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A New Exploration of Natural Clay Mineral in Saudi Arabia

Refat El-Sheikhy*

Department of Civil Engineering, King Saud University, Riyadh, Saudi Arabia

Abstract

New nano tube clay has been explored in Saudi Arabia soil. It is green natural nanoclay of two dimensional nano particles having special properties and special dimensions. It is similar to halloysite but different where it can be called as halloysite-like clay nanotubes CNTs. The particles are transparent clearly where other particles can be seen through it. It has a special cross section which is almost not circular but near to be polygonal like hexagonal shape. Dimensions are unique where external width equals almost (20 nm-30 nm) while length is (50 nm-600 nm). Internal width of the lumen seems larger than other type of conventional halloysite with wall thickness less than other type. It can be used as nano containers. Surface area is larger than surface area of halloysite clay since surface area of conventional halloysite is 65 m^2/gm while current clay nano tubes surface area is (168 m^2/gm). It can be bent with a slight curvature because its inertia is large which means that the clay tubes will be always straight while in case of bending it will be bent with curve of large diameter. The new CNTs geometry, dimensions, microstructure, chemical composition, surface area and zeta potential have been characterized using SEM, TEM, EDS, langmuir surface area and ZP.

Keywords: Clay nanotubes • Natural clay • Exploration • Transparent nanoclay • Polygonal cross section • Langmuir surface area

Introduction

It is known that clay mineral has several conventional types. There are some different types can be considered as a rare earth material. Conventional clay such as smectite and kaolinite families have almost same structure and main chemical compositions with slight differences where main chemical structures consists of silicate aluminum. The properties of the conventional clay types can be easily characterized including crystal data, physical properties, geometry, dimensions, chemical composition, surface area and microstructure morphology [1]. These clay types are hydrophilic having the ability of absorbing water. Some types have high volume and shape change abilities producing high swelling or shrinkage ratios such as MMT clay called expansive clay. The particles of expansive clay types have strong bond between the layers of the clay agglomerating in large size. The structure of these types consists of agglomerated layers of platelets shape [2].

On the other hand, there are rare types known as tubular nano clay such as halloysite HNTs and imogolite. HNTs type has different structure, shape and properties. It is not expansive. It is not in platelets or layered shape. Halloysite is rare clay which can be found only in certain places around the world. Generally, conventional clay minerals consist mainly of Al and Si layers. It is always in the shape of platelets such as montimorillonite MMT. Halloysite clay, generally, can be considered as a member of kaolinite family [3]. It consists mainly of just two layers in the shape of tubes of external diameter of about (50 nm) with lumen of diameter of about (15 nm) where external layer is Si and internal layer is Al with presence of O and H (H_2O) between the two layers. Current research could explore another type of nanoclay which is near and similar to halloysite nano tubes HNTs. HNT is nano tube consisting of double layers. The internal layer is Al while external layer is Si sandwiching H_2O layer. It has an empty lumen of about (15 nm) surrounded by aluminum layer, H_2O and then Si layer with global external diameter of about (50 nm) with average length of (1 micron-15 micron). The surface area is of 65 m^2/gm and specific gravity of 2.53 gm/cm^3.

The chemical composition is ($Al_2Si_2O_5$ $(OH)_4$. $2H_2O$). It can be used as nano container and nano reactor using the lumen. The study is long fundamental research which could lead to exploring of a new rare earth material in Saudi soil. Natural green nanotube material with new properties is explored [4]. The explored nanotube material has special dimensions and geometry with good purity. It can be produced easily without much effort for using in industrial, environmental and medical applications. Conventional MMT nanoclay consists of agglomerated flat layers in platelets shape. Each layer has the thickness of 1.0 nm, average width of 100 nm-200 nm and average length of about 400 nm and sometimes the length equals several microns µm. Each layer is one dimensional nano particle since only the thickness is in 1.0 nm size. It is known that the one dimensional nano means that just one dimension of the three dimensions of the volume (X, Y, Z) of the particle is in nano size [5]. It is always in sheets with thickness of 1.0 nm like MMT nanoclay.

***Address for Correspondence:** Refat El-Sheikhy, Department of Civil Engineering, King Saud University, Riyadh, Saudi Arabia; E-mail: relsheikhy@ksu.edu.sa*

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While the two dimensional nano particles means that there are two dimensions of the particle having nano size such as nano tubes, the three dimensional nano particles means that the particles are spherical with nano size in all dimensions (X, Y, Z). Therefore usually nanoclay such as MMT is one dimensional nano particles while halloysie is two dimensional. Clay is known as hydrophilic material with high ability to absorb water from surrounding environment as a liquid or vapor. Therefore nanoclay is always in agglomerated layers in micro size because of absorbing the water. Nanoclay is organic thermosetting brittle material with large surface area [6]. Always nanoclay of one dimensional nano particles is expansive material which can swell easily due to absorbing water or shrink easily due to drying such as MMT. The large surface area play an important role in the swelling mechanism since it allows the nanoclay particles to keep water. There is a special type of clay called halloysite with structure in the form of nano tubes.

