

IMMOBILIZATION OF ASBESTOS FIBERS ON NATURAL ZEOLITE

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ABSTRACT

The main purpose of this paper is to investigate the possibility of immobilization of chrysotile asbestos fibers on natural zeolite substrate, clinoptilolite, with prior structural characterization and physicochemical analysis. Conclusions regarding the obtained composite were derived taking into account physico-chemical similarities and differences between chrysotile and clinoptilolite.

The studied system (asbestos and natural zeolite) was characterized by determining the following properties: particle size distribution (PSD) and pore size distribution of zeolite, specific surface area, interfacial energy of the system asbestos-natural zeolite, morphology and chemical composition of both solid surfaces. The fluid-bed technology was used to achieve contact of the two phases.

Preliminary experiments indicate that there is a possibility of immobilization of asbestos fibers on the clinoptilolite substrate due to their mutual compatibility.

Keywords: Natural zeolite, Clinoptilolite, Asbestos fibers, Chrysotile, Immobilization, Fluid-bed technology

INTRODUCTION

Asbestos is a group of six fibrous hydrated silicate minerals that occurs in sufficient quantity and quality to be mined and processed for industry and market. Chrysotile asbestos ($\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$), the only fibrous member of the serpentine mineral group, is the most used form of asbestos and accounts for approximately 90-95% of the worldwide historic asbestos production [1]. There are severe consequences of asbestos fibers to humans' health: the excessive deposition of collagen (fibrosis) at various thoracic sites, tumours of the pleura or peritoneum (mesothelioma) and lung cancer [2]. The natural zeolite clinoptilolite $(\text{Na,K})_6(\text{Al}_6\text{Si}_{30}\text{O}_{72}) \cdot 20 \text{H}_2\text{O}$ belongs to the tectosilicates group with relatively strong aluminium-silicate framework that is pervaded with cavities connected by channels filled with exchangeable cations (Na, K, Mg, Ca) and water [3-4].

Many countries dispose the asbestos waste as hazardous disposal in landfills or by solidification and stabilization of asbestos waste. An attractive way of recycling the waste materials containing asbestos entities is certainly its temperature degradation into harmless silicate structure. This process has been recognized as efficient one, but also with questionable financial viability [5]. Substantial effort has been provided in order to find alternative methods for separation of asbestos from surrounding media.

In this paper, we introduce the immobilization of asbestos fibers on natural zeolite as a potential technique for effective separation of asbestos fibers from environment. Such adhesion is a surface phenomenon and inherently driven by the surface properties of both solid phases. Our attempt here is to determine the relevant properties for potential adhesion and to assess the capability of such separation technique by using surface analysis techniques (stereomicroscopy, XRD, SEM, and EDAX).

EXPERIMENTAL

First, samples of natural zeolite from the deposit Vranjska Banja (VB) were ground in a laboratory planetary ball mill in dry conditions in order to prepare substrates with different granulometric properties. Particle size distributions (PSDs) were determined in dry mode applying laser diffraction method (SALD-3101, Shimadzu, Japan). PSDs are expressed, on the volume basis, with normalized probability density function, $q_3(d)$. The derived results indicate that all entities in the VB sample are in the size range 0.2-22.0 μm . The BET surface areas, pore volumes and pore size distribution were estimated from nitrogen adsorption and desorption isotherm data using an ASAP 2000 apparatus (Micromeritics Corporation, USA). Standard samples of chrysotile were used for immobilization on zeolite substrates. Secondly, chrysotile and VB samples were brought into contact by their intensive, stochastic movement in a fluid-bed unit (Uni-Glatt, Glatt GmbH, Deutschland) at 25°C for 10 minutes [6-7].

Measurements of the adhesion parameters were done in order to get an insight into the thermodynamic compatibility of the studied minerals.

