Applied Clay Science 131 (2016) 140–143

Contents lists available at ScienceDirect

Applied Clay Science

journal homepage: www.elsevier.com/locate/clay

# Mixture of palygorskite and montmorillonite (Paly-Mont) and its adsorptive application for mycotoxins

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ARTICLE INFO

*Article history:*
Received 28 August 2015
Received in revised form 9 March 2016
Accepted 14 March 2016
Available online 31 March 2016

*Keywords:*
Paly-Mont
Palygorskite
Attapulgite
Montmorillonite
Mycotoxin

ABSTRACT

Fuller's earth is a general term to refer to clays or earthy material that are suitable for bleaching and sorptive uses and it could include attapulgite, sepiolite, and smectite clays that have natural bleaching and/or sorptive capabilities. Paly-Mont refers specifically to a natural mixture of montmorillonite and palygorskite minerals that has sorptive property. Compared to other industrial minerals, palygorskite clay is very rare in nature. However, Paly-Mont is even rarer. The comparison of the basic structure of montmorillonite, palygorskite and their mixture Paly-Mont is that montmorillonite has platy structure and palygorskite has needle shaped structure. Paly-Mont is in between. Paly-Mont can be processed to bleaching clay using low dosage acid. It is also an excellent source clay for mycotoxin binder. After dispersion, Paly-Mont shows clearly base montmorillonite structure and the palygorskite needles above the base structure. It is this unique structure that may help for this special mixture to have high absorption to mycotoxins and at same time to have much lower nutrients to be adsorbed compared to montmorillonite.



## 1. Introduction

Both palygorskite clay and montmorillonite clay are two very important industrial clays (Murray, 2007). They find many application for industry uses. For palygorskite, it has found more than one hundred applications (Jones and Galán, 1988). However, they are relatively rare in nature. There are only five commercially available deposits worldwide. These deposits are in Quincy, Florida to Meigs, Georgia, USA; Guanshan and Xuyi, Eastern Central China; Thies, Senegal; Andhra Pradesh State, India; and Lake Nerramyne, Western Australia. Another name for palygorskite clay is attapulgite, which was first given by Lapparent (1935) to a clay mineral found in deposits in Attapulgus, Georgia, and Mormoiron, France. International Nomenclature Committee has declared that the preferred name is palygorskite (Murray, 2007). Montmorillonite clays are mainly sodium and calcium types. They have even more diversified applications. For simplicity, the term Paly-Mont is used in this paper to refer to the naturally mixture of palygorskite and montmorillonite clay.

Compared to palygorskite or montmorillonite, Paly-Mont is even rarer and is truly a very unique clay. There are only two known locations, south eastern US and central eastern China. In the patent # 5008226, Taylor and Ungermann (1991) used the following description of this unique mixture of clay: naturally occurring mixtures of calcium bentonite and attapulgite clay. The mixtures can be treated with low level of activating acid to make acid-activated bleaching earth for oil purification purpose.

The purpose of this study is to find good clay source raw material to produce high quality mycotoxin binder. Mycotoxins are secondary metabolites produced by many types of fungi and can affect the health of both humans and animals in many ways. As much as twenty five percent of world food crops are contacted by mycotoxins (Alonso-Debolt, 1999). Mycotoxins affect feed nutrition value and livestock performance. There are many research done for adsorption of mycotoxins especially for aflatoxins on montmorillonite (Ramos and Hernández, 1996; Ramos et al., 1996; Liang et al., 2014). However, the adsorption of nutrients is also generally high from our actual test of montmorillonite samples. Palygorskite clay has very good gelling and sorption property in general. But its adsorption of mycotoxins is low (Schell et al., 1993). With the funding of MinTech (Tianjin) Minerals Co., Ltd, our goal is to evaluate the mycotoxin binders which have high adsorption rate and must be good at selective property, i.e. high adsorption of mycotoxins and low adsorption of nutrients. In addition, the mycotoxin binders need to have low enough content of heavy metals and free of dioxins. With extensive testing of 297 clay samples from various locations worldwide, it is found that the unique type of the naturally mixtures have excellent adsorption property to mycotoxins, with high adsorption rate to tested mycotoxins and low adsorption to nutrients. This paper