Materials and Methods

The halloysite is opaque particles. The nanoclay always used as a filler material to enhance the properties of some other materials such as polymer producing new materials as nanocomposites called clay-based polymer nanocomposites. The current research includes exploration and production of a new very rare and special type of clay nanotubes. It is similar to halloysite but it is not opaque where it is transparent material [7]. The structure is different from halloysite since its length is longer than the known halloysite. The swelling-shrinkage phenomenon of the new explored nano tube clay is very weak but almost zero since its surface shape cannot permit for keeping the water and the tube shape does not allow for keeping water between the particles [8].

The surface area is high of about 168 m^2/gm shown in Table 4. It is also not agglomerated but it is always in single particles. It is a transparent and is shown as exfoliated particles without agglomeration, which means that it is not swelling material. Its dimensions are unique. It can be considered as a rare earth material. It can enhance the properties of the polymer matrix better than other nano clay platelets because of its properties. It needs special method for extraction. The research has three parts; first part is exploration of nanoclay tubes, second part is a technique for extraction of that new clay nano tube and third part includes industrial applications (second and third parts will be published separately soon) [9,10].

Characterization

Characterizations are made to check each of the microstructure, geometry, dimensions, chemical composition, surface area and zeta potential. Characterizations included using each of Scanning Electron Microscope SEM, Transmission Electron Microscope TEM, langmuir surface are and zeta potential. Microstructure, geometry, shape, dimensions and chemical composition by EDS will be checked by using SEM. Shape, geometry (length, diameter), dimensions, aspect ratio, microstructure, cross section shape, lumen, curvature (straight or curved), chemical composition by EDS and transparency will be checked by using TEM microscope. Surface are and density will be checked by langmuir surface area method. Electrical charges, agglomeration or exfoliation ability will be checked by zeta potential to check the ability of the swelling of the new explore nanoclay [11].

Results

Natural green nanotube material with super properties is explored. Nanotube of special type of nanoclay is founded in Saudi soil. The explored nanotube material has special dimensions, mechanical properties and fracture properties. It is found in good purity. The new material is near and similar to halloysite clay type but it is best. It can produce very special materials and composites with high quality and high grade of mechanical and fracture properties rather than the thermal properties. It can be produced easily without much effort for using in industrial, environmental and medical applications. Cross section of the new nanotube clay is not circular but hexagonal [12].

Scanning Electron Microscope (SEM) analysis

Figure 1 is showing natural composition, shape, structure, dimensions of clay that is not curved, not bonded, separating, straight, tubes. Regarding each aspect of shape, geometry, dimensions, appearance, arrangement, structure and morphology can be seen in, the new clay nanotubes can be considered as halloysite-like [13]. The particles are shown as tubes clearly arranged up of each other without having certain direction, length, dimensions or direction can be easily measured using SEM images. It is shown that it is straight particles. In comparison to other types of nanoclay such as MMT, it is known that MMT are always agglomerated. In large particles and cannot be shown in separated particles of micro size while HNTs particles clay can easily be seen in separate particles as shown in Figure 1. Using SEM, the chemical composition is predicted in Tables 1 and 2 [14]. It is shown also that it can be bent with slight curvature without bonding between particles while MMT particles are always bonding to each other producing large size particles of at least 70-100 layers bonded to each. The aspect ratio of (diameter/length) can clearly be estimated from SEM image (Figure 1).

Element	Wt%
Oxygen (O)	47.56%
Aluminum (Al)	8.1%
Silicon (Si)	30.48%
Calcium (Ca)	13.64%
Total wt%	100%

Table 1. EDS chemical composition of newely explored clay nanotube of SEM analysis.

Element	Wt%
Oxygen (O)	48.31
Aluminum (Ai)	10.15
Silicon (Si)	30.57
Calcium (Ca)	1
Potassium (K)	2.6
Magnesium (Mg)	3.76
Ferrite (Fe)	3.57
Total	100%

Table 2. EDS chemical composition of newely explored clay nanotube of TEM analysis.

Transmission Electron Microscope (TEM) analysis

Figures 2-6 are showing the transparency, dimensions, quasi-circular quasi-polygonal cross section, length, diameter, shape, bending, curvature, etc. TEM images are regarding predicting of very important aspects and parameters of clay nano tubes HNTs as transparency once directly as the irst look at the ten images, the transparency of the clay nano tubes can be seen and recognized easily [15]. It is shown that the cross section is not only circular or rounded but also it has rectangular or polygonal shapes.

