Technical Papers Discussing Vermiculite
by Mike Darling
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Theoretical and Applied Implications of the Structural Order of Irradiated Vermiculite
http://ammin.geoscienceworld.org/content/99/10/1818.abstract
Author: Celia Marcos
Publisher: 2014 Mineralogical Society of America
Abstract: Vermiculite is a layered silicate with a complex crystalline structure, as it is characterized by the existence of a large density of defects—even in the case of the most pure vermiculite [e.g., Santa Olalla, Huelva (Spain)]. As a result of their lamellar structure, vermiculite structures present a broad diversity of behavior and are interesting from both the applied and scientific point of view. Vermiculite is used to examine interesting physical properties such as mixed-cation effects and two-dimensional magnetism. The existence of frustration and disorder is a key feature for understanding the mechanisms of spin-glass, for example. The dimensionality of magnetic interactions, which plays a central role in controlling the critical dynamics of SG systems, is still not resolved. Probably, magnetic studies on structurally ordered vermiculites will elucidate the true nature of spin-glass-like phases. One way to provide structurally ordered vermiculites might be by irradiation with ultraviolet or γ rays. These types of radiation induce structural order in vermiculites leading to materials with enhanced opto-electrical properties, which improve its utility as an electronic insulator and a thermoluminescence dosimeter for innovative dosimetry applications in a radiation-rich environment (Kaur et al. 2014, this issue). Other layered minerals irradiated with γ rays exhibit enhanced radiation shielding capacities and electronic insulating properties

This above paper is one of several related to the academic study of the vermiculite of the Santa Olalla, Huelva district in Spain. Abstracts of other related papers can be found at:
http://ammin.geoscienceworld.org/content/95/1/126
http://ccm.geoscienceworld.org/content/56/3/380.short

Ion-Exchanged Vermiculites with Lower Expansion Onset Temperatures
http://repository.up.ac.za/handle/2263/18592
Authors: Muiambo, Hermínio F.; Focke, Walter Wilhelm (Routledge, 2012-02)
Abstract: South African Palabora vermiculite was modified by ion exchange with ammonium and selected alkali metal and alkaline earth metal ions. In the exchanged vermiculite with ammonium ions, it was found that ammonia and water were the blowing agents and they were simultaneously released during thermal degradation. In the increasing ionic potential series: Na, Ba, Ca and Mg, it was found that the onset expansion temperature also increased dramatically. Exchange with relatively low ionic potential species, namely sodium, potassium, and ammonium, lowered the exfoliation temperature of vermiculite to below 300°C
Keywords: Vermiculite; Ion exchange; Exfoliation; Interstratification; Thermal analysis.

Thermal Properties of Sodium-Exchanged Palabora Vermiculite
http://repository.up.ac.za/handle/2263/15874
Authors: Muiambo, Hermínio F.; Focke, Walter Wilhelm; Atanasova, Maria; Van der Westhuizen, Isbe; Tiedt, Louwrens R. (Elsevier, 2010-09).
Abstract: Palabora represents an interstratified vermiculite-biotite containing less than 50% vermiculite. The sodium-exchanged form was prepared by immersion in saturated brine at ambient conditions. The sodium content reached an equilibrium level within the first month of exposure. However, XRD spectra continued to evolve and sharpen over a six month period. The thermal-activated exfoliation was studied using thermo-mechanical analysis, expansion of the neat “vermiculite” commenced at temperatures above 420°C. In some applications a lower exfoliation temperature is desirable, i.e., in the range 200 - 350°C. This study revealed that simple sodium exchange is effective towards this goal as it lowered the onset temperature by about 120°C., the linear expansion reached a maximum of about eight-fold at temperatures around 700°C and decreased again at higher temperatures. Keywords: Vermiculite; Ion exchange; Exfoliation; Interstratification; Thermal analysis.

