageing affected viscosities of bentonites, the viscosity increases with storage time in usual manner. The effect of pH on viscosity can not be concluded because of other factors e.g. bentonite type and electrolyte used for adjusting pH.

7. Both standard and treated bentonites were proven to be a good emulsifying agent in acne cream and better colour of the cream was obtained with treated bentonite.

8. Aluminium tube was not good material for packing and refrigeration condition was needed for this acne cream formula. Treated bentonite by method 2 reacted with aluminium tube more than the one by method 1.

9. As a suspending agent standard bentonite was better than treated bentonite in calamine lotion. Suspensions containing standard bentonite can be redispersed easier than the ones containing treated bentonites.

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Table 1. Swelling power, gel formation and pH of washed bentonite, treated bentonite and standard bentonite.

Bentonite	Method of preparation	Alkali used	% alkali (W/V)	Swelling power (ml)	Gel formation	pH
Standard	-	-	-	24	pass	9.54
Washed sample 1	-	-	-	9	not pass (3ml)	8.10
Treated bentonite sample 1	1	sodium carbonate	0.2	22	pass	9.93
			0.3 ($A_{1S0.3}$)	27	pass	10.14
			0.4	25.5	pass	10.19
			0.5	21	not pass (2.5ml)	10.26
			0.6	15	not pass (2.5ml)	10.49
		sodium hydroxide	0.2	26	pass	10.02
			0.3	20	not pass (2.5ml)	10.14
			0.4	19	not pass (2.5ml)	10.27
			0.5	17.5	not pass (2.5ml)	10.32
	2	sodium carbonate	0.2	23	pass	9.33
			0.3 ($A_{2S0.3}$)	27	pass	9.47
			0.4	27	pass	9.50
			0.5	27	pass	9.53
			0.6 ($A_{2S0.6}$)	26	pass	9.89
			0.7	26	pass	9.71
			0.8	26	pass	9.79
			0.9	26	pass	9.88
Washed sample 2	-	-	-	11.5	not pass	8.25
Treated bentonite sample 2	1	sodium carbonate	0.2	21	pass	9.95
			0.3	18	not pass (2.5ml)	10.15
			0.4	18	not pass (2.5ml)	10.22
			0.5	18	not pass (2.5ml)	10.35
			0.2	28	pass	9.10
			0.3	28	pass	9.18
			0.4	27	pass	9.18
			0.5	26	pass	9.32
			0.6	26	pass	9.42

Table 1. Continued.

Bentonite	Method of Alkali preparation : used		% alkali (W/V)	Swelling power (ml)	Gel formation	pH
	2	sodium carbonate				
			(0.2) 30% HCl 0.6 g	25	pass	9.88
			(0.2) 20% NH_4Cl 1.0 g	24	pass	9.92
			sample B_{2L1} large quantity	24	pass	9.92
			sample B_{2L2} large quantity	27	pass	9.62

Table 2. Brightness of standard, washed and treated bentonite.

Bentonite	Method	% (W/V) of sodium carbonate solution	Sodium dithionite (g/50 g bentonite)	% brightness
Standard	-	-	-	61.6
Washed	-	-	- 0.1 0.3 0.6	79.0 84.0 85.0 85.0
A_{1S}	1	0.3 0.5 0.6	-	71.5 69.5 68.5
A_{2S}	2	0.3 0.5 0.6	-	76.5 74.5 74.5

Table 3. Physical stabilities of acne cream after 3 month storage

Bentonite	Description of product	Vial dark|light	Vial refri|25°C|44°C	Aluminium tube refri|25°C|44°C
Standard	grey	had no effect from light	no change	no change
$A_{1S0.3}$	pale-yellow but darker than the one prepared by using bentonite B	had no effect from light	small change to darker colour	small change to darker colour
$A_{2S0.3}$	pale-yellow	had no effect from light	small change to darker colour	the colour change similar to the one in vial but at 44°C became black and had bad smell