These circular or rounded cross sections can be curved, other CNTs of polygonal cross section are almost straight. The diameter or width of the tubes perhaps are between (15 nm-50 nm) while the length is about 50 nm-600 nm (Figures 1-6).

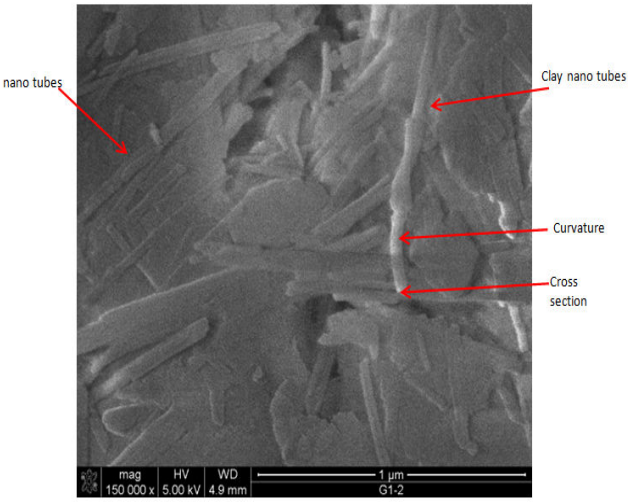


Figure 1. SEM micostructure, geometry and dimensions of new explored Saudi clay nanotubes.

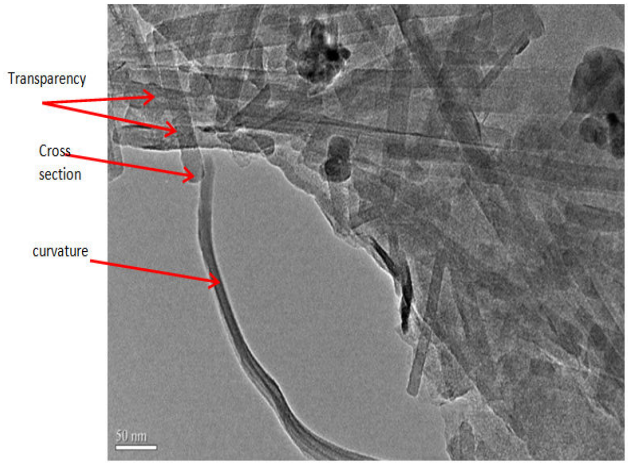


Figure 2. TEM image showing direction, curvature and transparency where bottom particles are clearly seen through other top particles specially at intersecion of paticles.

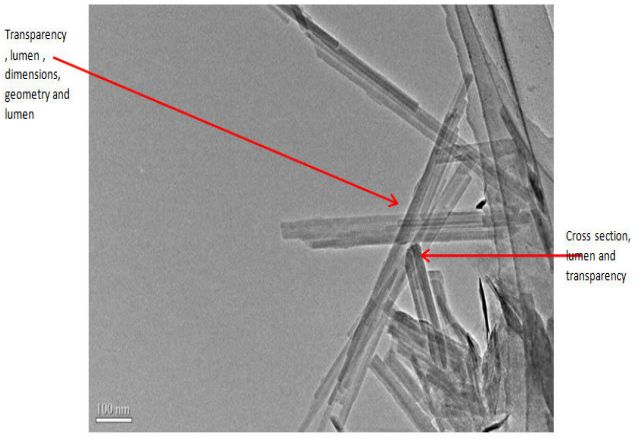


Figure 3. TEM image showing micostructure, geometry, direction, curvature, cross section, dimensions and transparency of newly explored Saudi halloysite-like clay nanotubes where bottom particles are clearly seen through other top particles.

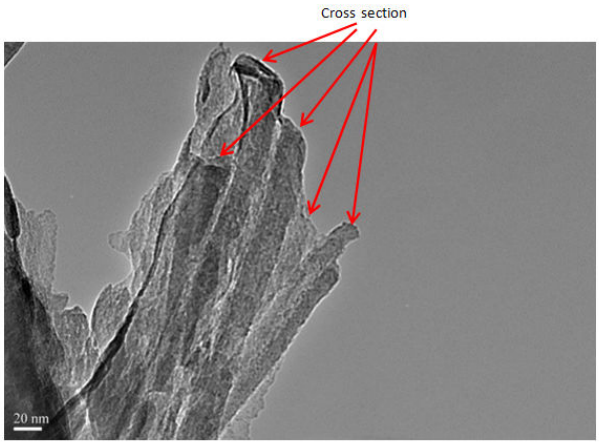


Figure 4. TEM image showing micostructure and cross section of newly explored saudi halloysite-like clay nanotubes.

