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Influence of processing in vapors of quaternary compounds of ammonium (triamon) on the Portland cement sorption properties

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The electro-physical parameters of cement-containing capacitive structures are studied using dielectric spectroscopy under water vapor sorption conditions. For surface treatment of ordinary Portland cement from vapor phase, we used triamon as a substance-modifier. The composition of triamon corresponds to the chemical formula $[(HOC_2H_4)_3N^+CH_3][CH_3SO_3^-]$. The frequency dependence of electro-physical parameters of the structures were studied in the frequency range 12 Hz – 100 kHz using the Goodwill *LCR*-meter (model 819). For this technique the samples was pressed with tin foil under high pressure (300 bar). The end thickness of such parallel-plate capacitor was ~1 mm. The electro-physical parameters of ordinary Portland cement weakly depend on the relative humidity of air up to ~ 75 %. For p/ps > 85 %, sorption of water vapor may lead to the capillary condensation in non-modified Portland cement. Increase of hydrophobic properties of an ordinary Portland cement as a result of processing in vapors of quaternary compounds of ammonium is revealed. The found effect may be useful for industrial production of dry cement mixes.

Keywords: ordinary Portland cement, quaternary ammonium compound, adsorption modification, water repellency

Методом диэлектрической спектроскопии исследованы электрофизические параметры цемент-содержащих конденсаторных структур в условиях сорбции паров воды. В качестве объекта исследования был выбран портландцемент без добавок марки М500 D0 (ГОСТ 31108-2003). Из цементного порошка при давлении 300 атм. прессовалась таблетка диаметром 10 мм и толщиной 1 мм с оловянной фольгой в качестве верхнего и нижнего электродов. Электрофизические характеристики сформированных конденсаторных структур (емкость, сопротивление, тангенс угла диэлектрических потерь) измеряли в частотном диапазоне 12 Гц – 100 кГц с помощью *LCR*-метра (Goodwill-819), с усреднением по десяти измерениям. По электрофизическим характеристикам портландцемент незначительно сорбирует пары воды при относительной влажности окружающего воздуха до 75 %. При значениях относительной влажности более 85 % сорбция водяных паров может проходить по механизму капиллярной конденсации. Обработка парами триамона приводит к значительному повышению гидрофобности портландцемента. Обнаруженный эффект может быть использован при промышленном изготовлении сухих строительных смесей.

Ключевые слова: портландцемент, четвертичные соединения аммония, адсорбционное модифицирование, гидрофобность

Introduction

Moisture content in various construction materials can undergo considerable changes, and determination of their parameters demands carrying out researches of humidity influence on their characteristics. During the hardening and formation of

structure of a cement stone there is a chemical interaction of free water with cement, also water evaporation. Electro-physical methods, including various variants of dielectric spectroscopy [1-4], take an important place among experimental studying methods of water interaction with a dispersed matrix.

Control of structure on a nano-level is the key issue in elaboration of hi-tech construction composites of new generation. Application of the organic surface-active substances (surfactants) is the effective way of modifying of cement mixes influencing hydrophilic and hydrophobic characteristics of components and interphase interactions.

Despite a significant amount of investigations of a surfactant role in formation of structure and properties of cement systems of hardening, searching of effective, technological, economic and ecologically safe plasticizers is actual.

A prospective solution of this fundamental problem is use of dry cement processing in vapors of quaternary compound of ammonium (triamon) which efficiency in formation of surface properties of metals nano-powders is proved in practice [5]. Use of this nano-modifier for control of surface properties of cement systems is new.

Experimental

For surface treatment of ordinary Portland cement from aqueous solution and vapor phase, we used triamon as a substance-modifier, which is used to impart antistatic properties to the textile and polymer materials. The composition of triamon corresponds to the chemical formula $[(HOC_2H_4)_3N^+CH_3][CH_3SO_3^-]$.

The frequency dependence of electro-physical parameters of the structures were studied in the frequency range 12 Hz – 100 kHz using the Goodwill *LCR*-meter (model 819). For this technique the samples was pressed with tin foil under high pressure (300 bar). The end thickness of such parallel-plate capacitor was ~1 mm. The sample under investigation was placed into a hermetically sealed cell, in which a dryer with silica gel was used for removing water vapor. The required values of relative humidity p/p_s were set by the standard method using saturated solutions of various salts. The time of stabilization of stationary states in the sorption – desorption processes for structures was about 24 h. The temperature of all measurements was 295 K.

Results and discussion

The frequency dependence of the structure capacitance is monotonic, and it increases systematically with the relative humidity of ambient air and upon a decrease in the measuring signal frequency. As it was shown earlier [6], dependence of electric capacitance of structures with hydrophilic dielectrics on relative humidity is determined by amount of adsorbed water and its distribution in insulator.

At low frequencies of a measuring signal, the recharge of interphase boundaries gives the significant contribution to the value of electric capacitance (Maxwell–Wagner effect). Capacitance at a high frequency [7] is defined generally by amount of free water in insulator. Therefore, the dependence of the capacitance C of this structure on the relative humidity (p/p_s) in this case reflects qualitatively the form of the isotherm of water vapor sorption by insulator (cement).

Figure represents such typical dependence for an ordinary Portland cement measured before and after its processing in triamon vapors. The initial parts of curves is similar the adsorption isotherm corresponding to the monomolecular and poly-molecular layering. Cement slightly adsorbs water vapors at relative humidity up to 75 % then on

curve C (p/p_s) essential growth with a tendency to saturation at $p/p_s \geq 85\%$ is observed. It can reflects the capillary mechanism of condensation of water vapor [8] in mesopores with a characteristic diameter ~ 10 nm.

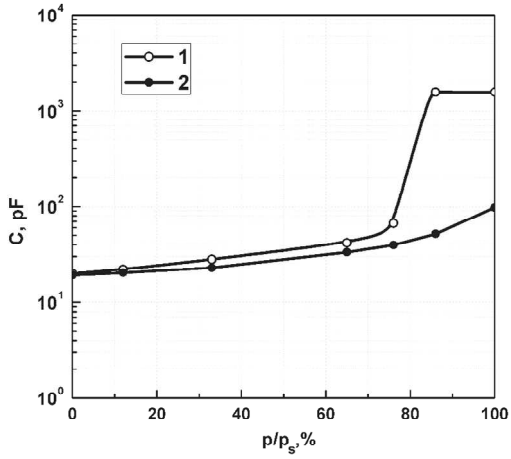

Fig. 1. Dependence of the capacitance of the cement-containing structure on the relative humidity for virgin (1) and modified (2) Portland cement. Frequency of measuring is 10 kHz

Processing of cement in triamon vapors leads to essential increase of its water repellency. Electric capacitance slightly increases to p/p_s=85%, remaining at absolute humidity ten times less its value for non-modified cement.

Conclusion

Thus, the electro-physical parameters of ordinary Portland cement weakly depend on the relative humidity of air up to ~ 75 %. For $p/p_s > 85$ %, sorption of water vapor may lead to the capillary condensation in non-modified Portland cement. Increase of hydrophobic properties of an ordinary Portland cement as a result of processing in vapors of quaternary compounds of ammonium is revealed. The found effect may be useful for industrial production of dry cement mixes.

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