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http://dx.doi.org/10.1016/j.clay.2016.03.012
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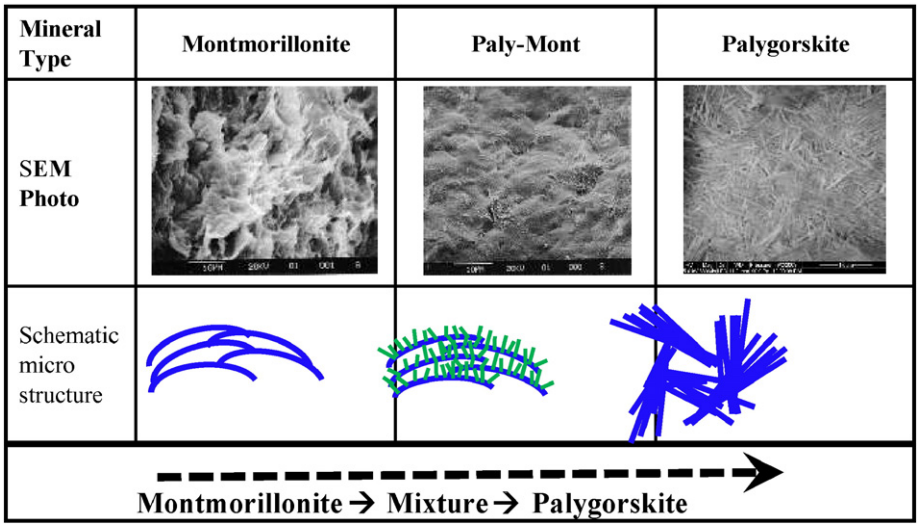


**Fig. 1.** Comparison of SEM photos and schematic micro structure of montmorillonite, palygorskite and Paly-Mont (three samples for SEM are from Mingguang, Anhui, China).

**Table 1**
Chemical analysis results.

| Major chemical element | $SiO_2$ % | $Al_2O_3$ % | $Fe_2O_3$ % | MgO % | CaO % | $Na_2O$ % | $K_2O$ % | $TiO_2$ % | $P_2O_5$ % | MnO % | Other % | Total % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Palygorskite | 68.57 | 9.59 | 5.14 | 14.05 | 0.58 | 0.15 | 0.87 | 0.79 | 0.15 | 0.11 | 0.01 | 100.00 |
| Montmorillonite | 74.61 | 16.70 | 2.14 | 3.53 | 2.47 | 0.24 | 0.15 | 0.12 | 0.00 | 0.00 | 0.05 | 100.00 |
| Paly-Mont | 74.09 | 14.21 | 2.87 | 6.01 | 1.98 | 0.24 | 0.30 | 0.22 | 0.02 | 0.02 | 0.04 | 100.00 |

will discuss the basic mineral properties of Paly-Mont and its adsorptive property.

## 2. Material and methods

### 2.1. Material

The purpose of the study is to evaluate the adsorption capacity of clay minerals to mycotoxins, specifically focusing on aflatoxin B1, The type of clay minerals studied include montmorillonite, palygorskite, sepiolite and the mixtures of any two or more of these minerals and/or with other minerals. The total 297 samples of these minerals were taken from various locations in China, Somalia, Turkey, and US, Samples from Somalia and Turkey are sepiolite and the samples from US are palygorskite. Samples from China include montmorillonite, palygorskite, and Paly-Mont.

### 2.2. Methods

All the samples were dried to moisture between 12% to 16% and ground to the top size at 200 mesh (200 mesh dry retain less than 3%). The aflatoxin B1 test was performed for all samples. Each sample is tested under pH at 3.0 and pH at 6.5 with addition of the clay at 0.1% and 0.4% to the 200 ppb mycotoxin B1 solution. The more detailed test procedure can be referred to the manual of testing equipment such as HPLC by Shimadzu or Waters. The types of nutrients tested for adsorption include Methionine, Threonine, Tryptophan, and Vitamin B6.

## 3. Basic mineral properties

As well documented in many scientific papers and books, the basic structure of montmorillonite is composed of two silica tetrahedral sheets with a central octahedral sheet and called as a 2:1 layer mineral

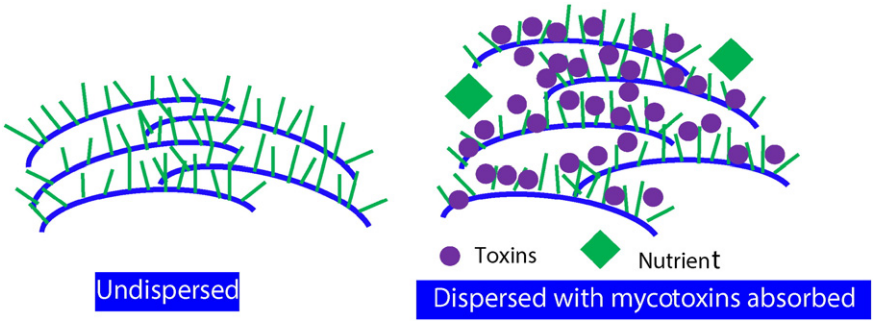


**Fig. 2.** Schematic structure of Paly-Mont and its selective adsorption.