Study of activation energy and reaction parameters on the pozzolanic reaction using quartz and silica nanoparticles.

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Abstract

In order to check the influence of temperature and morphology in pozzolanic reations, different types of silica were tested for a range of temperature. The pH measurements were utilized to plot the activate energy curve and check the advance of reaction. This range of data allows us to conclude that the better condition to conduct these tests is 75°C. Besides, fumed silica produced by Tecnosil presentes lower induction time and better fitting when compared to theoretical curve and when linearized by integer methods.

Key words:

Activation energy, induction time, silica nanoparticles.

Introduction

Particle morphology determines specific behaviors of a compound such as reaction development, induction time and quality of the final product. Silica presents pozzolanic characteristic when it possess a certain degree of reactivity with calcium ions in aqueous medium. Such characteristic provides several applications to silica such as electronic devices, ceramics, laboratory materials, optical components and mineral additive to concrete¹. Aiming to check the influence of the environment and kinetics in amorphous silica formation, three different samples were tested: nanoquartz, amorphous silica produced by LIQC/Unicamp², and amorphous silica purchase from Tecnosil. In addition to the study of chemical kinetics parameters - such as the activation energy - induction time and curve fitting were tested for a better understanding of the method.

Results and Discussion

In order to evaluate the reaction kinetics, aqueous solutions of CaO and SiO₂ in a 1:4 proportion were prepared, by varying the temperature while the pH was measured every 10 minutes. The obtained data were processed by integral methods, and the linear coefficient of the function was used to determine the activation energy.

The table below provides the numerical data for activation energy. Nanoquartz and LIQC's amorphous silica shows a lower value for activation energy, the reaction is expected to occur faster in lower temperatures.

Chart 1.Activation energy of nanoquartz, LIQC's and Tecnosil's amorphous silica.

Component	Nanoquartz	Tecnosil's amorphous silica	LIQC's amorphous silica
Activation energy (kJ)	1.78×10^3	1.77×10^3	2.43×10^3

Image 1 shows induction time for each sample in different temperatures. It is clear that nanoquartz produced at LIQC takes more time until the reaction begins and both amorphous silica present better results to induction time. Comparing this data to the activation energy above, it is possible to conclude that Tecnosil's amorphous silica shows better results: induction time is shorter and it is possible to conduct this reaction in lower temperatures.

This behavior can be explained by its particle size and shape³.

Image 1.Induction time for nanoquartz, LIQC's and Tecnosil's amorphous silica in different temperatures.

It is interesting to notice that using the temperature above 75°C provides results with lower confidence level and temperatures below 60°C takes longer periods to provide any relevant data.

In general, the ideal condition to conduct these pozzolanic tests is 75°C. This value was acquired by checking the fitting curve and reaction advance curve, which presented higher value of R² and greater similarity with the theoretical tendency.

Conclusions

Amorphous silica produced by Tecnosil showed better results for this pozzolanic reaction with lower activation energy and lower induction time. This characteristic provides the material a good technological application such as high performance concrete. Future studies can be conducted to test the improvement into these materials by using regular nanoquartz and amorphous silica.

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