In addition, characterization of individual samples and mixed samples (VB and chrysotile) was carried out by using XRD analysis (Siemens D-5000 diffractometer using $\text{CuK}\alpha$ radiation). Samples of natural zeolite (VB) and asbestos fibers (chrysotile) were analyzed with a stereomicroscope (Olympus SZX 16, Japan) and the SEM microscopy before and after the contact in a fluid-bed unit. Elemental analysis of samples was performed by using energy the dispersive X-ray spectroscopy (EDXS) analysis within the LINK ISIS 300 system, linked to a scanning electron microscope JOEL JSM 5800.

RESULTS AND DISCUSSION

The preliminary experiments were carried out in order to determine the morphology and chemical composition of natural zeolite (VB) and asbestos fibers (chrysotile) before and after contacting those two in the fluid-bed unit. XRD analysis of samples (Figure 1) reveals the presence of major phases (Table 1) which have been previously confirmed [8].

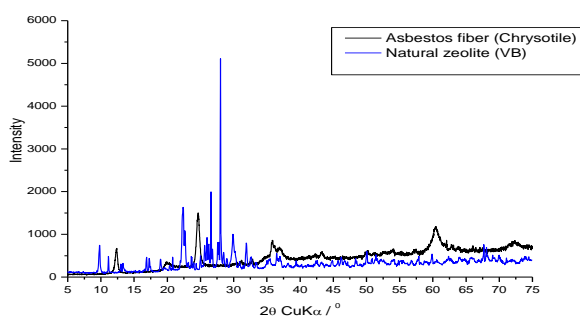


Figure 1. X-ray diffraction patterns of Asbestos fiber (chrysotile) and Natural zeolite (VB)

Table 1. Phase composition of Asbestos fiber and Natural zeolite (VB)

Asbestos fiber	Natural zeolite
The main phases	
Chrysotile	Clinoptilolite
Lizardite	Feldspar
Zinc, Cobalt, Gallium, Iron and Manganese Oxide	Quartz

According to morphological structure shown on Figure 2, the clinoptilolite natural zeolite (VB) occurs in platy (lamellar) shape (a) while chrysotile asbestos occurs in fibrous shape (b). The morphological composition was confirmed by using SEM analysis.

Samples of natural zeolite (VB) were analyzed by stereomicroscope before and after contact with chrysotile in the fluid-bed. It was found that certain compatibility of the two silicate phases does exist (Figure 3).

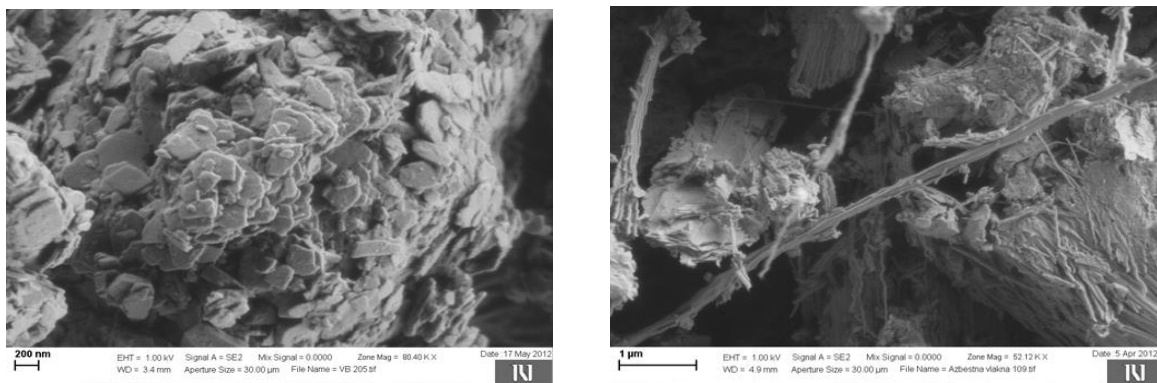


Figure 2. The morphological structure of both samples: a) natural zeolite – Clinoptilolite (VB); b) Chrysotile-asbestos fiber