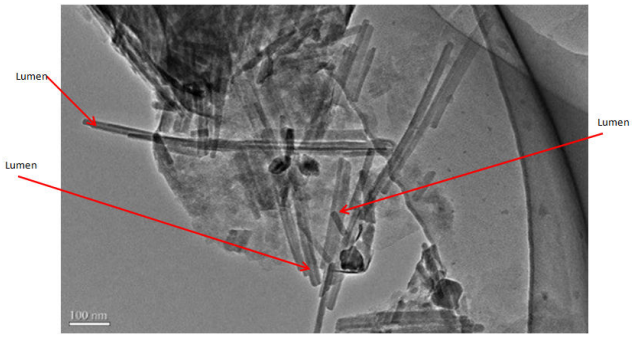


Figure 5. TEM image showing micostructure, geometry, curvature, transparency, cross section and dimensions of newly explored Saudi halloysite-like clay nanotubes.

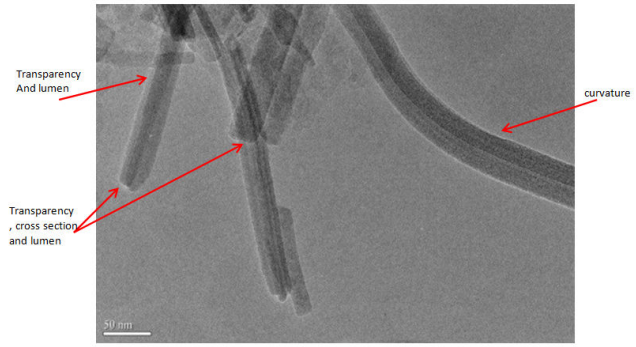


Figure 6. TEM image showing micostructure, geometry, cross section, transparency, curvature, and dimensions of newly explored Saudi halloysite-like clay nanotubes.

Chemical composition EDS

Figures 7,8 and Table 1 are showing chemical composition through electron beams of SEM and TEM respectively. The results of the chemical composition using SEM, TEM are almost identical. The EDS is more believable since the TEM chemical composition is more pure than the SEM sample although the results are almost identical. EDS prove that cross section is almost circular since Al ratio is half of Si ratio when Al is internal layer while Si is the outside layer where Al/Si=(1/2). The results of the chemical composition are matching the results of the shape, geometry and dimensions of the HNTs. Therefore, EDS chemical composition analysis results using SEM electron beam are matching identically the EDS results using TEM electron beam [16].

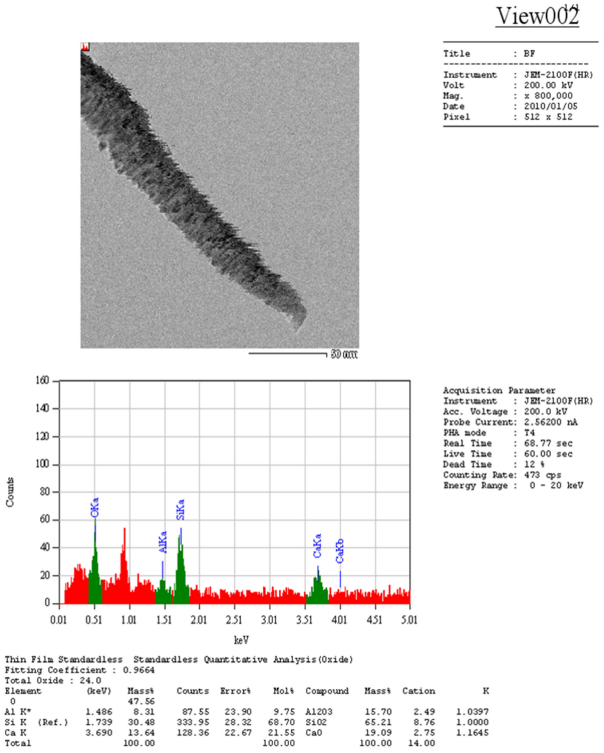
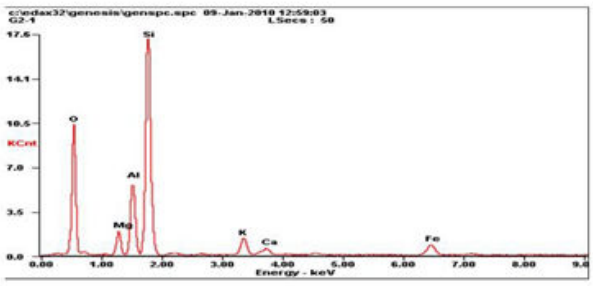


Figure 7. TEM-EDS chemical composition of newly explored saudi halloysite-like clay nanotubes.



