INTRODUCTION OF OF POLYPYRROL NANOPARTICLES IN CEMENT PASTE TO IMPROVE THE PHYSICAL PROPERTIES

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The introduction of different nanofillers in cements is frequently used to give mechanic reinforcement or flexibility and to hydrophobe the material.

In this work we introduced polypyrrol (PPy) nanoparticles at low concentrations in the cement paste, and we studied their influence in the physical properties of the cement.

The cement powder (CEM I 52.5N) and the desired concentrations of PPy in an aqueous emulsion, were introduced in a reactor and mixed during 5 minutes at 300 r.p.m. The initial water/cement ratio of 0.4 was maintained constant for all the samples.

The complex impedance and admittance was measured during the hardening of the cement, as a function of frequency between 1 Hz and 5 MHz, in order to follow the evolution of electrical properties with the hydration time as well as the effect of the nanoparticles.

Dielectric measurements were carried out using an 850 Stanford Research lock-in amplifier. The method consists in the measuring of the 'in phase' and the 'out of phase' components of the output signal, and these quantities were then used to calculate the values of effective resistance and capacitance in a parallel RC model of the sample. All the measurements were carried out at constant temperature of 23 ^{o}C.

Using the Cole-Cole model of dielectric relaxation [1],

$$Z^*(\omega) = Z_\infty + \frac{Z_0 - Z_\infty}{1+(i\omega\tau)^\beta}, \tag{1}$$

$$Y^* = i\omega\left[C_\infty + \frac{C_0 - C_\infty}{1+(C_0 - C_\infty)/A_0(i\omega)^\beta}\right] \tag{2}$$

we calculated the relaxation parameters.

In these expressions, which are empirical modifications of the Debye equation [2], Z_∞ is the high frequency impedance, Z_0 the low frequency impedance, τ the relaxation time, β a parameter between 0 and 1 that reflects the homogeneity of the system, C_∞ the high frequency capacitance and C_0 the low frequency capacitance. An angle of depression can be defined as

$$\alpha = (1-\beta)\frac{\pi}{2}. \tag{3}$$

and is a measurement of the heterogeneity of the material.

The calculated parameters of the dielectric response had given information about the porosity of the material [3], which was confirmed by the measurement of the contact angle at water.

Figure 1 shows the evolution of the depression angle, during the hardening process, for the cement with several concentrations of PPy nanoparticles. For the higher concentration of nanofillers, the homogeneity, measured by this angle, increases.

References:

[1] K. S. Cole, R. H. Cole, J. Chem. Phys., **9** (1941), 341.
[2] P. Debye, *Polar molecules*, Chemical Catalog Company, New York, 1929.
[3] F. Henry, M. Reis, L. C. Costa, C. Freire, Mater. Sci. For. (submitted).

Figures:

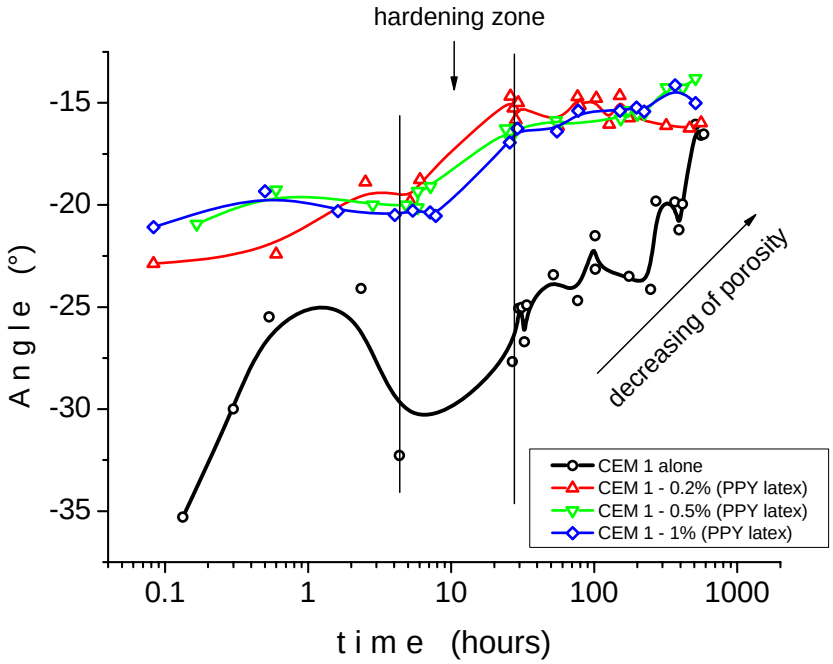

Fig. 1- Depression angle, during the hardening process, for the cement with several concentrations of PPy nanoparticles.