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Radon adsorption by zeolite

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HIGHLIGHTS

- Measurements of radon adsorption by various zeolite granulation are done.
- Adsorption coefficients for natural zeolite and activated charcoal are determined.
- The adsorption coefficients for activated charcoal and natural zeolite are compared.

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ABSTRACT

Due to well defined three dimensional nano- and micro-porous structure, one of the most important properties of zeolite is its surface adsorption capacity. Nevertheless, a natural zeolite adsorption capability of ^{222}Rn has not been thoroughly investigated. The objective of this paper is to review the research concerning the application of natural zeolite in ^{222}Rn adsorption. To achieve this goal the investigation based on measurements of radon adsorption by various zeolite granulation was done. Ball mill is used to achieve different granulations of zeolite in the range of μm–mm, whereas the particle size distributions are determined by particle size analyzer, Mastersizer 2000. The zeolite samples were exposed to elevated radon concentrations up to 1800 Bq/m^3 inside a closed chamber (volume $\approx 5.4 \times 10^{-3}$ m^3). The absorbed radon quantity was measured by high resolution gamma spectroscopy. The influence of particle size was measured and discussed. We found that the adsorption coefficients that were obtained in our experiment for natural zeolite samples for different granulations are similar to adsorbing coefficients for silica gel, but they are an order of magnitude lower than radon adsorbing coefficient for synthetic zeolite. The adsorption coefficient for activated charcoal derived in our experiment (≈ 3 m^3/kg) is in average 50 times higher comparing to the adsorption coefficients obtained for zeolite samples (0.038 m^3/kg–0.11 m^3/kg). All adsorbing coefficients are determined for very low relative humidity of air of about 7%, since our simple experimental setup did not allow possibility to change the relative humidity, or temperature. In addition, we explored the perturbation of radon concentration inside small-volume radon chamber caused by the presence of adsorbing sample and influence of this perturbation on obtained values of adsorbing coefficients.

1. Introduction

Due to the gaseous properties of radon, it is easily emanated from ground or building materials and it can reach high levels of activity in poorly ventilated buildings. Hence, the regular measurement of radon is necessary in order to control the radioactivity levels and take appropriate measures in case of elevated concentrations. Since the late 1980s the main method for short-term measurement of radon concentration indoors is usage of activated charcoal canisters. In the recent years there is an increase in number of studies oriented toward measurement of radon adsorption by alternative types of adsorbing material, and one of those materials is zeolite. It is a naturally occurring mineral group consisting of many different minerals, and it has special porous crystalline structure (Baerlocher et al., 2007). Zeolites can be adapted for a variety of uses, and its ability to adsorb radon should

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be investigated in detail. Studies that measured adsorption of radon by zeolite have shown relatively good adsorbing properties of both, natural and synthetic zeolites (Mortazavi et al., 2009; Paschalides et al., 2010). However, their adsorption properties can vary greatly, due to the pore size distribution and composition of natural ores, as well as the degradation of adsorption characteristics over time due to sensitivity towards ionizing radiation in synthetic zeolites (Hedström et al., 2012). Few article reported data on the subject, although the ability of natural zeolites to adsorb radioisotopes is known; for example *Clinoptilolite* was used extensively in dealing with the effects of Chernobyl accident, while *Chabazite* has been used in the Three Mile Island clean-up (Dyer et al., 2000).

It should be also emphasized that removal of radon from indoor air by contacting the air with a silver-exchanged zeolite was patented (Patent US 7381244 B2).

2. Experiment

For radon adsorption measurements, we used highly porous natural zeolite material, produced by FiMö-Aquaristik GmbH, Germany. We used this material from original, hermetically closed fabric boxes, without its exposure to higher temperatures. Different granulations of this material are obtained by different times of milling (10, 20 and 40 min). Milling was performed in a planetary ball mill Fritsch Pulverisette 5. A hardened steel vial (250 cm^3 volume) and hardened steel balls (10 mm in diameter) were used. The mass of the milled sample was 50 g, and the angular velocity of the supporting disc and vial were 400 and 800 rpm, respectively. Particle size distribution was determined using a Malvern Mastersizer 2000 particle size analyzer capable of analyzing particles between 0.01 and 2000 μm. This analyzer records the light pattern scattered from a field of particles at different angles. The device then uses an analytical procedure to determine the particle size