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Elem	Wt %	At %	K-Ratio	Z	A	F
O K	48.31	62.97	0.1377	1.0271	0.2774	1.0006
MgK	3.76	3.22	0.0156	0.9881	0.4174	1.0089
AlK	10.15	7.85	0.0513	0.9596	0.5206	1.0115
SiK	30.57	22.70	0.1636	0.9882	0.5412	1.0006
K K	2.64	1.41	0.0200	0.9363	0.8067	1.0027
CaK	1.00	0.52	0.0081	0.9599	0.8477	1.0019
FeK	3.57	1.33	0.0313	0.8804	0.9960	1.0000
Total	100.00	100.00				

Element	Net Inte.	Backgrd Inte.	Error	P/B
O K	1152.18	0.16	0.42	7201.13
MgK	237.14	2.10	0.93	112.92
AlK	798.92	0.80	0.50	998.65
SiK	2451.04	0.22	0.29	11141.09
K K	233.14	0.94	0.93	248.02
CaK	87.54	1.00	1.53	87.54
FeK	178.48	0.30	1.06	594.93

Figure 8. SEM-EDS chemical composition of newly explored Saudi halloysite-like clay nanotubes.

Chemical analysis is carried out for the clay nano tubes CNT using both of SEM EDS and TEM EDS. The TEM EDS predicted chemical composition as Table 1 since it is natural (not synthesized), it can include some other elements. The purity of CNT is about 87%. This ratio of purity can be considered as a good ratio specially it is just natural without puri ication or chemical additives which may change the analysis. Other tested samples have purity ratio near 100%. It is shown from the analysis that Al/Si ratio is (8.31/30.48) which means (1/3.67). This ratio is matching the structure of CNT since it consists of two layers where the inner layer is Al (smaller) while the outer layer is Si (larger). This means that CNT structure is matching the chemical composition. On the other hand the EDS of SEM predicted that chemical composition is as Table 1. Electrical charges on the outer surface of clay nano tube will produce repulsion preventing the particles to agglomerate. The purity ratio is about 89.07% for natural CNT without any puri ication process [17]. It is indicate that Al/Si ratio is about (1/3.01) while the ratio through EDS by TEM is (1/3.67). The two ratios are almost same.

Langmuir surface area

As shown in Table 3, surface area of natural clay nano tubes NT using langmuir method of surface area test results, it is clear the surface area of nature clay nano tube is larger than the surface area of conventional halloysite with percentage ratio equals 258% since the surface area of conventional halloysite is 65 cm^2/gm while surface are of nature clay nano tube equals 168.23 cm^2/gm. This result means that CNT has many advantages makes it different from and better than halloysite nanotubes.

Variables	Test results
Sample mass	0.32 gm
Single point surface area	120.73 cm^2/gm
BET surface area	123.144 cm^2/gm
Langmuir surface area	168.2294 cm^2/gm
Micro pore area	27.47 cm^2/gm
External surface area	95.6726 cm^2/gm
Adsorption cumulative surface area of pores between 17 A and 3000 A diameter	101.604 cm^2/gm
Single point pore volume	At diameter less than 656.028 A 0.2156 cm^3/gm
Micro pore volume	0.011815 cm^3/gm
Adsorption cumulative volume of pores between 17 A and 3000 A diameters	0.24692 cm^3/gm
Average pore width	70.0605 A
Average pore diameter	97.209 A

Table 3. Test results of langmuir surface area.

Zeta Potential (ZP)

Table 4 show the results of Zeta Potential ZP. It shows the electrochemical changes and stabilities of the HNTs. It is a good record of CEC capacity of energy and bond between particles. Zeta potential tests were carried out for different samples including natural Saudi kaolinite samples, synthesized USA sample of nanoclay MMT produced by nanocore US company with organic surfactant modifications in addition to samples of current materials of natural Saudi clay nano tube. Each test is carried out three times. The average result of Zp is considered for each sample for all samples. ZP is measured at room temperature of 25°C using Malvern device using laser doppler electrophoresis. The average ZP of clay nano tube=-40.85 mV which means good stability without agglomeration or flocculation which means that explored nanoclay is not expansive.

Sample	1	3	8	9	2	6	5	7
Material	Kaolin	Kaolin	Kaolin	Kaolin	Kaolin	Kaolin	Clay nano tubes	Clay nano tubes
ZP (mV)	-1.7	-15.1	0.1	0.9	-0.7	-1.2	-37.5	-44.2
ZP stability	Rapid coagulation (aggregation)	Incipient instability	Rapid flocculation (aggregation)	Rapid coagulati on (aggregation)	Rapid coagulation (aggregation)	Rapid flocculation (aggregation)	Moderate stability	Good stability

Table 4. Zeta Potential ZP for different samples of clay including clay nano tube material.