Stabilization of Cr (VI) from fine ferrochrome dust using exfoliated vermiculite

http://repository.up.ac.za/handle/2263/19185
Authors: Delphin Mulange wa Mulange, Andrie Mariana Garbers-Craig.
Conclusions: This batch adsorption study proved that South African vermiculite can be used to remove Cr (VI) from fine ferrochrome dust after it was leached in aqueous solution. Measurement over a 12 month period showed that no additional Cr (VI) leached from the treated ferrochrome dust. The FCD can therefore be safely disposed of. The adsorption process was found to be highly pH dependant. The optimum pH of Cr (VI) adsorption onto vermiculite was found to be 1.5. The adsorption capacity is reduced when the pH is further increased. Adsorption increased with an increase in contact time and reached equilibrium after 2 hours. It was also observed that the adsorption of Cr (VI) onto vermiculite is rapid in the initial stages, followed by a progressive uptake. After equilibrium was reached, no significant change in uptake was observed. Increase in adsorption dosage led to an increase in Cr (VI) adsorption. The optimum Cr (VI) uptake was obtained at an adsorbent dosage of 10 g L⁻¹.

XRD analysis of the adsorbent showed the major peak of the vermiculite phase at 2θ = 7.2° drastically decreased in intensity after adsorption. It was also observed that the extent of Cr (VI) adsorption onto vermiculite slightly increases with increase in concentration of the vermiculite phase, which confirms the major role of the vermiculite phase in the adsorption process.

The Cr (VI)-loaded vermiculite also remained unchanged over 12 months, when it was evaluated with the ASTM and TCLP leaching methods. However, Cr (VI) was released from the vermiculite up to concentrations above the South African regulation limit of 0.02 mg L⁻¹, when the vermiculite was evaluated with the Acid Rain Test.

Vermiculite Filler for Polymeric Nanocomposites: Thermal and Dispersion Study

http://www.ingentaconnect.com/content/asp/jscp/2010/00000002/00000001/art00008
Source: Journal of Scientific Conference Proceedings, Volume 2, Number 1, April 2010, pp. 42-44(3)
Authors: Martynková, G. Simha; Buchtík, O.; Plevová, E.; Barabaszová, K.; Holešová, S.; Valášková, M.
Document type: Research article
Publication date: 01 April 2010
Abstract: The demand of nanocomposites for filler properties which is expected utilization. Natural minerals are keeping one of the prior positions in that significance. The thermal properties and strength of the requested properties expected to be improved for polymeric
materials. Modification of that layered materials is still necessary to assure the compatibility of the filler with polymer with non-polar character. The organically modified montmorillonite is still the most frequently studied mineral for the application as the filler. Comparing montmorillonite and vermiculite we can note the difference in layer charge of silicate layer. Thus the vermiculite with higher charge could be more stable. Modification of jet milled vermiculite with amine and phosphonium salts using thermal treatment was performed using 10% of organic amount. The changes of interlayer space of samples after intercalation and nanocomposites were studied using X-ray diffraction analysis. Higher degradation temperature for nanocomposites with vermiculite was defined using thermogravimetry.

**Keywords:** Nanocomposite; Nanofiller; Polystyrene; Vermiculite

**Polyol-Assisted Vermiculite Dispersion in Polyurethane Nanocomposites**


**Authors:** Park YT¹, Qian Y, Lindsay CI, Nijs C, Camargo RE, Stein A, Macosko CW.

**Abstract:** The largest use of polyurethane (PU) is as closed cell rigid foams for thermal insulation. One problem is loss of blowing gases, which leads to slow increase in thermal conductivity. PU composites with plate-like nanofillers create a diffusion barrier, reducing gas transport and slowing insulation aging. In this research, a new in situ intercalative polymerization is described to disperse vermiculite (VMT) in PU. When VMT was modified by cation exchange with long-chain quaternary ammonium, the dispersion in methylene diphenyl diisocyanate (MDI) was significantly improved. Dispersion of clay in MDI was further improved by combining high intensity dispersive mixing with a polyol-clay preblend (master-batch). The VMT dispersibility was characterized using rheology, microscopy, and X-ray scattering/diffraction. With the method of polyol-assisted VMT dispersion, electron microscopy revealed extensive intercalation and exfoliation of clay particles. In contrast, simple mixing of organoclay in MDI resulted in macroscopic localization and poor distribution of clay particles in PU. The final nanocomposites prepared by the master-batch method showed enhancement of mechanical properties (85% increase in elastic modulus) and reduction in permeability to CO₂, as much as 40%, at a low clay concentration of 3.3 wt %. ACS Appl Mater Interfaces, 2013 Apr 24;5(8):3054-62. DOI: 10.1021/am303244j. Epub 2013 Apr 2.