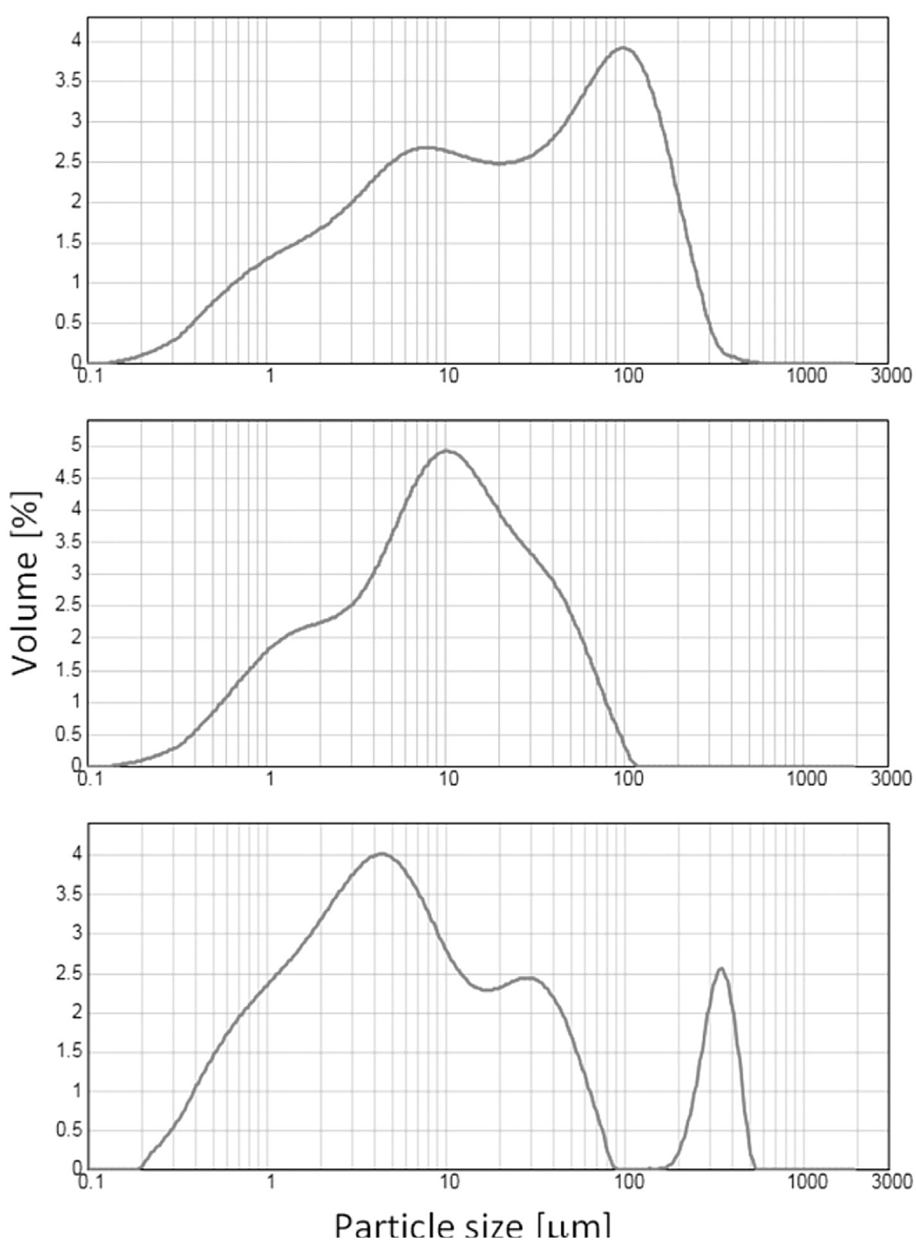

Fig. 1. Particle size distributions for different milling times (from top to bottom: 10 min, 20 min and 40 min).