Table 4. Sedimentation volume and caking of calamine lotion

Formula	Bentonite	Sedimentation volume (%)						Times for dispersing suspension by shaking bottle upside up and down	
		1 week	2 weeks	3 weeks	4 weeks	8 weeks	12 weeks	1 month	2 months
1	Standard	98.0	97.0	94.0	94.0	94.0	94.0		10
	$A_{2S0.3}$	98.0	97.0	94.0	94.0	94.0	94.0	9	32
	$A_{2S0.6}$	98.0	97.0	94.0	94.0	94.0	94.0	8	30
2	Standard	96.0	94.0	92.0	92.0	92.0	92.0	7	9
	$A_{2S0.3}$	97.0	94.0	93.0	93.0	93.0	93.0	8	30
	$A_{2S0.6}$	97.0	94.0	93.0	93.0	93.0	93.0	8	27

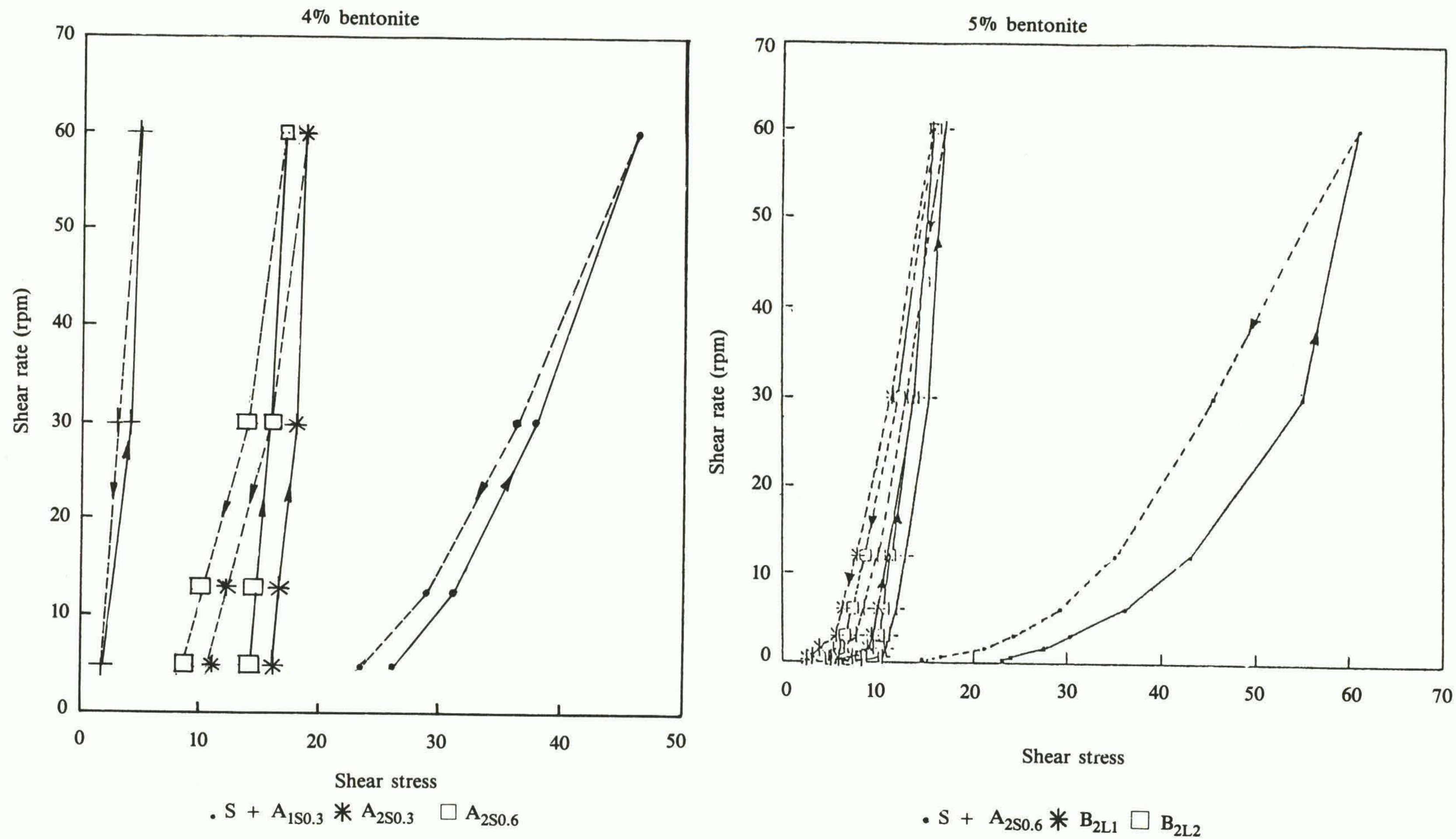

Fig. 1 A plot of shear rate versus shear stress of 4% and 5% bentonite

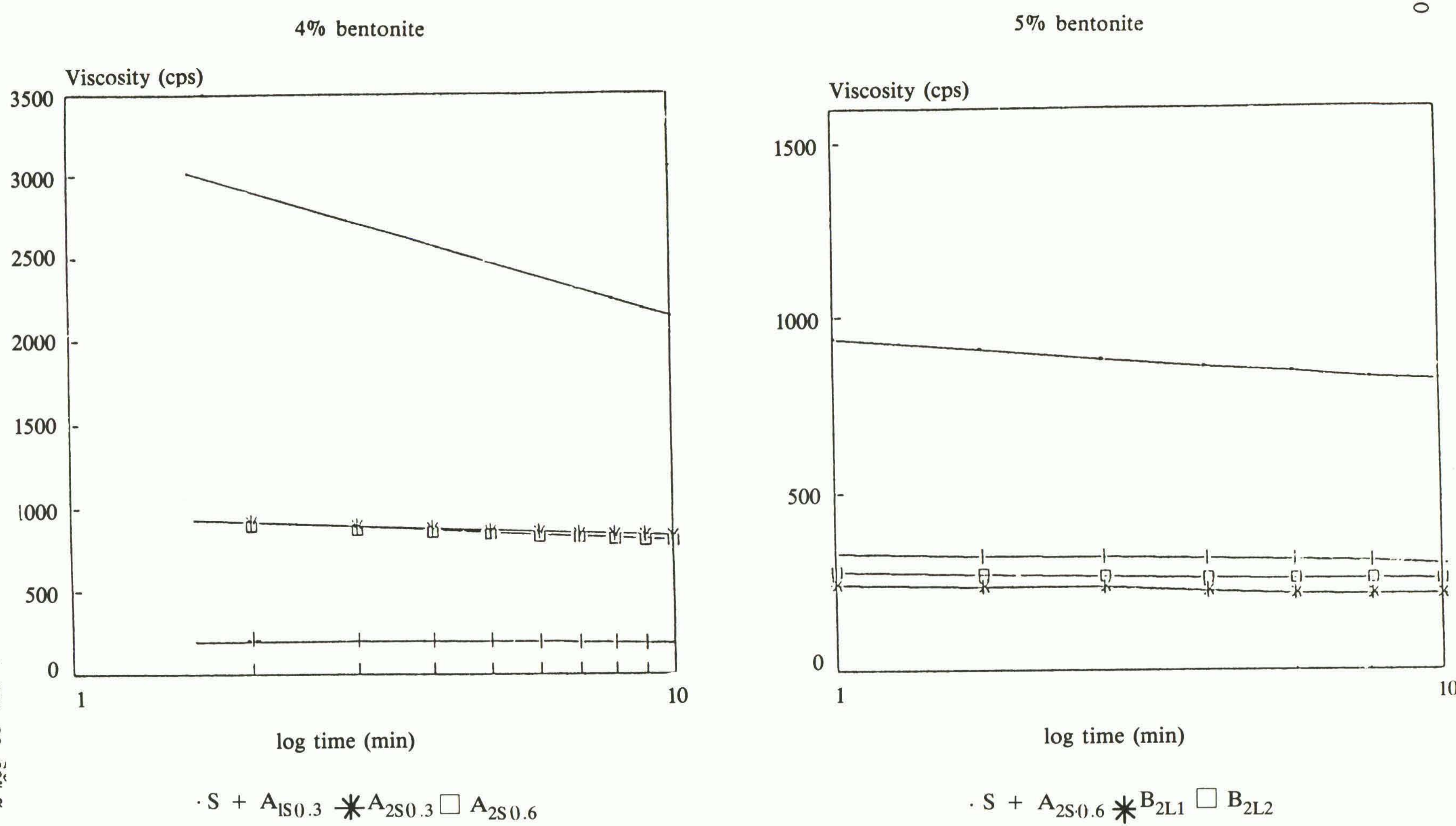

Fig. 2 A plot of viscosity verusus log Time of 4% and 5% bentonite