**Microporous Cordierite Ceramics Prepared from Clay Mineral Mixtures Containing Vermiculite**

http://www.ingentaconnect.com/content/asp/jscp/2010/00000002/00000001/art00010?token=00431847b479973a7e2a46762c6b792176666c7045495b5f2a673f582f4749f8d24

**Source:** Journal of Scientific Conference Proceedings, Volume 2, Number 1, April 2010, pp. 49-52(4)

**Authors:** Valášková, Marta; Martynková, Gražyna Simha

**Publisher:** American Scientific Publishers

**Document type:** Research article

**Publication date:** 01 April 2010

**Abstract:** The porous cordierite ceramics were prepared using six clay mineral mixtures of talc, kaolinite and Mg-vermiculite, which has not been used for cordierite synthesis till now. The basic cordierite precursor was mixture consisted of talc, kaolinite and alumina. Other mixtures contained clay minerals and/or alumina with the stoichiometric MgO, SiO₂ and Al₂O₃ ratio close to cordierite, 2MgO·2Al₂O₃·5SiO₂. Ceramic samples contained cordierite enstatite and corundum. Pure cordierite formed from kaolinite and vermiculite. Vermiculite contributed to the formation of large pores, alumina influenced struts architecture. The
Porosity of cordierite ceramics was in the range from 46% to 70%. Cordierites showed structural geometry close to the high-temperature hexagonal $\alpha$-Mg cordierite.

**Keywords:** Cordierite; Structural properties; Vermiculite; X-ray powder diffraction

**Removal of Cu (II) in Fixed Bed and Batch Reactors Using Natural Zeolite and Exfoliated Vermiculite as Adsorbents**


**Authors:** Konstantinos G. Moustakas, Maria D. Loizidou, Marinos A. Stylianou, Simos Ph. Malamis and Vasilis J. Inglezakis

**Source:** Desalination 215 (2007) 133-142

**Abstract:** The ability of natural zeolite (clinoptilolite) and exfoliated vermiculite to remove copper from aqueous solutions was studied in fixed bed column and batch reactors. The effect of agitation speed (0, 100, 200, 400 rpm), temperature (25, 45, 60°C), and particle size [2.5-5.0 mm, dust (<0.25 mm)] and solution pH (1.00–4.00) on the removal of heavy metals was studied. Fixed bed experiments were conducted, using three different volumetric flow rates of 5–7–10 BV (Bed Volumes)/h, under an initial normality of 0.01 N (317.7 mg/L), at initial pH of 4.00 and ambient temperature (25°C). Vermiculite was found to be more effective for the removal of copper in batch mode reactors under all the tested conditions, while the removal efficiency follows the order: vermiculite > clinoptilolite dust > clinoptilolite 2.5–5.0 mm. The removal of Cu(II) using vermiculite reached 67.6%, at ambient temperature and at the agitation speed of 400 rpm, while it was approximately 42.5% at 60°C with no agitation. The highest removal level in the case of clinoptilolite use reached the percentage of 37.3% at the temperature of 60°C without agitation; the same removal efficiency was obtained at ambient conditions with an agitation speed of 400 rpm. Clinoptilolite dust is found to be more efficient than granular clinoptilolite under all the conditions that were tested. Agitation and temperature also affect the uptake of the specific ions. Finally, the acidity of the aqueous solution influences the removal of copper by minerals. In column studies, the decrease of the flow rate resulted in the increase of the removal efficiency.


**Characterization of Vermiculite Structure Using X-Ray Powder Diffraction Before Its Use Into Nanocomposites**

http://www.ingentaconnect.com/content/asp/asem/2011/00000003/F0020001/art00025

**Author:** Valášková, Marta

**Source:** Advanced Science, Engineering and Medicine, Volume 3, Numbers 1-2, April/August 2011, pp. 119-121(3)

**Publisher:** American Scientific Publishers

**Document type:** Research article

**Publication date:** 01 April 2011

**Abstract:** The structural characteristics of Zr-vermiculite as a precursor of zircon in cordierite composite were determined using X-ray powder diffraction method at reflection and transmission arrangements. The aim was to determine how intercalation using the zirconyl chloride in acidic solution affects the vermiculite characteristics obtained by the X-ray powder diffraction. Reflection and transmission diffraction patterns were basis for calculating the lattice parameters and degree of layer stacking order. Elemental analysis supplemented chemistry changes of the structure of Zr-vermiculite which corresponds with the change in the layers storage.

