

SALT BINDING PARAMETERS OF CERAMIC BRICKS

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1. Introduction

Durability and service life problems of building materials and structures induced by salt attacks are becoming very actual topic for researchers and building practice. The main reason is certainly the expenses that have to be expended to the reconstruction of salt damaged structures. Although in Central European countries there is not problem with sea aerosols containing high amount of NaCl, many salt sources can be identified, e.g. underground soils contaminated by salts, salts from the winter road and pavements maintainance, and acid forming gases. For prediction of behaviour of materials exposed to the salt attack, computational modelling is often used.

In modelling salt transport (or, more precisely, ion transport) in a porous medium, the two basic phases, namely the free phase and the bound phase, should be distinguished. Therefore, salt (or ion) binding isotherms have to be determined, which express the equilibrium relation between the amount of free ions in the solution and the amount of bound ions (by both physisorption and chemisorption) on the pore walls in the porous medium. In this work, experimental assessment of ion binding isotherms of two different types of ceramic bricks is presented.

2. Description of the applied method

The common method of determining the chloride binding capacity, and therefore also the chloride binding isotherms, involves dissociating the free chloride fraction from the total chloride content by analysing the pore solution squeezed out from the porous material under high pressure [1]. The total chloride content may be determined using acid-soluble extraction (see, e.g., [2]). However, it has been reported that pore solution expression under pressure results in the release of some loosely bound chlorides, which in turn may result in an overestimation of the level of free chlorides. Acid-soluble extraction may underestimate the total chloride content.

In this work, modified adsorption method proposed by Tang and Nilsson [3] is employed. In this method a crushed sample of a material dried at 11% relative humidity is put into a cup. After that the cup is vacuumed in a desiccator for 2 hours before being filled with a specific concentration salt solution. The volume of the solution inside the cup is calculated from the increment of mass of the cup and the density of the solution. The cup is covered and stored at 20°C to reach equilibrium. Then the inside solution is pipetted to

determine the salt concentration. The bound ion content is then calculated using the known values of the molar mass of the anion, the volume of the solution, the initial and equilibrium concentrations of salt solution and the mass of the dry sample. The free ion content is supposed to be equal to the equilibrium concentration of salt solution in the cup. However, there is the possible problem with the adsorption method because it was originally designed for crushed samples. In fact, this method presents certain idealization of the binding problem assuming that ions can get in direct contact with every small grain of a material. However, in a real building materials specimen the interior pore surface is certainly smaller than the total surface of a crushed specimen. The ion binding capacity can be then affected by many other factors such as the change in the porous structure and pore distribution due to the application of different aggregates, the presence of various admixtures etc. Therefore, the result obtained by the adsorption method in its current form can be considered as a certain upper limit to the real ion binding capacity.

In this paper, a slightly modified adsorption method, taking into account the above considerations and problems associated with its original version is employed. The modification is based on using the specimens of more realistic dimensions and was proposed by Jiříčková et al. [4].

3. Experimental

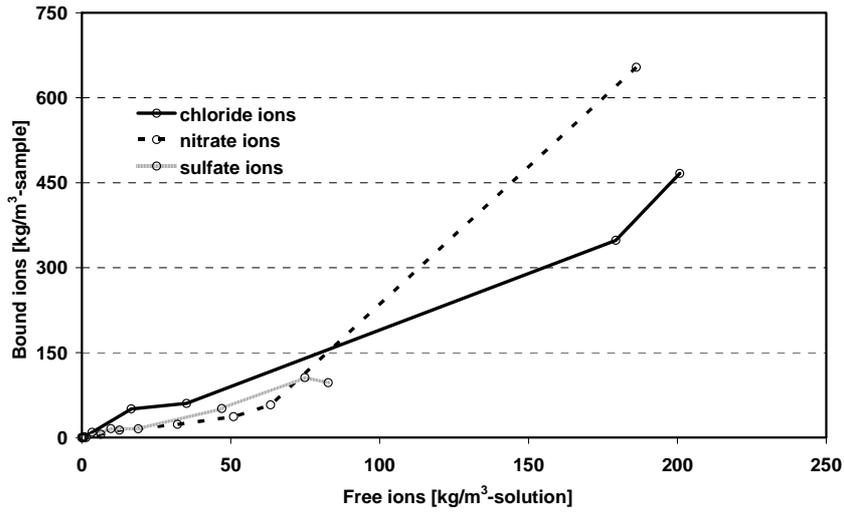
Two types of ceramic bricks denoted BRCZ and BRH were investigated. The bulk density of BRCZ was 2044 kg/m^3 , for BRH it was 1959 kg/m^3 . The binding capacity of the studied materials was measured for NaCl, KNO_3 and Na_2SO_4 solutions. The tested samples were cut into $40 \times 40 \times 10 \text{ mm}$ slices. At first, they were stored in laboratory conditions to remove a part of moisture and then dried in a vacuum oven at $105 \text{ }^\circ\text{C}$. The drying process was finished when sample mass changed no more than 0.01% in three-day period. From the fully saturated solution there were diluted other solutions of the specific concentrations. The samples were placed into the cups with 200 ml salt solution. Then they were stored in laboratory at the temperature of $22 \pm 2 \text{ }^\circ\text{C}$ to achieve equilibrium. The inside solutions were analyzed at first after 6 months, then three times in two days period to verify the measurement reproducibility.