It is well known that zeta potential (ζ-potential) is a scientific term for electro kinetic potential in colloidal dispersions. From the theoretical point of view, it represents the electrical potential in the interfacial double layer at the location of the slipping plane relative to a point in the bulk fluid away from the interface. ZP (ζ-potential) is the potential difference between the dispersion medium and the stationary layer of luid attached to the dispersed particle. Therefore, it is caused by net electrical charge included within the region bounded by slipping plane depending on the location of that plane. Therefore, it is widely used for quanti ication of the magnitude of the electrical charge. Therefore, it is almost the only method for

characterization of double layer properties. ZP is an indicator of the stability of colloidal dispersions.

Its magnitude indicates the degree of electrostatic repulsion between adjacent similarly charged particles in the dispersion. High ZP indicates stable particles electrically without agglomeration while low ZP means particle agglomerations. Zeta potential ZP equals (40.81 mV) which means that the Saudi natural clay nano tube is a good stable in the water electronically. This means that the nano tubes cannot be agglomerated but there high repulsion between the nano tubes which means that nano tube clay is not expansive and the CEC is very low. Therefore, in the water it will not be sediment easily but it will take a long time to sediment based on its own weight. The sample of nano tube still suspension while other samples are sedimentation. All samples of ZP are prepared in distilled water of pH equals (7.0) to be tested in same conditions, room temperature of (25°) and tested in same time by same person. The test results proved that clay nano tube is not swelling clay and cannot be agglomerated. It is just still in shape of exfoliated nano tubes. ZP test also proved that kaolinite and MMT clays can agglomerate easily to large particles and sediment easily in short time based on its velocity, size and dimensions in addition to absorbing water. This means that MMT and kaolinite have high CEC and are highly expansive clay. Figures 9 and 10 show the samples during testing. Table 4 and Figure 11 are indicating the results of ZP for all samples. Since CEC test has several methods and takes a long time for testing time and the results are approximate and easy to be wrong with large uncertainty, the ZP test is the best (Figures 9-11).

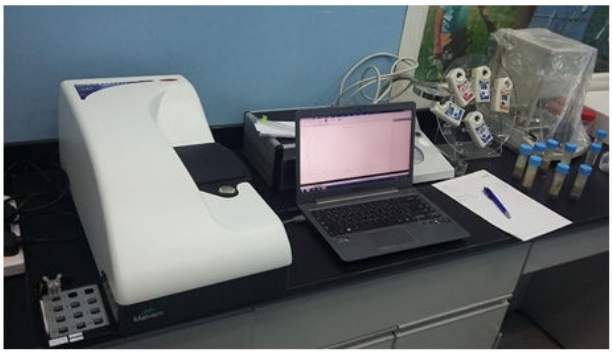


Figure 9. Malvern device for measuring zeta potential.

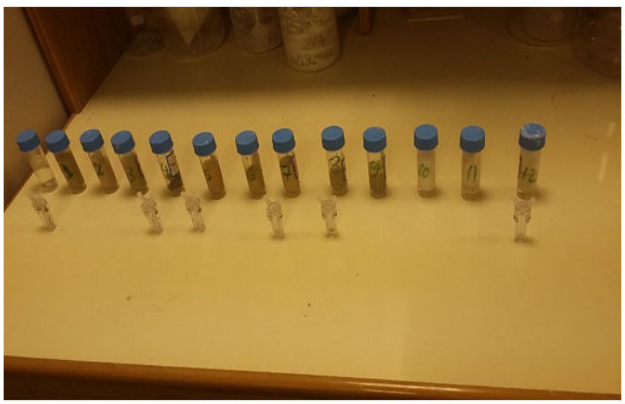


Figure 10. Samples and cells for testing zeta potential.

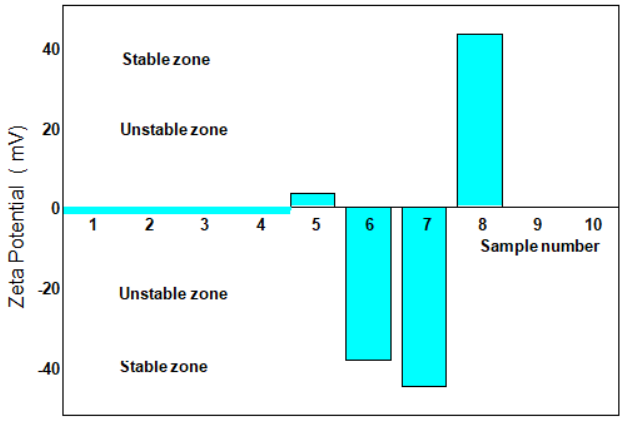


Figure 11. Results of zeta potential testing.

Swelling-shrinkage phenomenon

It is shown clearly that the new Saudi clay nanotubes are not swelling based on ZP results in addition to each of geometry, shape, dimensions, structure and chemical composition.