**Keywords:** Acid treatment; Intercalation; Vermiculite; X-ray powder diffraction; Zirconium
Delamination of Vermiculite Particle Using Ultrasonic Treatment

http://www.ingentaconnect.com/content/asp/asem/2011/00000003/f0020001/art00029

Authors: Seidlerová, Jana; Majorová, Petra; Martynková, Gražyna Simha; Slíva, Aleš

Source: Advanced Science, Engineering and Medicine, Volume 3, Numbers 1-2, April/August 2011, pp. 144-148(5)

Publisher: American Scientific Publishers

Abstract: Natural expanded vermiculite (particles size < 100 μm) was used for the investigation of exfoliation effect after hydrogen peroxide and/or ultrasonic treatment at 70°C. Powder samples were treated in water and in hydrogen peroxide solution with variable concentration: 10, 30 and 50 vol.% of hydrogen peroxide. Delamination was monitored using X-ray diffraction methods and particle size distribution measurement. The significant reduction of the basal 001 peak intensity indicated the partial exfoliation of vermiculite particles after treatment with the highest concentration of hydrogen peroxide solution (50 vol.%). The particle size distribution measurement showed the reduction of average particle size in case of treatment in solution with 30 and 50 vol.% of hydrogen peroxide concentration. To describe the mechanism of exfoliation, the content of Na, Ca, Mg, K, Si and Al in water solution after treatments were determined using the atomic emission spectrometry with inductive coupled plasma.

Issue 117: Comparing Growing Media


Abstract: Seeds were sown on 18 September 2010 in a specific seedling medium (Promix). Germination occurred between the 27th and 30th of September and seedlings were transplanted into the various mediums in the experimental tunnel on the 16th and 17th of October. Seedlings were irrigated four times a day at intervals that were changed as plants demonstrated vegetative growth and after consideration of weather/seasonal changes during the growing phase.

Plants showed a strong vegetative growth during the first 30 days (15-20 cm per week), and the first flower clusters appeared during the first and second week of November. Plants were constantly pruned to eliminate side shoots, and were tied to trellises from the third week.

Plants in sawdust developed to various heights with impressive first cluster fruit size, but significantly, the medium compacted and drain analysis suggested a low nutrient uptake compared to other mediums. Drain flow was higher than other mediums (i.e. the medium did not hold the water effectively during irrigation with the majority of input water and nutrients draining away). As a result, plants experienced longer stress periods, which affected the upper fruit clusters and produced less fruit per cluster and smaller in size.

The plants in Vermiculite performed the best in terms of vegetative growth. They reached the 2-metre trellis cable inside 60 days. Interestingly, the flowering and fruit-set stage was slow with less flowers and fruit on mature clusters (average three to five), but fruit size was impressive. Compared to the sawdust medium, Vermiculite’s water retention capacity is high and over-draining of water was due more to the saturated medium rather than lower water retention capacity. This may have affected the overall uptake of nutrients due to low capillary dynamics, which affected fruit formation.

From the mixed mediums, the combination of palm pith 50% / Perlite 50%, and the same mediums at 70% / 30%, produced the best balanced vegetative development as well as perfect flower clusters, fruit number and size.
The mixed palm pith 40% / Vermiculite 30% / Perlite 30% performed well, but due to the water retention characteristics of Vermiculite and palm pith, the medium had a more soggy texture. The vegetative plant development was impressive but fruit set and size differed slightly from the previous medium, but not significantly.

During the first 60 days first and second flower clusters started setting fruit when definitive characteristic of the various growing media started showing differences. Plants grown in palm pith showed a very pronounced and strong vegetative growth, especially leaves. Plants became bushy while fruit developed quickly into full fruit clusters (6-7 fruits) with significant fruit size. Plants in Perlite developed thinner, less pronounced leaf density, but larger fruit clusters. In both mediums – palm pith and Perlite – plants did not develop significant height.

The pot-soil 50% combination with 50% Perlite did not perform well. The pot-soil was structured from large particles of organic matter with minimal water-holding capacity and fermented (similar to sawdust) into a very moist environment. The Perlite improved the water-holding capabilities of the mixed medium, but contributed to increased moistness and expedited the fermentation process. The medium became more acidic and compact over time, which is the reason for the development of tall spindly plants and a significant drop in fruit set and low number of fruit per cluster (two to three) – the smallest fruit size when compared to the other mediums.