The chloride and nitrate concentration was determined using the equipment pH/ION 740 with ion selective electrodes (ISE). The most important step is to calibrate particular selective electrodes with different known chlorides or nitrates concentrations diluted from standard solution. The amount of ions in liquid samples can be then easily and rapidly determined using selective electrodes. The ISE cell is immersed into measured solution and chloride and nitrate concentration in mg/l solution is shown on the display of the pH/Ion measuring device.

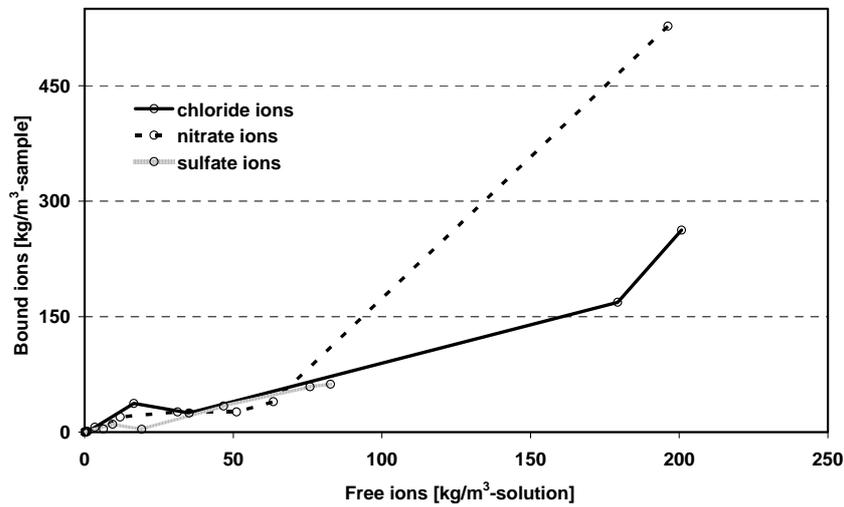
The sulfate concentration was determined on liquid chromatography principle. The measuring apparatus for liquid chromatography consists of microprocessor controlled Chrom sds 150 Pump, which contains DeltaChrom Manual Injection Kit, conductivity detector SHODEX CD-5 and apparatus SS420 χ synchronizing actions between devices. It should be noted that liquid chromatography is highly sensitive method and it is important to use ultra-pure water with conductivity below $0.1 \text{ } \mu\text{S/cm}$.

4. Results

The obtained results are shown in Figs. 1, 2. We can see that the ceramic brick BRCZ exhibited much higher binding capacity than BRH. This was observed for all studied salt solutions.



Obr. 1 Vazebné izotermy pálené cihly BRCZ
Fig. 1 Binding isotherms of ceramic brick BRCZ



Obr. 2 Vazebné izotermy pálené cihly BRH
Fig. 2 Binding isotherms of ceramic brick BRH

We can attribute it to the difference in specific surfaces of the investigated bricks. Concerning the difference in binding of particular salt solutions, the highest values of bounded ions were obtained for KNO_3 solution. Na_2SO_4 was bounded in much lower extent. The results achieved for NaCl solution were for both studied materials somewhere in between. For explanation of these results, detailed micro-physical and chemical analysis will be needed.

5. Conclusions

On the basis of the research work presented in this paper, important data describing the salt binding in ceramic brick materials were found out. The obtained results give information about the materials behaviour exposed to salt ingress what can be used for some rough estimate of salt induced damages of the studied materials. The data will find also use in computational modelling of coupled moisture and salt transport.

References

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AKUMULAČNÍ PARAMETRY SOLÍ PÁLENÝCH CIHEL

Anotace

Práce popisuje experimentální stanovení vazebných izoterem NaCl , KNO_3 a Na_2SO_4 pro dva typy pálených keramických cihel. Experiment je proveden na principu adsorpce iontů solí z roztoku na základě modifikované metody Tanga a Nilssona. Pro měření koncentrace solí ve výluhu je využito iontově selektivních elektrod a v případě síranu sodného iontové chromatografie. Získané výsledky představují cenné informace nezbytné pro pochopení adsorpce iontů solí na stěny porézního prostoru a mohou být použity například jako vstupní data pro počítačové modelování kombinovaného transportu vlhkosti a solí.