Discussion

The research is a new exploring of a new rare earth material in Saudi soil. Natural green nanotube material with super properties is explored. Nanotube of special type of nanoclay is founded in Saudi soil. New explored nanotube material has special dimensions, mechanical properties and fracture properties. It is found in good purity. The new material is near and similar to halloysite clay type but it is best. It can produce very special materials and composites with high quality and high grade of mechanical and fracture properties rather than the thermal properties. It can be produced easily without much effort for using in industrial, environmental and medical applications. Cross section of the new nanotube clay is not circular but hexagonal. New explored nano tube clay has been explored. The research is an investigation and characterization of the newly explored natural nanoclay of two dimensional nano particles. It is green nano tubes having special properties with special dimensions. The research is exploring of green nano tubes without chemicals. It is clay nano tube which is similar to halloysite. It is transparent clearly where other particles and objects can be seen through it. It has a special cross section which is almost not circular but near to be polygonal like hexagonal shape. The dimensions are unique where the external dimension equals almost (20 nm-30 nm) while the length is (50 nm-600 nm).

The internal diameter of the lumen seems larger than the other types of known halloysite with thickness less than other types. Therefore it is very easy to be recognized as transparent. It can be filled with other different materials working as nano containers. Surface area is larger than the surface area of other halloysite and MMT clays since the surface area of conventional halloysite is 65 m^2/gm while current clay nano tubes surface area is (168 m^2/gm). It is not swelling clay as MMT. Since its dimensions are very special and the lumen is larger (because it is very clear transparent with thin walls (thickness), it cannot be bent (bending) easily because its inertia is larger than other halloysite type. Therefore the curvature is a slight. This is a good property which means that the clay tubes will

be always in straight shape and in case of bending it will be bent with curve of large diameter which will makes it appear as slight curve similar and near to straight one. The cross section of the new nanotube clay is not circular perfectly but near to hexagonal or pentagonal or elliptical shapes. The result is exploring of new Saudi rare earth material of natural green nano tubes in Saudi soil with very special properties and dimensions.

For the industrial and medical applications, as example adding a small ratio of the new current halloysite to polymers will enhance the mechanical properties with at least (20%) larger than conventional clay in addition to thermal and fracture properties with controlling and preventing the degradation. Its stiffness is larger than the stiffness of other clay materials. By adding it to polymers to produce polymeric nanocomposite, the mechanical and thermal properties of polymers will be enhanced dramatically better than adding the other types of nanoclay such as montimorillonite MMT with the same amount of ratio what is called nanoclay loading or nanoclay content. Moreover, it is expecting that the fracture properties on HNT/polymer nanocomposite will be better than MMT/polymer nanocomposite. The new CNTs dimensions, microstructure, particles size analysis, chemical analysis, surface area and zeta potential have been investigated and characterized using SEM, TEM, EDS, langmuir surface area and ZP. The results are matching each other. In comparison to other types of clay, the new CNTS is clear different with unique properties. The study is long fundamental research which could lead to exploring of a new rare earth material in Saudi soil. Natural green nanotube material with super properties is explored.

Nanotube of special type of nanoclay is founded in Saudi soil. The explored nanotube material has special dimensions, special mechanical properties and special fracture properties. It is found in good purity. The new material is near and similar to halloysite clay type but it is best. It can produce very special materials and composites with high quality and high grade of mechanical and fracture properties rather than the thermal properties. It can be produced easily without much effort for using in industrial, environmental and medical applications. It consists of layers in agglomerated platelets shape. Each layer has the thickness of 1.0 nm, average width of 100 nm-200 nm and average length of about 400 nm and sometimes the length equals several microns μm. Each layer is one dimensional nano particle since only the thickness is in 1.0 nm size. It is known that the one dimensional nano means that just one dimension of the three dimensions of the volume (X, Y, Z) of the particle is in nano size. It is always in sheets with thickness of 1.0 nm like MMT nanoclay. While the two dimensional nano particles means that there are two dimensions of the particle are in nano size such as nano tubes, the three dimensional nano particles means that the particles are spherical with nano size in all dimensions (X, Y, Z). Therefore usually nanoclay such as MMT is one dimensional nano particles. Clay is known as hydrophilic material with high ability to absorb water from surrounding environment as a liquor vapor.

Therefore nanoclay is always in agglomerated layers in micro size because of absorbing the water. Nanoclay is organic thermosetting brittle material with large surface area. Always nanoclay of one dimensional nano particles is expansive material which can swell easily due to water absorbing or shrink easily due to drying such as MMT. Large surface area plays an important role in the swelling mechanism since it allows the nanoclay particles to keep water. There is a special type of clay called halloysite with structure in the form of nano tubes. Halloysite is opaque particles. The nanoclay always used to as a filler material to enhance the properties of some other materials such as polymer. The current invention includes exploration and production of a new very rare and special type of clay nanotubes. It is similar to halloysite but it is not opaque but it is transparent material. The structure is different from halloysite since its length is longer than the known halloysite. The swelling-shrinkage phenomenon of the new explored nano tube clay is very weak but almost zero since its surface shape cannot permit for keeping the water and the tube shape does not allow for keeping water between the particles.