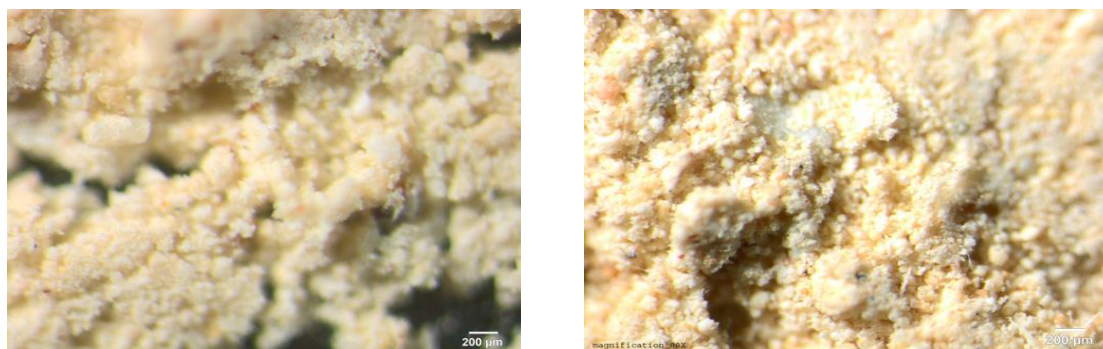


Figure 3. Analysis of natural zeolite (VB): a) before contact with chrysotile; b) after contact with chrysotile in the fluidized bed by stereomicroscope

The compatibility of the mixed sample (VB + chrysotile) was further confirmed by using SEM analysis (Figure 4). It can be seen that there is immobilization of one phase (asbestos) onto the second phase (natural zeolite).



Figure 4. SEM analysis of mixed sample (VB + chrysotile)

From the comparative graph (Figure 5), which shows atomic share (at. %) of certain elements in the analyzed samples (VB, chrysotile and mixed samples (VB+chrysotile), we can determine the increase in the share of oxygen and aluminium in the mixed sample (VB + chrysotile) in relation to the basic components. Share of magnesium was the highest in the sample of chrysotile which is the expected value with respect to its chemical composition.

Silicon content in the sample is the highest in the natural zeolite (VB), and the lowest in the sample of chrysotile. The proportion of iron was the highest in the natural zeolite (VB). Other elements in all samples are present in smaller content values.

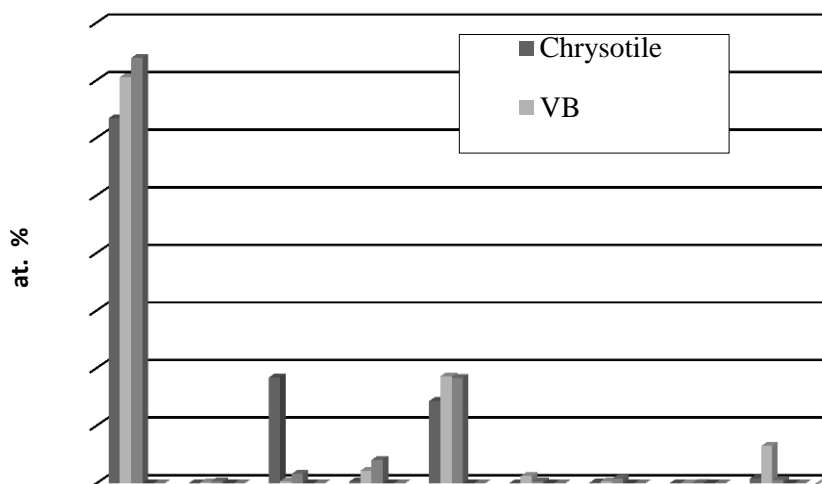


Figure 5. The comparative graph of three different samples (chrysotile, clinoptilolite-natural zeolite (VB)) and mix sample (VB+chrysotile).

CONCLUSIONS

This paper provides preliminary insight in the process of immobilization of waste asbestos by using natural zeolite adsorbents. Fluid-bed mixer was found to be a convenient process unit for adhesion of asbestos fibers on natural zeolite samples. Surface analysis techniques indicate the mutual compatibility of two silicate phases and consequently the suitability of using such zeolite in effective disposal of harmful asbestos fibers. Adhesion of chrysotile might be a result of different net charges on their surfaces.

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