The surface area is high of about 168 m^2/gm as shown in Table 2. It can be considered as non-swelling material. It is also not agglomerated but it is always in single particles. It is a transparent and is shown as exfoliated particles without agglomeration, which means that it is not swelling material. Its dimensions are unique and it is a new type. It can be considered as a rare earth material. It can enhance the properties of the polymer matrix better than other nano clay platelets since it is not agglomerated like MMT nanoclay platelets. It is natural material. It needs special method for extraction. The reseach has two parts. The first part is the exploration for the time for this new type of nanoclay as a new material. The second part is the new invented technique for producing and extraction of that new clay nano tube material. The research is a new exploring of a new rare earth material in Saudi soil. Natural green nanotube material with super properties is explored. Nanotube of special type of nanoclay is founded in Saudi soil. The explored nanotube material has special dimensions, mechanical properties and fracture properties. It is found in good purity. The new material is near and similar to halloysite clay type but it is best. It can produce very special materials and composites with high quality and high grade of mechanical and fracture properties rather than the thermal properties.

It can be produced easily without much effort for using in industrial, environmental and medical applications. The cross section of the new nanotube clay is not circular but hexagonal. The research an exploration of a new rare earth material in Saudi soil. Natural green nanotube material with new properties is explored. The explored nanotube material has special dimensions and geometry. The cross section of the new nanotube clay is not circular but hexagonal. It is found in good purity. The new material is near and similar to halloysite clay type but it is different. It can produce very special materials and composites with high quality and high grade of mechanical and fracture properties if it is added as industrial filler material as a reinforcement for other materials like polymers to produce nanocompoite (will be published soon). Saudi clay nano-tube has very special unique properties including physical, optical, mechanical, chemical properties, structure, dimensions and geometry. These unique properties are clear from the characterization data as the following section. Characterization steps of the investigated Saudi clay nano tube soil predicted that it is similar to hallosite clay but it can be considered as special type of halloysite nano tube. SEM and TEM microscopy characterization have been applied for investigating the shape, geometry, dimensions, aspect ratio, cross section shape and dimensions,

length, bending, curvature, transparency, microstructure and nano structure morphology.

Surface area, pore volume and pore size are investigated using langmuir method. Chemical composition is characterized using EDS. The importance of new explored nanoclay tubes include each of exploring of material with special dimensions, special properties, transparent material, cross sectional shape of the new nano tube clay paticles is hexagonal, length of the new nano tube clay particles is about 4-6 microns and important applications in industrial fields. From the characterization, it is shown that current explored nanoclay tubes have internal layer of aluminum Al_2O_3 and external layer of silica Si_2O_2, with internal diameter equals (10-15) nm. Shape of cross section is almost polygonal as octagonal, hexagonal or pentagonal. It is known that while the conventional clay types have several applications, halloysite has more different applications which cannot use the normal clay types because of the properties and structure of the clay which consists mainly of platelet or sheets bonded together in microscale while halloysite structure consists of hollow nano tubes separated individually.

The halloysite nanotubes are naturally eco-friendly with unique and versatile structure composed of double layered aluminosilicate mineral with a predominantly hollow tubular structure in submicron range. Therefore, in current paper, a new type of clay is discovered. It is near to the halloysite ($Al_2Si_2O_5$ $(OH)_4$. $2H_2O$) type although it has different properties. It can be classified as a type of halloysite of classified as a new different clay type. The investigated Saudi clay nano-tube soil has very special and unique properties including physical, optical, mechanical, chemical properties, structure, dimensions and geometry. These unique properties are clear from the characterization data. The characterization steps of the investigated Saudi clay nano tube soil predicted that it is similar to halloysite clay but it can be considered as special type of halloysite nano tube.

Conclusion

Advantages of newly explored nanotube Saudi clay in include that it is transparent while other types are opaque, it is not agglomerated while others like kaolin clay layers are agglomerated, easy to be exfoliated while other types clay needs complicated processing, has high surface area, can be used as nano container, can be used as nano reactor, not swelling/shrinkage clay. The cross section of newly explored nanoclay is not circular completely but it may be near to the circle, rectangle, octagonal, hexagonal and pentagonal). This makes it has high bond to polymer in CPNC especially with its high surface area. It is shorter than conventional halloysite, which means that newly explored nanoclay is better than conventional halloysite in the processing. It is also always straight without high curvature or bending. Also, based on these properties, it has no fractions or breaking during processing while halloysite can easily be broken. Newly explored nanoclay type has very special transparency phenomenon and high surface area.

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